Doctoral thesis

A Study on Agricultural Production Policies in Senegal for Food Self-Sufficiency:

Rice and Maize Production in Senegal River Valley

식량자급을 위한 세네갈의 농업생산정책 연구:

세네갈 리버벨리 지역의 쌀과 옥수수 생산을 중심으로

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A Study on Agricultural Production Policies in Senegal for Food Self-Sufficiency: Rice and Maize Production in Senegal River Valley

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DEDICATIONS

This work is dedicated to:

- *My dear courageous, untiring, entrepreneur, fighter ...mother, Mss Elisabeth Diatta. She has spared no efforts to support and encourage me to move forward. My Dear helped and supported me to face with dignity the obstacles of live.*

  Sincerely, I shall never know neither enough to thank her. May GOD, Subhana Wa Talla, bless her as well as all mothers; give her long live with prosperity, peace and faith in HIM, ALLAH.
- *My deceased Grandmother, AMY NDIAYE,*
- *My young sister, FATOU KINE DIOUF*
- *All my brothers, sisters and cousins*
- *All members of Senegal embassy in South Korea*
- *All professors, teachers and students.*

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Abstract

Senegalese agriculture relies mainly on seasonal production activities marked with low productivity. This contributes to high dependency on imports as far as food self-sufficiency is concerned. This dependency on cereal imports, primarily of rice, wheat and maize has increased gradually due to their low incentive to produce in comparison with cash crops (e.g., peanut and cotton), inappropriate policies and failures in improving agricultural productivity. Domestic agricultural production of cereals in Senegal covers approximately 40% of country's demand. And it is characterized by a low level of fertilizer application and low accessibility of inputs such as seeds and fertilizer. Reflecting these obstacles, the dependency of rice and maize on imports in Senegal reaches up to 80% and 50%, respectively.

Given the shortage of cereal production, a number of agricultural policies has been implemented to lessen country's dependency rate on imports and to improve agricultural productivity in a sustainable fashion. For example, policies such as one targeting to regulate and strengthen agricultural institutes, building agricultural infrastructure, providing easy access to production factors (e.g., certified and improved seed, improved land, fertilizers) and stabilizing a producer price have been implemented. The Senegalese agriculture is well known for its over-provision of agricultural policies, which generates many problems including a lack of consistency, inadequacy and ineffectiveness of agricultural policies in Senegal. This contributes to high dependency of cereal production on imports, low productivity, and a small share of agriculture in GDP.

The purpose of this dissertation is to investigate the current status of Senegalese agriculture with a focus on aforementioned agricultural productivity issues. This contributes to build up future prospects of Senegalese agriculture. To do this, main efforts are given to (i)

investigating yield gap (current vs. potential), (ii) estimating factors affecting yield of rice and maize in Senegal River Valley area, (iii) testing market integration between rural and urban areas and (iv) providing policy tools for a potential international agricultural cooperation between Korea and Senegal.

The findings from this research are summarized as follows:

1) At the country level, the gap between current and potential yield is estimated to be 49.75% and 79.75% for rice and maize production, respectively. But in Senegal River Valley, these yield gaps are found to be less severe; they are 37.9% and 58.8% respectively. These yield gaps are caused by many factors including biophysical, socio-economic and institutional factors. Among them, problems associated with harvest and post-harvest hindrances need to be addressed. And, as domestic financial support for loosening up these constraints is not easy because of a lack of financial capacity of government and farmers, one must look for financial support from overseas. Without funding from outside, many governmental agricultural projects targeting to boost up domestic agricultural production are under a danger of failure.

2) The stochastic production function estimates of rice and maize in Senegal River Valley demonstrate the possibility to reach self-sufficiency of rice in Senegal. Nonetheless, its fulfillment requires many accompanying measures in rice and maize production. These measures include all upstream and downstream activities related to agricultural production for their efficiency and sustainability in rice and maize production to maintain the country's comparative advantages and competitiveness. Then priorities should be given to agricultural infrastructure building, establishment of credit markets, and providing an easy access of production factors (e.g., improved land, fertilizers, improved and certified seeds, as well as

agricultural machines). Furthermore, policy makers should provide a larger incentive in terms of producer price to encourage farmers to increase considerably their outputs, thereby farmers face smaller risk of having non-sold outputs. And during an early harvesting period, appropriate policy measures are in need to prevent farmers from dumping their products under severe social and economic pressures such as children schooling and loan payment, etc..

3) In the market sector, we found a weak correlation relationship between the Free On Board (FOB) price of rice and domestic price (i.e., import price + government subsidy + transportation costs) of rice (coefficient of correlation = 0.3189) as well as between FOB price of maize and domestic price of maize (coefficient of correlation = 0.4436). These results are due to subsidy policies on rice and Senegalese preference of local maize, respectively. In the area of Senegal River Valley, local prices of rice and maize are found to be highly correlated in Saint-Louis market, which is located in an urban area (a coefficient of correlation = 0.7025) and in Mpal market as well, which is located in a rural area (coefficient of correlation = 0.6852). This implies rice and maize are substitutes in Senegal. In addition, Granger-causality test results reveal that the causality direction is from urban area to rural area for the price of rice and from rural area to urban area for the price of maize. These results suggest that the amount of subsidy on rice imports needs to be redirected toward productivity and quality increase to shift the consumption of rice from imported rice to domestically produced rice. For maize, policy attention should be given to the increase of productivity of domestic maize given Senegalese preference for local maize. This effort would increase the supply of domestic maize with which the price of domestic maize in a rural market would decline. Given Granger-causality test results for maize; this would signal a downward pressure on the price of imported maize in an urban market where imported

maize is mainly consumed in a livestock sector and agri-industry.

4) South Korea agriculture development is backed by many combined factors such as R&D, continual technological innovation as well as financial resources availability and accessibility. Nonetheless, land constraint handicaps Korea to fulfill its duty to satisfy the country's domestic demand in many grains except rice. Then in order to achieve the objectives of self-sufficiency and food security, Korean government stipulated its willingness to support Korean investors to access to overseas arable lands which led to the creation of several international agricultural cooperation projects around the world. The establishment of such win-win cooperation between Korea and Senegal may develop and sustain Senegal's agriculture through infrastructure building, training of agricultural agents and transfer of technology. This in turn helps solve food self-sufficiency problems of Senegal.

In conclusion, the concept of improving agricultural sector has to consider all the components of overall sector which range from downstream to upstream for its efficient and substantial consolidation. For that, policies must be designed to simultaneously consider farmers' living standards, consumers' requirements and environment protection improvement, satisfaction and sustainability. Only the achievement of these combined objectives can move Senegal from its vicious circle (low income, low savings and low domestic production) to a virtuous circle (satisfying domestic demand and achieving Senegal's sustainable economic growth).

Keywords: Agricultural Production Policies, Food Self-sufficiency, Yield Gap, Stochastic Production Function, Granger-causality Test, Senegal River Valley

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I. INTRODUCTION

1.1 Context

For more than ten years, prices of mass consumption products (rice, maize and other staples (oil, diary,...)) have continued to increase domestically and internationally because of combined effect of many factors such as world agricultural production decrease, climate changes, the weakness of food crop stocks, the increasing demand of agricultural products in bio-fuel (Kim and Urim, 2010), energy price increase and speculation effects of main actors (producers and dealers). The high price affected negatively the financial situation of Senegal because of the lost of huge foreign currency due to imports. Indeed, in Senegal, domestic agricultural production covers only 40% of local demand (Annex 10, ANSD (National Agency of Statistics and Demography, 2011)). The country depends on imports to cover the deficit. This shortage for rice and maize are respectively 80% and 50% of Senegalese consumption (Annex 11). And mainly for rice, prices on Senegalese markets are continuously increasing because of numerous international reasons (FAO and Africa Rice, 2010) such as the gap between the growth rate of world consumption (1%) and productivity (0.5%), increase of arable land for bio-fuels and loss of 4 million hectares arable land in China assigned to a rapid urbanization making the country a big rice importer (35% of the world market quantity). This situation had led exporters to decrease, see to stop their sales in order to replenish their stocks and stabilize their domestic prices (Niang and Ndiaye, 2010) because supply was limited and producers' countries needed to protect the sustainability of their markets.

The increase of rice prices in the country is due to a huge dependency on imports, low self-sufficiency (20% of local demand in rice (70% from Senegal River Valley and 30%

from the rest of the country (ISRA (Senegalese Agricultural Research Institute)) and 50% in maize) and the high price of rice and maize (Annex 13) is sometimes accompanied by the scarcity of staple grain in markets particularly for rice. This rice scarcity is assigned to its monopolization by a restrained close and partner people. For these reasons significant administrative and financial measures have been taken by the government to soften the shock of price increase, to avoid people's protest, to assure food security and to attain sustainable food self-sufficiency.

Indeed, during 2008 food crisis which was marked by prices soaring, the government adopted a radical improvement strategy to reduce Senegal's dependency on imports. The Great Agricultural Offensive for Food and Abundance (GOANA) was announced in 2008 and triggered a massive boost of government spending in agriculture to achieve self-sufficiency in food by 2015. Policy makers' expected objectives are based on bringing new land into cultivation, assistance to farmers and training of farmers, facilitation of credit access, modernization of irrigation systems and water conservation (e.g. artificial retention pond via rainfall runoff). GOANA program relied on an exponential hike in food production, especially in major cereal commodities such as rice, maize, millet, sorghum...

If self-sufficiency means an ability to satisfy its own needs without outside aid, food self-sufficiency for instance is the capacity of a nation to assure its food security from its domestic production. And according to FAO "food security exists when all people, at all times have physical, social and economic access to efficient, safe and nutritious food which meet their dietary needs and preferences for an active and physical healthy live". In this case diversification in agriculture is imperative and also an important mean for maintaining soil fertility and environmental preservation. However this diversification should be done

efficiently through semi-intensive or/and intensive agriculture systems in order to reach high quality and quantity agricultural production.

In Senegal, rice is the largest imported cereal and maize the third one after wheat. Wheat production in Senegal has been stopped for more than thirty four years (Macoumba Diouf, Director of ISRA (Senegalese Agriculture Research Institute). Then, as threshold profitability of wheat production in Senegal is about 4t/ha according ISRA (2008), the government is struggling to motivate farmers in its production mainly in SRV (Senegal River Valley).

Rice and maize production improvement has a huge partition to fill in the implementation of food self sufficiency by their contents in nutriments and their potentiality of jobs creation which can improve mainly the income of rural people. Rice is an important staple in the world. Its production is a source of income of billions of people in different countries. So it is simultaneously in terms of regional, sub-regional, continental and international exchanges, a factor of outgoing (loss) and incoming (gain) foreign currency for many countries. And this aspect defines its sensible impact on huge rice producers, consumers and importers countries. Furthermore, rice is the largest produced cereal in the globe after wheat and the principal staple in several Asian and African nations, feeding the largest share of the world population. And for Rice Trade organization, rice production is locally concentrated in Western and Eastern Asia which are the biggest rice producers and consumers in the world.

Geographically, rice is the crop the most perfectly distributed around the globe because all countries except Antarctica are activated in rice production in a different scale. However the current characteristics of the rice market make it a very attractive and strategic

area. Developing African countries, highly dependent on rice import recognized the huge and accumulated lack in agricultural investment and decided to stand some participative strategic programs for a best sustainable and diversified development achievement. Aware of the greatness and complexity of this concern, leaders and agricultural sector actors recognized that it must be and can be solved, fixed efficiently by concerted cooperation between actors (public and private). In that context, WARDA (West Africa Rice Development Association) or Africa Rice undertook many policies upstream and downstream rice production in order to reverse this high dependency on imports. Indeed, in Sub-Saharan Africa, Senegal is the second rice importing country after Nigeria. But per capita (imports divided by the total population), Senegal is the leader in the world in rice imports. This rice imports affects increasingly its financial deficiency. The financial deficiency of Senegal was weakly redressed in1980 years with the CFA (Africa Financial community) currency over valuation but since its devaluation in 1996 (imports cheapness) the situation is worsened continuously, pushing authorities without any other alternatives to focus their preoccupations on the improvement, incitation and boosting of diversified local agriculture.

Under this angle, many programs and projects supported by the government, donors, financial institutes or organization have been developed for food security in Senegal. And since some years an increasing importance is given to maize production because of the emergence of agri-industry and livestock intensification in urban areas (poultry). But the domestic production of maize covers just 50% of local demand. And contrary to others countries where there is coexistence of food and bio-fuel used in maize production, in Senegal the second one is legally forbidden.

In policy implementation, concerned the rice sector, production improvement should

be accompanied by a strategic marketing system as preference is given to imported rice. However in maize sector, less effort can be devoted because local maize is highly desired by Senegalese.

1.2 Motivation

Normally Senegal should not be so dependent on rice and maize imports (Annex 12) because of its huge comparative advantages (environmental and human resources advantages) in the production of rice and maize. Among them there is the sun exposure, land availability of 3.8 million arable hectares with 2.5 million hectares cultivated (MEF (Ministry of Economy and Finance), May 2008), water availability of 4,192 sq Km (water surface) and Senegal River Valley as well as Anambé Basin suitable to double cropping with annual water availability (development of irrigated crops).

Indeed this dependency of Senegal on imports can be explained by sustainable socio-economic factors since the colonial period. Cereal production was neglected during colonial and post colonial period since it was not as profitable as cash crops (peanut and cotton). These commercial crops were characterized by high income resources comparing to other crops (rice, millet, sorghum, maize..., etc) with an efficient support from the government and some European countries as France, and a well organized commercialization in the entire sector (from input production to output marketing). And from these cash crop emergence to now, Senegalese's rice market is characterized by a persistent preference of broken imported rice despite of its low quality in the world market. Furthermore local rice price is always lower than the imported one (Annex 13). This phenomenon is due to people's adaptation to the available rice during colonial and post colonial period.

Thereby in order to overcome foreign currency loss, economic recovery through food crop production is important because foreign currency loss caused by imports is about $240 million for the rice and $20 million for the maize per year since 2006 (ANSD, 2011). And the government has lost $6 million because of subsidies on rice imports and suspension of custom duties on imported rice trade. Then loss in foreign currency caused by 2008 crisis would have been lower if import dependency was less.

1.3 Purpose

Given the importance of cereal crops in Senegalese dietary habits, the purpose of this study is to investigate rice and maize sectors of Senegal for a possible future self-sufficiency. The main objectives of this investigation are firstly to analyze the performance of domestic rice and maize production and its improvement factors. This analysis will rely on current Senegal's as well as Senegal River Valley's rice and maize yield gap exploration and factors causing yield gap in the country. The second investigation will be on how to achieve progressively rice and maize self-sufficiency and the third, how to promote local product consumption through agricultural policies and market policies.

Senegal rice and maize self-sufficiency achievement test will be supported by different agricultural policy elaborated instruments and the estimates of the stochastic production function. In the market, domestic agricultural product price redress is based on their market price structures and on Granger-causality test results.

1.4 Literature review

Rice and maize production i.e. in general cereals have been forgotten many years in scientists'

researches and economics literature (OFS, 2010). And demand satisfaction relied on expansive agriculture with unimproved local varieties which led to non sustainable agricultural production (FAO and WARDA 2004-2005 report). Furthermore water scarcity and extensive livestock created in West Africa little plant availability and wondering desertification which increases productivity randomness because of locusts and insects attacks (WARDA 2004-2005 report). In that context, the Africa Rice Centre in collaboration with JICA launched the NERICA (New Rice for Africa) variety (short-term variety) and cultivable even in the most harsh, complex rice ecologies (JICA, 2006). In Senegal, this initiative named Participatory Varietal Selection led to the creation of fifteen short cycle new varieties (Africa Rice, 2009).

Indeed, it is two decades since interest in this area is growing up because of the country huge dependency on imports (MEF, May 2008) and the 2008 food crisis which renewed concern on the improvement of local agricultural production (Niang and Ndiaye, 2010). Many agricultural policies have been vainly elaborated in order to adjust the agricultural production of Senegal contrary to China where agrarian reforms (1978~1984) were significant on agricultural growth (Lin, 1992). And according to many studies focus should be concentrated on two main and essential elements of production. Those are, improved and appropriate rice and maize seed use (WARDW/2004-2005 report, ISRA and BEZELGA And KEITA, 2006) and agricultural practices amelioration in order to secure the current and future generation needs by “reducing the gap between average and potential yields” (Lobell, Cassman, and Field, 2009). For that, priorities should be canalized on sustainable production and consumption through local resources and human capital valorization (GOANA, 2008), technical (itineraries: land tillage and agricultural

intensification) and financial means improvement (MEF, May 2008) as well as processing and marketing systems amelioration (David Neven and Matty Demont, 2010). In fact, the combination of these instruments increased rice productivity by 18% in 2008 compared to 2007 and processing loss decrease between 15 and 25% compared to 40% before (WARDA, January-March 2011).

In the market, government interventions in rice market to control and regulate subsidized prices were negative. They caused the insistence of prices soaring and stable scarcity (retention and intractability) for the rice (MEF, May 2008 & Niang and Ndiaye, 2010). However, they were positive in the maize sector because maize market is characterized by local varieties prices higher than imported maize prices due to its preference by Senegalese. And the emergence of product/sell contracts boosted the maize sector by making it more organized and attractive (Andrew Keck, July 2011). Then, as for rice the preference is given to the imported rice, the cropping of tasty and quick to cook rice will increase the domestic demand of rice (IRRI, 2011). Indeed with 60% and 49% of food budget share on revenue, rice consumption represents 16% and 11% of Senegalese spending respectively in rural and urban area with an increasing perspective (World food program, 2008). For that, the challenges of Africa Rice and Senegalese agricultural agents rely on how to produce sufficient and affordable rice that meet the preferences of its fast growing and increasing urbanized population (Niang and Ndiaye, 2010 and IRRI, 2011) . In this context according to the huge comparative advantage of Senegal in cereal production, mainly rice and maize (Africa Rice, DAPS, and ISRA, 2009), and the complexity of market redressing, particularly the rice sector one, for World food Program paper 2008, priorities should be on a selective subsidy system, import rationalization to avoid re-import in others neighboring

countries, a creation of a dynamic consulting and dialogue framework between agricultural actors and an enhancing domestic agricultural production to reduce progressively and sustainably the country dependence on imports.

1.5 Methodology

The methodology of analysis of this subject is axed in three main models. The first model relies on yields gap assessment and management by using farmers' average yield and potential yield notions to evaluate agricultural production improvement. The yield gap is analyzed in a given year, year 2011, by using ISRA official potential yields and 2011 rice and maize agricultural results in Senegal and in Senegal River Valley. In the second model, the impacts of agricultural policies on production growth will be analyzed by estimating a stochastic production function with a focus on seed price and producer price to analyze the impacts of direct subsidies on RSV output. The producer price is the government buying price of rice and maize from farmers. And finally in the third model part, Senegal rice and maize dependency structure and price correlation analysis is investigated by utilizing Granger Causality tests between rural and urban markets in SRV. This Granger-causality test results will help in policy recommendation to straight simultaneously domestic production and market prices.

The first chapter is an introductive chapter and through the three models analysis subdivided in five chapters is added a chapter of international cooperation. This sixth chapter will focus on Senegal dependency alleviation by calling public and/or private foreign investors. And finally at the end, the conclusion and policy recommendations will be given.

1.6 Data

The data used in this subject include domestic and SRV rice and maize production as well as import. At the country level, data are from FAO and ANSD web sites. And for factors affecting the yield gap data are from survey of West Africa Agricultural Productivity Program done in 2009. The data collection in SRV necessitated divers' contacts from divers' institutes as there is not a centralized information system in Senegalese agriculture sector like in most of developing countries (all sector included). A number of adjustments are also done after main literature review to make the data suitable to an empirical analysis. The main sources of data in SRV are from the Agriculture Office (DA), SAED and ANSD. In the market, all data in prices are from the Office of Food Security of Senegal in Dakar.

1.7 Limits of the study

The principal limitation of this study is detailed data availability mainly at the production level. Then the analysis of production factor impacts will be just limited to their general stage as there is no specific information on inputs. Furthermore, as statistics are not centralized in institutes, the data collection was done by the contact of main previous actors of each program and project.

1.8 Presentation of Senegal

Senegal 196712 sq Km with 2.1% water surface, West African country is bordered by the Republic of Mauritania in North, Ocean in West, the Republic of Mali in East and the two Guineas in South and the Republic of Gambia constituted a quasi enclosed the Atlantic country inside Senegal around 300 km. Its long maritime facade with the Atlantic Ocean,

other surface waters and ground waters resources are some palliative means for the country to overcome the current water scarcity because of its Sudano-Sahelian climate character (short and shrinking raining season: raining season from June to October and non raining season from November to May) and global warming (DA). These water resources are requirement in the development of agriculture sector and also its sustainability for future food self-sufficiency.

The Senegalese population is estimated around 13 567 338 inhabitants for a density of 65.9 inhabitants per square kilometer according to 2006 census (ANSD, 2013) with 70% of the population employed in agricultural sector. However agriculture represents a marginal part in the GDP of Senegal. Indeed Senegal has a GDP of USA $ 12.31 billion (World Bank, 2012 ($984.032 per head)), corresponding to an annual growth rate of 4.1%. This rate is constituted by: Agricultural sector 17%, Industry sector 19.7% and Services 63.3% (ANSD). This pitiful situation reflects the badness of socio-economic indicators which are judged to be slightly improved through these last year's according ANSD. Those indicators are: HDI is 0.459 (UNPD), illiteracy rate of 57.5% (2005-2006 Social protection and health survey prevision), infantine mortality of 72‰ (Ministry of Health/WHO), unemployment rate of 48%, population below poverty line is 43.4%, extern loan is 22.5% of the GDP (32% of the government spending) and an inflation rate of +3.4% (ANSD). In fact, despite all strategies and policies implemented by government since Senegal independence in 1960, and its advantageous political stability, Senegal remains a low-income and food-deficit nation. The situation is the consequence of post-colonial policies. During colonial period and after independence, the government policies were oriented toward groundnut production and commercialization. Senegal was the giant of the peanut sector that constituted a huge source

of income, while neglecting all cereal production. Then the nation became progressively and sustainably one of the more dependent countries on cereal import specially in broken rice. This country dependency on rice import combined with a declining peanut sector affected severely Senegal financial statement with a serious financial deficit.

For that, based on previous programs and projects failure, financial crisis, world cereal stocks weakness (main producers' output decline) and the comparative advantages of the nation on agricultural production, policies and deciders makers oriented their views toward local production improvement (qualitatively and quantitatively) for food security and self-sufficiency focusing on productivity increase (skill to produce enough food to support the population needs). This new system bet on appropriate, participative technologies and practices, and efficient follow up of producers. It is accompanied by a strategic integrated crop management specified according the potentialities of each agro-ecological zone of Senegal.

Senegal is divided into six agro-ecological zones each one has its dominant crop, with a high development and intensification opportunities of its or their exploitation.

Niayes: in which coexist an irrigated and rain fed agriculture. Irrigated system from shallow groundwater allows the production of diversified vegetables and the development of a semi-intensive livestock. And during the rainy season subsistence agriculture is the main activity of producers (millet, cowpea, and groundnut). It is also associated to an extensive ranching (cattle, goats and sheep) in regression.

Senegal River Valley: there is a rain fed subsistence agriculture in the Diéri, a recession cropping in regression and a huge agricultural production in large irrigated perimeters. Rice is the dominant producing cereal with several alternatives (diversified)

production depending on season: rice, maize and sorghum, vegetables, industrial tomato and peanut. There is also in the Diéri-Ferlo an agro-pastoral system based on pastoral resources use and characterized by a mixed activity, extensive breeding associated to rain fed farming in the Diéri.

Peanut Basin: agricultural production is mainly subject to rain fall. There is a subsistence crops (millet, sorghum, cowpea, little peanut...) in small farms (less than 5 ha), small herd size (from 0 to 1beef and some goat / sheep cattle) and poultry. The second system of exploitation is based on peanut / millet rotation system. It is practiced on medium (between 5 and 8 ha) and large farms (> 8 ha) and the 3rd year fallow has almost disappeared. Peanuts and millet occupy 90% of cultivated land. Watermelon and cassava crops are also exploited in and provide significant revenue to producers. Agricultural production is generally under animal traction.

Pasto-forestry zone: four systems coexist in this Ferlo area. The Pasto-forestry system based on grazing exploitation around points of water (boreholes, ponds) is characterized by a low extend movements of cattle within toward drillings and a traditional or exceptional transhumance in function of temporary availability of pastures and ponds with an average herd size of 50 cattle and 70 heads for small ruminants. The agro-forestry system is characterized by a much closer integration between agriculture, forestry and livestock. Crops are the same, but fields are characterized by a much higher density of trees per hectare. The system is based on mixed farming in the southern Peanut Basin, where conditions (rainfall, soils) are more favorable to crop diversification. It is under rain fed (groundnuts, millet, sorghum, rice, maize ...) or irrigated (fruits tree cultivation and market gardening) production system. And at last the agro-pastoral system where livestock is sedentary or semi-sedentary. It

is based on the practice of transhumance when pastures become insufficient and is generally associated to a rain fed crops (millet, groundnut) and an extensive breeding less productive.

Casamance: The average size of family farms varies from 1.5 ha in Lower and Middle Casamance to 5 ha in Upper Casamance. The production systems are very diverse with predominance of crop activities. Livestock is usually present in the farm and is an important secondary activity. In general in dry season, herds are left in wandering and entrusted to a Fulani herdsman during the rainy season. Agricultural activities are more diversified in this zone with a higher rainfall quantity and longer raining season among the country. Rain fed crops is cultivated on slopes and uplands under cereal, groundnut and fallow rotation in regression with agriculture intensification in which exists a less or more developed animal traction in uplands. In lowland crops system, hydro-morph soil; is exploited rain fed flooding rice. An operating upstream system on improved irrigated perimeters due by anti-salt dams permit flooding transplanting rice cultivation in lowlands. This system is added by irrigated ground water rice production. These irrigated crops production systems coexist with a subsistence fishing system in mangroves.

Agro-forestry-pastoral zone: in this area farms size are larger than in other zones with an average of 5 ha in which there is usually several cropping systems based on soil topography. The first system is composed by compound farms and bush farms less fertilized in follow after 3-8 years exploitation. Operating system in hydro-morph land concerns flooding rice production done by women during rainy season, and maize or sorghum production during flood recession. The management of Gambia River in the Eastern part of Senegal allowed the creation of improved irrigated perimeters along it and its affluent provide a rice production system. Livestock, dominated by cattle is a significant activity in this zone

and usually associated to agriculture. It helps to maintain the fertility of farms near houses.

1.9 Description of Senegal River Valley

The Senegal River watershed covers 289 000 Sq km and is split up into three parts; delta (downstream of Dagana), the valley (from Bakel to Dagana) and the upper basin (upstream of Bakel). The delta area in which flow several branches of the river is very flat and invaded by salt water during dry season. The valley is composed by a flooded area which the width can reach 25 km during rainy season. And soils regenerated by the river swollen are very fertile. The upper basin is the wettest area, but agricultural activities are less important in this area.

In Senegal River Valley, agricultural year is divided into two seasons: rainy season and dry seasons. The first begins in May and ends in October. In the second, significant rainfall can happen, but generally it is eight months dry season without any drop of rain. In its downstream part, from Saint-Louis to Matam, the River watershed receives less than 300 mm annual average rainfall. Precipitations are more substantial and increasing going toward upstream area, reaching 600 mm to 1400 mm in the upper basin. As all Sahel countries, rainfall in Senegal is particularly irregular from a year to another. The country is subject to a high climate random and the succession of dry years, as cases of 70s and 80s. These periods were particularly painful, principally for rural people who income resource and also food subsistence depend directly on crops, therefore on rainfall. Then the functions of SAED (Senegal River Valley National Development agency) , as public institute in charge of SRV zones agricultural production improvement is generalized and enforced to alleviate the huge rain fed agriculture dependency.

The Senegal River is 1800 kilometers long. Its annual average flow is about 670m^3/s,

with large fluctuations. In September, the average flow can attain 3320 m^3/s while only $9m^3/s$ in May. These variations are also significant from a year to another, and the annual mean flow is six times greater during the wettest year than during the driest year (ISRA). These two extremes are respectively synonymous of serious damages (flooding), reduction of agricultural production and malnutrition.

Irrigation infrastructures in SRV are Diama (1998) and Manantani (1990) dams. The primary role of Diama dam is to prevent ocean salt water intrusion. Indeed before its construction, during the period of low tide, ocean salt waters' went back into the river, making water unsuitable for irrigation or drinking. The Diama dam helps also to establish a water monitoring plan (upstream of the dam) by raising water level in the river, which can irrigate ten thousand of hectares. It regulates at the same time the river navigability. Despite all its advantages, the Diama changed the river environment, and some consequences are particularly harmful for the population: Bilharzia and aquatic weeds that clog irrigation canals in particular and reduce significantly their effectiveness.

The main functions of Manantali dam is the regulation of river flow and hydropower production. Its reservoir capacity of 11 km^3 allows the storage of Bafing water recession or increases its flow. Regulation is set by consensus with the three countries concerned (Senegal, Mali and Mauritania) in function of downstream dam needs, mainly for agriculture. The objective of Senegal is to irrigate 255,000 ha in the valley. The release of water needed for electricity production are not always the same as those needed for irrigation and involves management decisions in favor of one or other of these two activities.

Senegal River Valley agricultural activities management is confided to SAED and is mainly irrigated agriculture system. In this area, with high agricultural potentialities, the main

and expensive prior agricultural activities are under government charges (planning, land layout and hydro-agricultural layouts management) in order to support lower income farmers. SRV constitutes with the Anambé Basin, managed by SODAGRI, the main attractive areas for foreign investors. Actually the main foreign actors in these zones are Europeans, Americans, Africans (Maghreb countries) and Asians (China, Japan) companies. Japanese and Chinese companies or institutions are increasing supplanting others principally in Anambé Basin where labor is cheaper than the SRV one. But infrastructures are less developed in Anambé Basin.

II. THE ASSESSMENT OF YIELD GAP

2.1 Introduction

Cereals have been the most important food resources in the world in term of both, direct consumption feeding of human being and indirectly consumption as inputs for animal production. Whatever happens in the cereal sector therefore has a strong bearing on the global food supply.

There has been a growing demand for cereals in both developed and developing countries which has created a need and exerted pressure for yield increase. According to FAO, in its report entitled “World Agriculture: Towards 2015/2030”, improvement of cereals yield account for about 70 percent in production increase in industrialized countries. Thereby, expansion of cultivation area in production increase represents just one quarter of the increase in production in those countries. However, in developing countries where land availability and low productivity are widely observed the production increase is hugely related to area expansion accounting for a larger share. This concern is particularly relevant for many developing countries in Africa, where expansion of area has contributed about 35 percent of the increase in production. For Latin America its accounts for 46 percent of production increase in 2002 (World Bank). Furthermore, reflected by Malthus theory, as food and energy demand are raising exponentially due to exponential increase of population and an arithmetic evolution trend of natural resources, yield improvement becomes never than before crucial to overcome current and future pressure on food demand due to the increase of the global population as well as an increase of food consumption with income growth (Lobell, Cassman and Field, 2009).

Yield gaps can be used as a parameter measuring agricultural production performance at different levels: locally, nationally, sub regionally, continentally or more widely. The concept of yield gaps was originated from studies conducted in the 1970s by IRRI (International Rice Research Institute) (MOMDAL, 2011). A study (FAO, 2004) also shows that most of maize and rice varieties fail to attain their potential yields at the farm gate around the world and mainly in developing countries. In the world, actual yields account for about only 4 to 6 ton/ha compared to a potential yield of 10 ton/ha to 12 ton/ha for rice farming. In Senegal like most developing countries, this concern of low yield needs to be highlighted. Senegal's yield gap for rice since 1961 as actual yield has been increased from 1.1 ton/ha to 4.1 ton/ha. But for the maize, this not the case as actual yield was stagnant at 0.8 ton/ha during 1961 to 1979 (FAO). And from 1980, the actual yield of maize has slightly increased to about 1.3 ton/ha with an exception of 2.3 ton/ha, 2.7 ton/ha and 2.8 ton/ha in 2003, 2004 and 2004 respectively due to a special program of maize launched in 2003.

In Senegal, the yield gap which is the difference between the potential yield and farmers' average yields can be attributable to many factors such as inefficient farming practices, socio-economic constraints, and poor organic traits of local varieties (Traoré et.al, 2010). Commonly, potential yield can be defined as a level of yield of an adopted crop variety or hybrid grown under the most favorable conditions without any constraints, limitations from water, nutrients, pests, diseases and others necessary factors of production. Thus, it can be identified in research stations. Notice that, this level varies with the level of improvement of varieties and/or local conditions related to agricultural production due to non-transferable environmental characteristics.

2.2 Evolution of rice and maize yield

Rice and maize are respectively the first and third world-dominant food crop and they are important strategic instruments in many countries for its national economic growth (De Datta and Singh, Nain, Hansra & Raina, 2011). Thus, many countries and mainly developed countries are struggled to overcome agricultural production constraints for progressive sustainable and efficient agricultural production.

In Senegal, the importance of millet/sorghum in grain production is not negligible and represents on average 57% of total grain production (2008-2009) in spite of the increase of rice and maize production and consumption. However, the production of millet and/or sorghum showed a slow rate of improvement over the period between 1995 and 2009 (average of 1% per year compare to an annual average of 3% for rice and maize) due to a very small increase of yield during this period (Ndiaye and Niang, 2010). This results in a low level of the annual average growth rate of domestic cereal production (1.4% per year, ANSD). Note that this is lower than that of the population growth rate (2.56%). Together, this contributes to the decrease of per capita domestic production in cereal.

2.2.1 Rice and maize production in Senegal

Basically in Senegal, rice farming was under rain fed and recession in Casamance (a southern part of Senegal), in the Northern part of the country and in certain Center pockets. These areas have a long tradition in rice production and consumption. For many years, the South part of Senegal, Casamance areas were considered to be the country's granary. However since 1980, policy makers and specialists in agriculture unanimously agreed that the Northern part of the country, more precisely along the Senegal River Valley, is the main source of Senegal

to achieve self sufficiency in food. This is because after the 1980s' frequent drought events that had affected much irrigated agriculture, many strategies and projects were implemented to boost agricultural production in Senegal River Valley.

Exception of Casamance area, millet was traditionally the main produced cereal in Senegal. But, the rapid development of groundnut farming, in the aftermath of the Second World War resulted to the shrink of area cultivated millet (Senegalese Agriculture Direction). This decline of millet farming promoted an important as well as massive rice import policy in order to satisfy the growing demand in cereals of Senegalese. With rapid urbanization and the decrease of the domestic production of millet outpaced by cash crop such as groundnut and cotton, rice became an important provision in Senegalese dietary. Thus, with the abundant rainfall and longer rain seasons that Casamance, the southern part of Senegal enjoys excellent yields and volume of production in maize should be attained. And can be reconverted to cash crop product because of its huge domestic demand.

Introduced in Africa in the sixteenth century by Portuguese explorers, maize is grown in Senegal mainly for its grain in four areas: the East of Senegal, Sine-Saloum, Casamance and Senegal River Valley. The development of this crop in these regions is either linked to the fact that maize is an ancient crop which is traditionally in people dietary or to the fact that maize can help to cross lean periods.

The total production of Senegal River Valley area in maize, which is manly an irrigated maize, does not exceed 10% of the total national area cultivated maize. The production of maize in Senegal has varied in saw-tooth with a relatively constant growth rate from 1961 to 1990. During the period 1991-2000 (FAO) it decreased slightly. And the main factors of constraint that restrict the production of maize in the country are:

① Drought and poor soil fertility,

② The lack of adapted varieties to the soil and climatic conditions,

③ The problems of plant protection,

④ Outdated equipment (depreciation) and

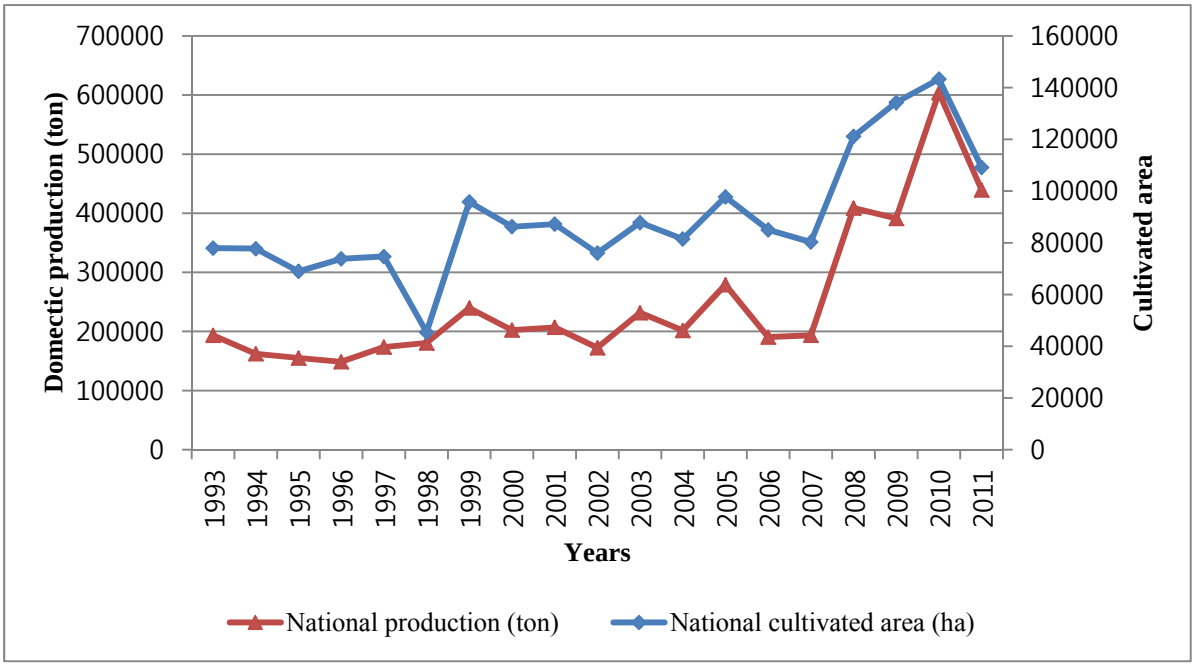
⑤ Lack of appropriate, efficient techniques of production and if they exist their accessibility to farmers.

Given the expected returns of the environment and early local varieties yielding up to 1 ton/ha, seed were improved to highly selected composites or synthetic varieties with a potential yield of 2 ton/ha to 4 ton/ha by ISRA in 1996. The use of hybrid maize seed is justified by a real willingness of intensive maize cropping system as well as the achievement of yields higher than 5 ton/ha (ISRA 2009).

Since its introduction in Senegal, maize was and is still cultivated as around compound crop in many areas. And it is often sold at the roadside by women who grill it with charcoal fire. This green maize commercialization is becoming increasingly important in urban cities. This green maize trading occupies and attracts new actors such as men, young and old villagers. Maize is nevertheless increasingly used as semolina couscous or desserts. And is frequently cultivated in a small part of the garden where women plant some plants for extra income and diverse meals. It productivity is currently low due to the poor quality of local and unimproved cultivars. Due to that, ears are relatively small. But the future promises a great expansion of maize with varieties particularly favorable to the country environment. Currently, maize is mainly cultivated in Senegal River Valley, in Sine-Saloum and in Casamance. However during the rainy season maize farming extends throughout the national

territory. If in Senegal rice production growth is related to area expansion rather than yield improvement, for the maize, extensive agriculture was not even able to enhance the national production.

Figure 1. Trends of rice production and harvested area



Source: FAO, 2012

From 1993 to 2011, the rice sector registered approximately a production and land use growth rate of 1.9% and 4.7% respectively. Nonetheless yield growth rate is lower than the production one. We can see that the annual domestic production of rice was relatively below 200 000 tons per year before 1999 and greater between 1999 and 2007. And since 2008 financial crisis, production increased more considerably. This increase of rice production can be attributed to the Grand Offensive for Agricultural and Food Abundance

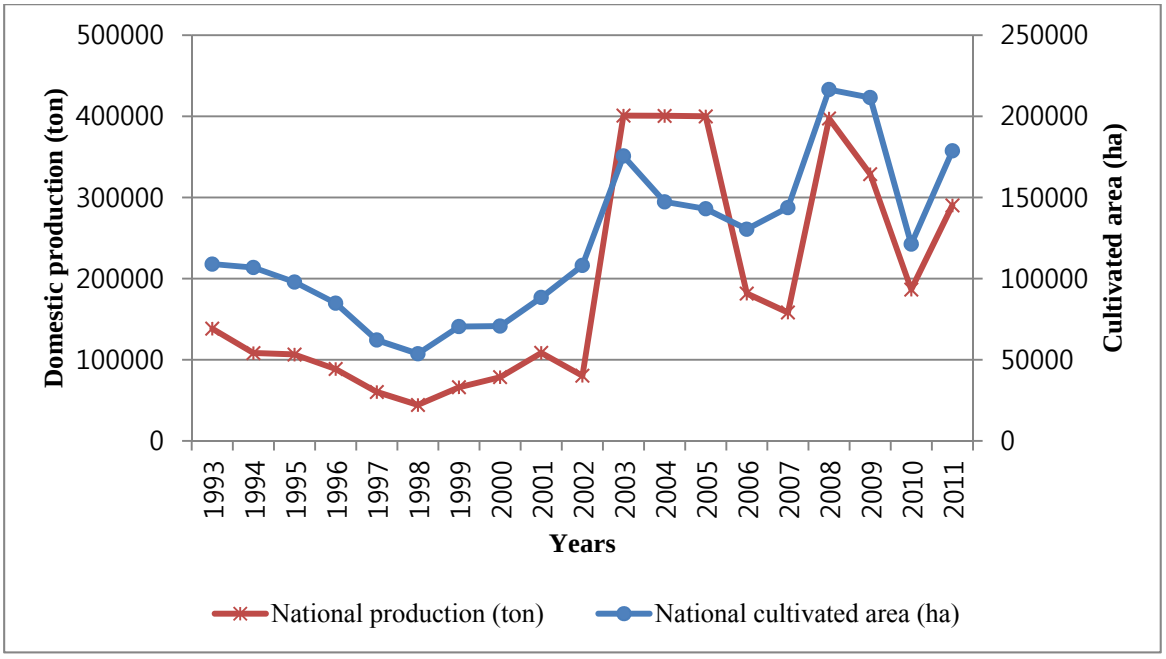
program (GOANA) launched in 2008 to boost efficiently cereal production. This improvement of production is obviously related to agriculture intensification because harvested land decreased by 3.4% from 2008 to 2011 with a production growth rate of 2.4%.

Nationally, in the maize sector, production and harvested area growth rates from 1993 to 2011 are respectively around 4.2% and 2.8% respectively. The production curve of maize has a decreasing trend shape. But from 1993 to 2001, the domestic production of maize increases slightly. Nonetheless, this increase remained lower than the immediate past years giving hereby a V shape production trend from 1993 to 2001. And according to the nature of maize, high level of requirement in fertilizers, the shortage of the domestic production can be correlated to soil exhaustion after many years of exploitation without or less organic input incorporation (enrichment). At that period, farmers focused mostly on the expansion of marginal land as evidenced by a 1.4% growth rate in harvested area comparing to only 0.85% increase in production.

However, in 2002, the production increased considerably. This period coincided with the revival program of maize launched by the government and the sell/contracts program between producers and industries which motivated farmers more in maize production. These programs gave better incentives to farmers and financial institutions to encourage many producers to produce maize. That program boosted nationally the maize sector by incentivizing and encouraging many producers willingness in maize farming. For that, maize yield approximated in 2003 and 2005 the rice one's and out passed it in 2004. Unfortunately, this progression was just for a while because four years after even thought maize yields were little bit improved, the annual gap between its homologue, the rice, varies between1.3% and 2.5%.

The growth rate of yields in rice and maize production, 2% and 1.4% respectively, between 1993 and 2011 exhibited the country's weakness to satisfy its local demand in cereals, rice and maize. Thus, there is a long way as well as many obstacles to strive to match the production of rice and maize with 2.56% population and 46.8% urbanization growth rate (ANSD, 2011).

Figure 2. Trends of maize production and harvested area

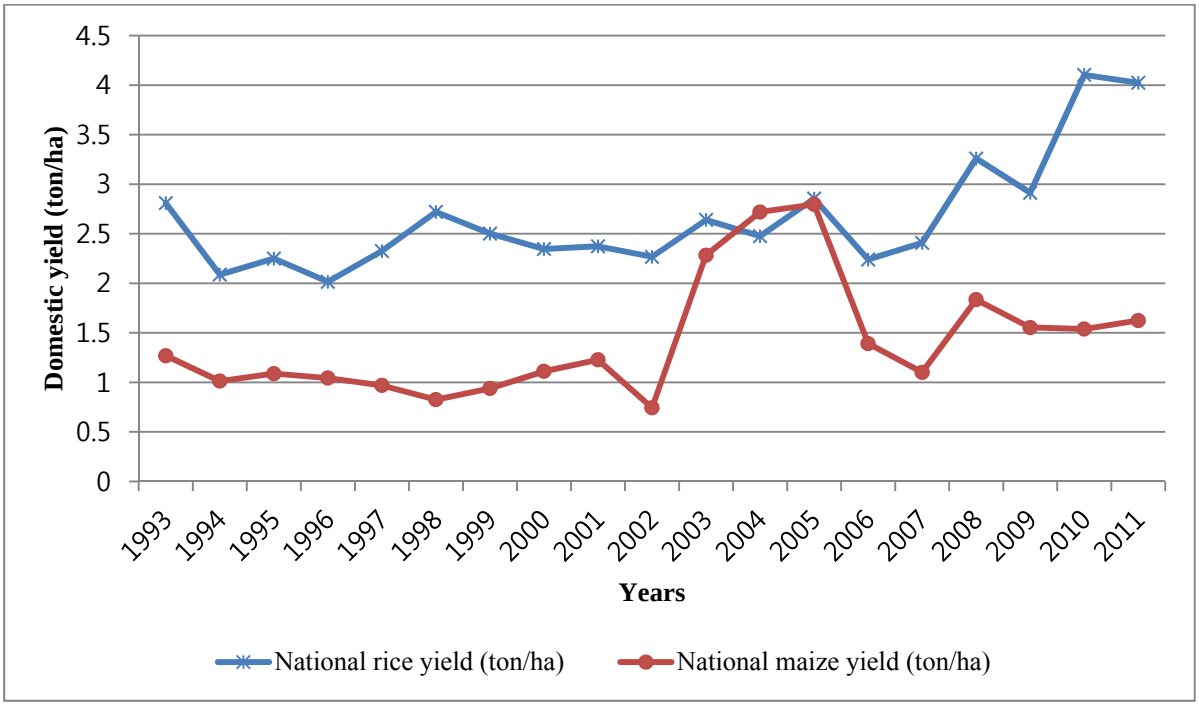


Source: FAO, 2012

The drastic decrease of the domestic production of Senegal in maize between 2006 and 2007 coincided with REVA event program. At that period the government incited people (retired workers, young, women ...) in cereal production, mainly rice, maize, millet, cowpea and cassava. However, input distribution and financial resources accessibility were hugely

criticized by agricultural actors. Many of them sought that facilities were distributed to new comers without any experience in agricultural production named “Sunday farmers” (les agriculteurs de Dimanche). And most of them focused on green maize production (grilled and market a cross roads) at a small scale.

Figure 3. The yield difference between rice and maize



Source: FAO, 2012

2.2.2 Rice and maize production in Senegal River Valley:

The Senegal River Valley is a unique, specific and strategic irrigated agricultural area in the country. The recession of the River flooding in river basins allows local residents to make a dry season crop farming on alluvial soil. Then, the River recession gives them the opportunity to practice double crop production during the dry season, complementary to the rain fed one.

The first improved hydro-agricultural layouts made in the Senegal River Valley (SRV) were implemented during the colonial period in the fifties years with stated objectives of diversified food self-sufficiency. Due to that, the government was heavily involved in the entire sector of production until the middle of ninety years. Since that time, the government started to withdraw gradually from the collection and the distribution of different agricultural products. But it continued structuring facilities, especially in the Senegal River Valley and to support producers. Indeed, Senegalese authorities relied heavily on this area to increase agricultural production and satisfy local demand for a number of potential below reasons that give the region the greatest possibilities of high output:

① Surface water availability,

② Quality of hydro-agricultural layouts and

③ Farmers' expertise.

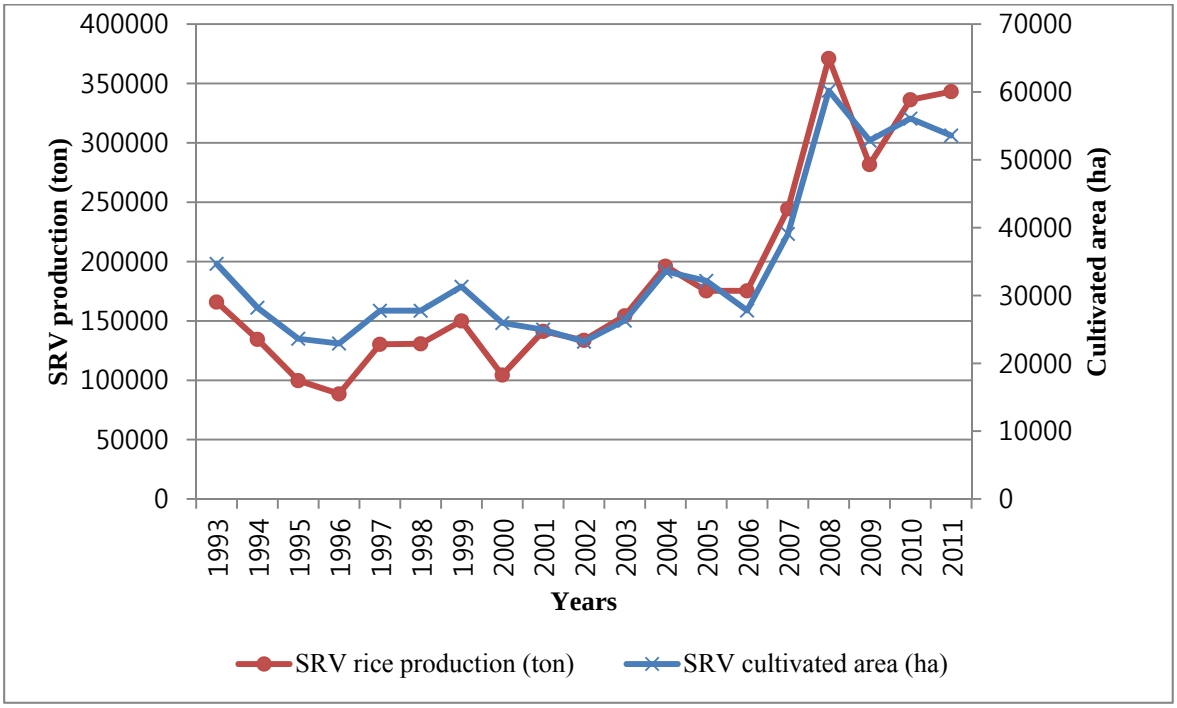
This agro-ecological region extends along the left side bank of Senegal River from Saint-Louis to Bakel. Its population accounts about 700,000 inhabitants spread over 44,127 sq Km representing 22.3% of the national territory with an average density of 15 inhabitants per sq Km (WAAPP, 2009). Rain fed system occupies 35% of the area, dominated by millet farming, followed by sorghum in Matam and Podor, cowpea and groundnut in Dagana. Traditionally, farmers cultivated crops like sorghum, maize and cowpea on damp embankments of the river, as withdrawal of the flood system (recession).

The development of Diama and Manantali dams which regulate the annual fluctuation flow of the river improved gradually rain fed and recession farming through irrigated agricultural. Irrigated agricultural offered a good potential to improve cereal

productivity mainly in rice and maize farming in the Delta River and the Middle Valley. The degradation of the environment due to ecological changes, the increasing salinity of irrigated land in the delta, wind erosion and the intensification of rice production by the misuse of inputs (fertilizers, pesticides) as well as land issues are the major constraints of the development of agricultural production in SRV. The SRV is trying now to diversify its production efficiency in order to secure the domestic demand. And in this strategy of agricultural products diversification, rice and maize are the main targeted cereal production due to their huge increasing share on imports.

Contrarily to the national domestic production where rice production increase is mostly related to area expansion, in Senegal River Valley the performance of rice farming is mainly due to agriculture intensification. From 1993 to 2011, a 2.45% increase rate of used land raised the production growth rate to 4.11%. This is due to agriculture intensification in SRV but also to its semi agribusiness aspect which was implemented in the valley since sixty years ago. For that, even thought the basic norm in fertilizers were not used, the quantity used was and is still better than in other areas exploited mostly for consumption, subsistence agriculture. Furthermore, soil is less poor compared to other places where soil fertility is decreasing drastically due to lack of organic or fertilizers incorporation.

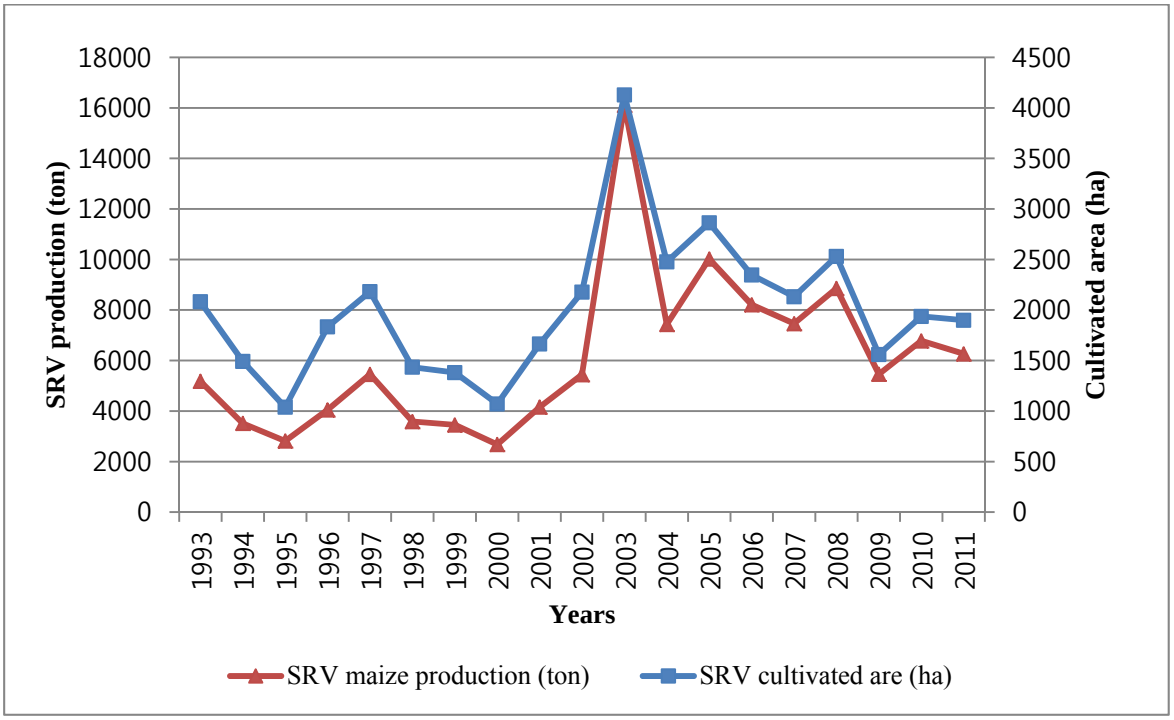
Figure 4. Rice production and harvested area in SRV



Source: SAED & ANSD, 2012

The growth rate of rice production in SRV (4.11%) is nearly close to the national one (4.66). That closeness shows the importance of this zone in rice production which secures 70% of this staple local demand (ANSD). Like in rice, maize production in SRV is more intensive than the national one's. But it intensification is lower than the rice one's. Nonetheless, this observation is not so surprising because maize was not traditionally cultivated in this zone. Its principal area of production is the Southern, central and eastern parts of the country since very long time ago. During the period 1993-2011 harvested area decreasing by 0.51% with about 1.1% increase in production. The maize program was also very productive in SRV in 2003 with a pick level of production of 16104 tons of maize.

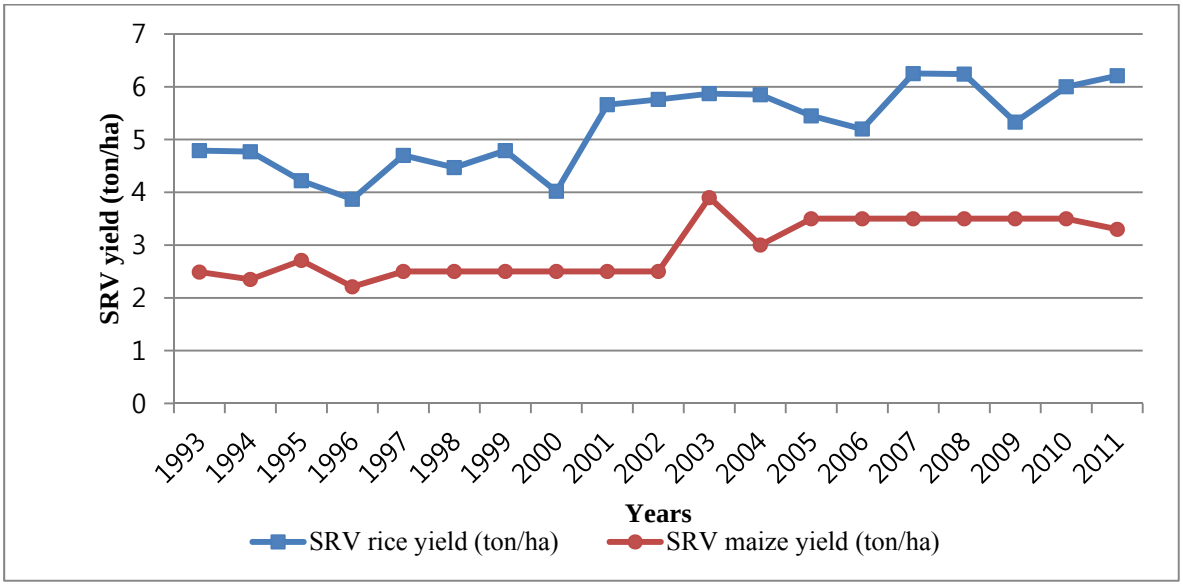
Figure 5. Trends of maize production and harvested area in SRV



Source: SAED & ANSD, 2012

Regarding rice and maize yield trends from 1993 to 2011, we can see that productivity (yield) is almost relatively constant. Then, the maize program and GOANA program were not even able to change remarkably the structure of productivity difference in SRV. This is due to farmers' efficiency, skill of agricultural production and organization under cooperative (for mutual social and financial support between them) but also to the fact that, the government furnishes almost the necessary heavy (expensive) facilities in the River (layouts, improved hydro-agricultural infrastructures).

Figure 6. The yield difference between rice and maize in SRV



Source: SAED & ANSD, 2012

2.3 Analysis of current yield gap

Generally existing varieties have a potential yield very higher than their actual yield in farm. This difference of yield is particularly observed in modern and hybrids varieties. There is considerable variation in actual achieved level of yield even under similar production system because of climatic factor variability and its randomness (FAO, 2004). This difference exists even in potential yield which varies according to the location of the research station and the growing season (Traore et.al, 2010).

In Senegal from 1993 to 2011 rice yield fluctuated only between 2 ton/ha and 4.1 ton/ha, while the potential yield of modern and hybrid varieties is about 8 ton/ha to 12 ton/ha. However in SRV farmers' average yield is between 3.87 ton/ha and 6.25 ton/ha while 4.02 ton/ha to 5.96 ton/ha and 4.02 ton/ha to 7.58 ton/ha for the rain fed season and the irrigated

rice respectively. For the maize, we have a yield of 0.74 ton/ha to 2.71 ton/ha and 2.35 ton/ha to 3.9 ton/ha respectively at the national level and in Senegal River Valley zone. Contrarily to the rice, the irrigated and rain fed farmers' average yield of maize in SRV are almost same. These yield difference among farmers in the same zone are frequently observed because of farmers' different levels of skill in crop management as well as other socio-economic conditions. Furthermore progressive (professionals) farmers usually obtain higher yields and more profits than ordinary farmers because of their knowledge and willingness in rice or maize production. However, attention should be given to ordinary farmers according the number of people under their charges (Seck et.al, 2010). Indeed, family farming death will create more labor for the agri-business but generated revenues will not be able to cover their needs of consumption as when they were cultivated their own farms.

Generally the yield gap between the potential yield and farmers' average yield ranges from 10% to 60% (FAO, 2008). And the yield gap concern is more persistent in rain fed, flooding (for the rice) and in "problem soil ecologies" (FAO, 2008) areas which tend to be the less exploitable in terms of yield gap narrowing.

2.3.1 Definitions

The yield gap also known as practical yield gap is the difference between the potential yield and farmers' average yield over some specified spatial and temporal scale of interest. It has been widely used in literature in the past two decades (Ittersum, 1997) and its definition is hugely related to the potential yield measurement.

2.3.1.1 Potential yield

The potential yield or the maximum attainable yield is the yield of experimental plots of an adapted variety of crop or hybrid which is grown under favorable physical conditions without any growth limitations from water, nutrients, pests as well as diseases and with the best–known management of practices at a given time in a given ecology system (Evans, 1993 and FAO, 2008). The potential yield is determined by three factors which are solar radiation, temperature and water supply for any given site and growing season (Traore et.al, 2010 and Lobell, 2009). As the three environmental factors vary throughout year, the potential yield will depend on the location as well as also on the crop sowing date and the maturity rating (Seck et.al, 2010).

The potential yield is usually used in irrigated system due to the fact that crop can be grown under adequate water supply throughout its growth period. Therefore, there is another expression used for the maximum possible yield under rain fed named water limited potential yield (IRRI) because "most rain fed crop suffer at least short-term water deficits at some point during its growing stage (Lobell, 2009) due to the rain randomness and its unequal distribution. The water limited potential yield itself is the yield of an adopted or hybrid variety grown under rain fed in a favorable condition without any growth limitations from nutrients, pests or diseases.

Some time the maximum farmers' yield can also be used as proxy potential yield value. That alternative potential yield estimation is to observe the maximum yield achieved among a sizeable sample of farmers in the zone of interest (Sadras et.al, 2002) which satisfy all standard norms on production factors.

2.3.1.2 Farmers' average yield

The farm-level yield or farmers' average yield is the average of farmers' yield in a given targeted area at a given time in a given ecology. It varies from one locality to another and depends on environmental factors but also on farmers' skill and their socio economic conditions.

2.3.2 The yield gap components

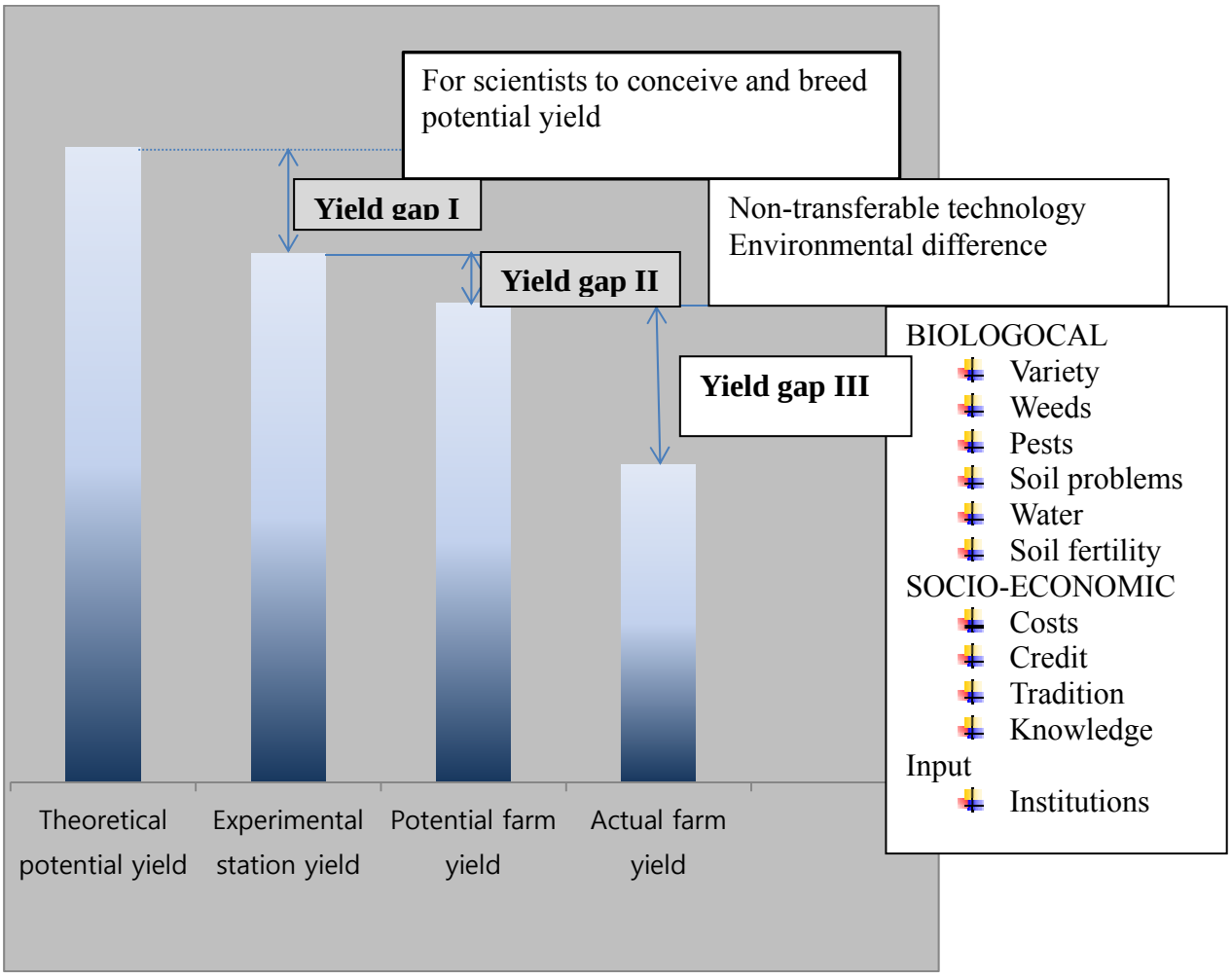
The yield gap can be subdivided into three components (Figure 7). The first yield gap, Gap I, is the gap between the theoretical potential yield and the station experimental yield for which scientists conceive and breed varieties such as super rice or maize.

The second component, Gap II, is the difference between the experimental station yield and the potential farm yield. That gap is caused generally by not transferable factors such as environmental conditions and some of the built-in component technologies which are available only at the station of research (Africa Rice, 2008). Therefore, it is very difficult to narrow this yield gap and it is often not economically exploitable. However the accumulated knowledge by farmers and the availability of innovative technology helped to reduce this gap in several countries, more concretely in advanced and industrialized countries.

The third component, Gap III is the gap between the potential farm yield and the actual farm yield and is mainly caused by differences in the management of practices. Usually farmers do not use adequate doses of input and recommended agricultural practices for many socio-economic factors. Contrarily to other yield gaps, this last one is manageable and can be narrowed by increasing efforts in research and by the transmission of innovative practices to farmers at real-time as well as by an appropriate intervention of the government

(particularly in institutional issues) in agriculture development.

Figure 7. Yield Gap components



Source: De Datta, 1981

2.3.3 Yield gaps of crop in Senegal

Yield gap exists in Senegal among different crops. In rice and maize farming, the Direction (Office) of Agriculture stipulated that their potential yields are respectively 8 ton/ha (rice and maize) in Senegal and 10 ton/ha and 8 ton/ha in SRV. SRV high yield is due to the fact that

the Sahelian zone is highly favorable to cereal farming, more particularly under irrigated systems (Sow et.al, 1995) with a potential yielding from 8 ton/ha to 13 ton/ha for rice. The frequent varieties of rice exploited in SRV area are the Sahel 108, Sahel 201 and Sahel 202. In the rest of the country, governments are struggling in encouraging farmers to use new improved varieties such as, mainly, the NERICA ones which are highly adapted to harsh production zones.

The average yield of farmers in rice and maize in Senegal (SRV) are 4.02 ton/ha and 1.62 ton/ha (6.21 ton/ha and 3.3 ton/ha) respectively. However, the potential yield under better management is 8 ton/ha (8 ton/ha and 10 ton/ha). The yield gap in percentage (37.9% and 58.75%) confirms again the importance of SRV zone in Senegal in the achievement of self sufficiency.

Table 1. Yields and Yield Gap

Yield level and Yield gap (ton/ha)		SENEGAL	SRV
Potential yield	RICE	8	10
	MAIZE	8	8
Farmers' average yield	RICE	4.02	6.21
	MAIZE	1.62	3.3
Yield gap	RICE	3.98	3.79
	MAIZE	6.38	4.7
Yield gap (%)	RICE	49.75	37.9
	MAIZE	79.75	58.75

Source: FAO, DA, ISRA and SAED, 2012

The national yield gap in rice and maize production which are 49.75% and 79.75% of potential yield are due to the huge environmental difference inside the country and by other socio-economic constraints of production. These socio economic factors contributed highly to output stagnation and decline in Senegal.

2.4 Factors affecting yield gap

The achievement of food security and the struggling against poverty are the major challenges that Senegal need to address. However their realizations are mainly constrained by:

① Weak agricultural productivity,

② Climate changes,

③ The degradation of monetary income

④ High growth rate of the population, strong rural exodus, rapid urbanization and

⑤ The increasing divergence between agricultural production and consumption systems.

Indeed agriculture did not respond positively to the new economic environment created by macro-economic policies and sectional policies reforms initiated by Senegal. The recovery conditions of agricultural production do not seem to be satisfied. Credits access, water management, input supply and products marketing are current difficulties hindering the improvement of the domestic production. These constraints are increased by the deteriorating terms of agricultural product trading as well as the reducing profitability and competitiveness of agricultural products.

2.4.1 Biophysical factors

Senegal's agriculture sector is facing a number of environmental constraints. Depending on regions, these constraints include:

① Low and irregular rainfall,

② Salinity, acidification, toxicity, and wind erosion of soil,

③ Reduction of grazing areas and overgrazing,

④ Reduction in area of forest formations with the vegetation destruction,

⑤ Advance of sand dunes and remobilization of ancient dunes,

⑥ Filling and sanding of shallow lands,

⑦ Risk of rupture balance between fresh water and salt water in the underground and

⑧ The threat of seawater intrusion.

2.4.2 Socio-economic factors

2.4.2.1 Constraints of increasing harvested area

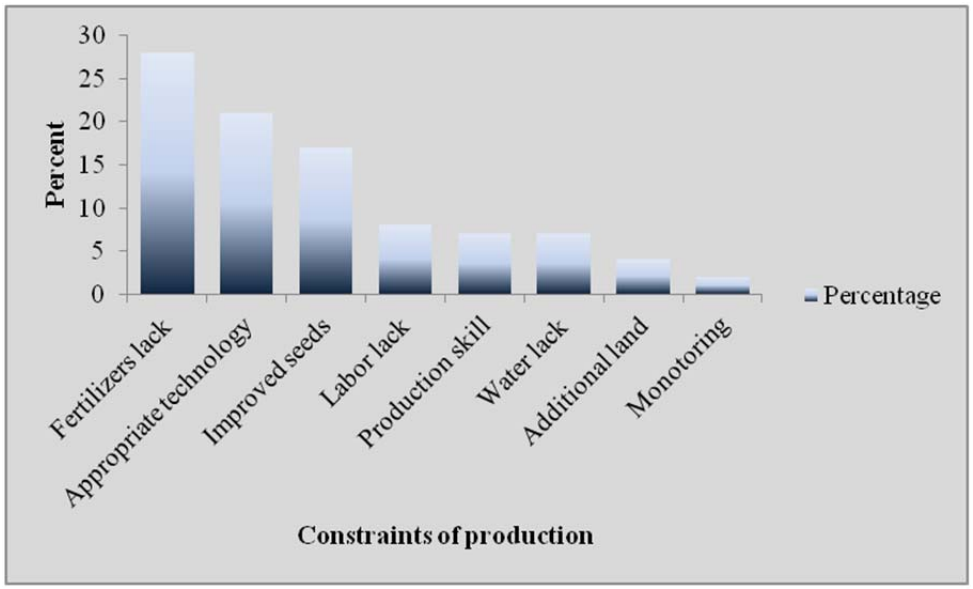
The first constraint of increasing harvested area is the lack of agricultural machinery (22%). Other constraints are the lack of inputs, seed (14%) and fertilizers (12%). And all these constraints are almost common in all different agro-ecological zones of Senegal (WAAPP, 2009). In the Middle Valley in addition of the above constraints there is a lack of labor. While in the Upper Valley, the light rainfall constitutes a constraint over than the lack of seed.

2.4.2.2 Constraints in production increase

The increase of the production is hampered by a number of constraints. The most important constraints are the lack of fertilizers (28%), lack of the availability of good seed (17%) and lack of appropriate technology for higher yield (21%). The other constraints, even they are less important remain some obstacles to production increase and are the lack of additional land, labor, water management, mentoring and production skill.

Availability of improved seeds is a general stress in the entire country. Constraints related to the lack of land (improved land), water, technology and labor are more persistent in the SRV. However in other areas, such as in the south, the lack of fertilizer is deplored by most farmers.

Figure 8. Production constraints

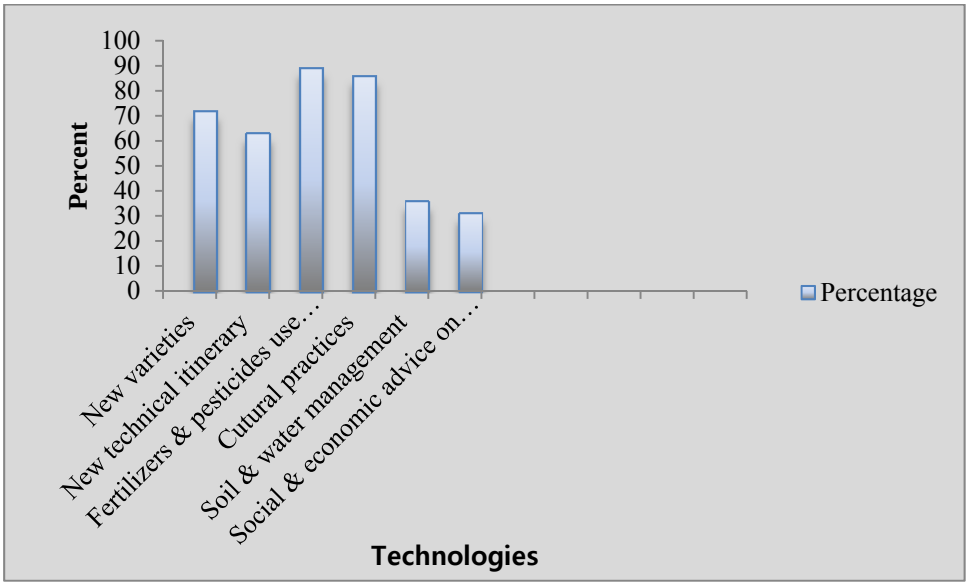


Source: WAAPP, 2009

2.4.2.3 New technology use constraints

Farmers who have adopted new technologies for the production of rice and maize are estimated at 35% of the population. These new technologies are mainly technical monitoring. The adoption of new technologies is more common in the Middle and Lower Casamance as well as in the southern Peanut Basin (38% and 30% of households). It follows the eastern part of Senegal and the central Groundnut Basin where 28% and 20% of households have adopted respectively new technologies. In other areas, only 10% to 13% of households have adopted new technologies in the production of cereals like rice and maize. Thus, in order to improve the efficiently crop productivity, farmers have to adopt new technologies in various fields. The most important are the method of application of fertilizer and pesticide as well as agricultural practices which represent respectively 89% and 86% adoption rate by producers. The other most important technologies involve new improved varieties and crop management for which the adoption rate is 72% and 63% respectively. Other technologies are soil and water management as well as economical and social advice on farming management which rate also around 30%. It should be noted that some producers are skeptical toward these innovative technologies.

Figure 9. Technologies

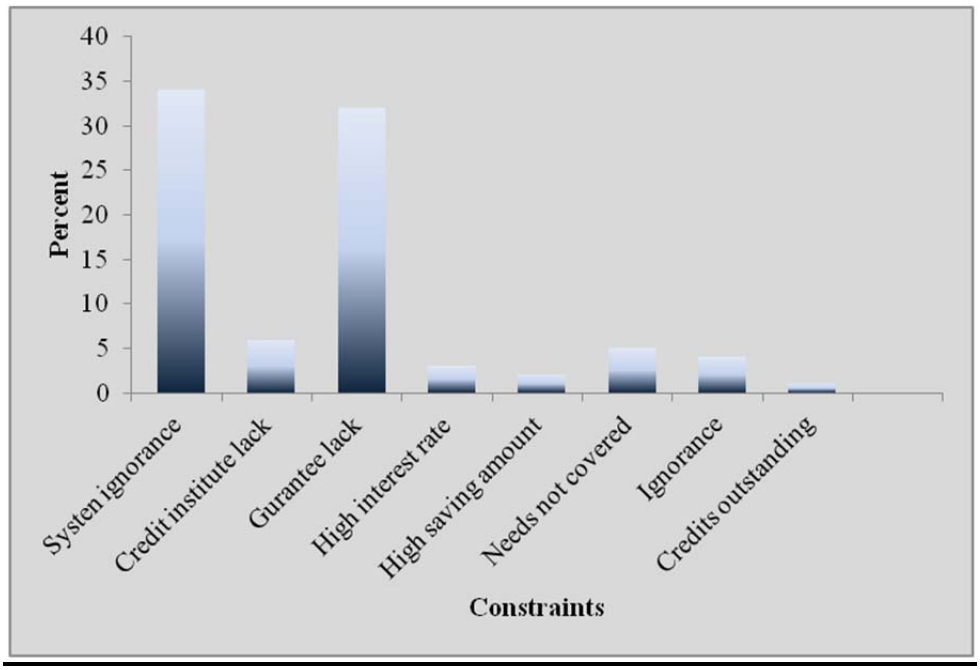


Source: WAAPP, 2009

2.4.2.4 Certified seed use constraints

Cereal seeds come mainly from farmers' previous years' production (withheld seeds). Only 15% of seeds are bought and less than 10% of them are certified seeds (WAAPP, 2009). This poses a real problem regarding the objective of increasing cereal yields (Office of Agriculture). Moreover farm households face particular difficulties in accessing to credit because of their lack of guarantee. These challenges are majored by the lack of knowledge on financial institute system. And the main lack of guarantee that discourages more than 30% of farmers is increased by risks related to rainfall production randomness. Other difficulties (high interest rate, credits outstanding...) are less important but are still barriers for some households.

Figure 10. Credit access constraints



Source: WAAPP 2009

2.4.3 Institutional factors

Management institutes of agricultural activities are not very present as a whole. Only 23% of the population benefits from technical or research of coaching organizations. It is in the eastern part of Senegal and in the Middle East of the valley that farmers receive more training from institutes, 43% and 40% respectively. In areas such as the Upper Valley and the Middle Valley, as well as Lower Casamance, households who receive coaching are 24% and 22% respectively. And in others areas of the country the ratios are very low.

Several structures are involved in agricultural regulation in order to sustain efficiently production activities of farmers. ISRA intervenes in the southern Peanut Basin, where 22% of the population benefits from its leadership and lesser in the central Peanut

Basin and Senegal Oriental. SAED occurs only in the Senegal River Valley. ANCAR is involved in all areas. SODEFITEX occurs only in the southern areas, meaning in Senegal Oriental and Middle Casamance where 80% and 19% of farmers are respectively benefiting from its frame. For other institutes only a small share of farms which is less than 10% is under their supervision. These are: the DRDR/SDRR, NGOs, Water and Forestry Services, PROMER and PADERBA.

2.5 Conclusion

The yield gap between the potential yield and farmers' average yield is still substantially high in rice and maize production in Senegal. However, if for the maize the main efforts of governments on yield improvement are still vainly achieved, for rice, these two last years were very constructive in this gap narrowing. This positive result is due to the big expert of Senegal River Valley farmers who produce 70% of the domestic production in two seasons; the rain fed and irrigated seasons. Its gap in maize production is also small. SRV performance in rice and maize farming shows and confirms the huge potential of this area in the improvement of cereals production as well as in the achievement of self security.

In order to sustain agricultural production and productivity, combined manageable constraints which caused the yield gap should be properly adjusted along rice and maize sector to enhance their production. For that there must be a wide collaboration between actors: scientists, monitors, farmers as well as private and public institutes (mainly financial institutes). This cooperation is imperative in yield gap narrowing. Indeed, the yield gap narrowing will not lead only to the improvement of yield and the domestic production; it will also improve the efficiency of land and labor use and decrease exploitation costs while

increasing its profit sustainability. For that, policy makers who are fully aware about the advantage of yield gap narrowing were and are still working on the keys factors of yield improvement. These keys factors are:

① Government policy support,

② Promotion of integrated crop management in maize and rice farming,

③ New proven technologies deployment,

④ Identification of spatial strategy according each locality comparative advantages and

⑤ Participative management strategies.

III. YIELD GAP NARROWING AND POST HARVEST ACTIVITIES

3.1 Introduction

Increasing rice and maize output are the primary goals of GOANA program launched in 2008. The program aimed to reduce imports and achieve national self-sufficiency in food by 2015. As yield gap remains higher than expected and given the availability of all technology packages, priorities should be focused also on the divulgation of agricultural practices as well as their adoption by farmers (Krupnik et.al, 2012 and IPTRID/SENEGAL 2004).

The concept of yield gap narrowing is not just static but dynamic. And according the population and urbanization growth rate of Senegal which is respectively 2.56% and 46.8% (ANSD, 2011), like anywhere in the world, priorities should be focused on intensive and efficient agricultural production rather than on traditional practices. In the country (Senegal River Valley) the yield gap in rice and maize are respectively 49.75% and 79.75% (37.9% and 58.75%) in 2011.These percentages show big challenges that are facing policy makers. For that "efforts should be made to update farmers' knowledge on the causes of yield gaps in crop and measures to narrow the gaps through training, demonstrations, field visits and monitoring by extension agencies to achieve high yield" (Mondal, 2011). In addition, the improvement crop yield and the achievement of food security rely on good agricultural practices (Lobell, Kenneth, Cassman and Field, 2009) as well as R&D on cultivars and fertilizers improvement (Seck et.al, 2010; Saito, Futakuchi, 2009 and Africa rice, 2008).

Indeed since many years' governments held vainly many strategies to boost cereal production, mainly rice one; in order to make them available at affordable prices to consumers for economic growth, social security and political stability (Singh et.al, 2011) of

the nation. And as draught, lack in infrastructures and production skill, water scarcity (ground water pollution and reload matter of groundwater, superficial water chemical pollution which implied the creation of many project and program for water management) are some of the main barriers of Senegal's agriculture sustainability and according to the context socio-economic of producers, efficient agricultural production as well as sustainable management of natural resources is imperative. For that in order to secure the current and future generation needs, priorities should rely on sustainable and efficient production through more efficient land preparation (tillage conservation) and water use (De Datta; Cannell and Hawes, 1993 and Elwell, 1993) as well as integrated pest and nutriment management (Seck et.al, 2010; World Bank, 1993 and Africa Rice, 2011).

Indeed, good agricultural practices follow up combined with a good weather (efficient quantity while better spatial repartition of the rain) increased the rice productivity by 18% in 2008 compared to 2007. Furthermore grain quality does not depend only on the crop production environmental but also on harvesting, processing and milling or shelling systems. Thus, post harvest activities amelioration may decrease de variation of losses while conserving the quality and tastes of grains (Dr Manful, IRRI and FAO, 2008).

3.2 Agricultural practices

Rice is clearly the most important food crop seconded by maize in Africa if we consider the area under rice and maize farming and the number of people depending on these crops (De Vries and Toenniessen, 2001). In the world by hectare rice ranks second after wheat but first in term of calories contents and maize occupies the third place (FAO).

According to WHO, the total calories needed by human being is 3119 kcal/per/day

and at the gate of farm, rice participates in at the level of 552 kcal/per/day representing 18% of the total. And the huge performance on rice production marked by a yield which attended 10 ton/ha (Africa Rice center, 2010) show the importance of this crop farming in hunger eradication and in the improvement of rural people income because it provides employment to a large share of rural population in producing countries (IRRI and FAO,). Those countries are: all Asian countries, most West and North African countries, some Central and East African countries, most of Southern and Central American countries, Australia and at least four States in USA (De Datta Surajit).

Contrary to maize, which a substantial quantity is used for livestock feeding and bio-fuel, most of rice crop is for human consumption and its productivity depends on nature (weather, soil proprieties) and agricultural practices. Data on weather (rainfall, sun exposure, day length (day light), temperature and humidity) are primordial in rice production because of human less action on it, as for the maize also.

3.2.1 Land preparation and crop establishment

Firstly land should be cleared for crops. And for new lands, heavy vegetations and large rocks must be removed. Clearing involves the removal of debris and vegetations to ease land tillage activities.

In Senegal, dried debris and vegetations were and are burn in the farm and the cinder spreading in farms again to increase soil fertility. However as burn was done with a high degree of fire, scientists discovered that, that high heat temperature destroy chemical organics of soil and even the concept of fertility of that cinder. Then debris must be burn at moderated temperature in order to increase soil fertility.

Land preparation which is prior to the planting stage has a huge impact on farmers' productivity as well as soil fertility maintain and improvement (Cannell and Hawes, 1993). At first, before any action farmers should have some basic information on the type and the composition of the land on which they are going to work on. Knowledge on soil characteristics and proprieties will help in the choice of appropriate techniques and adequate materials use but also on necessary amendment inputs needed in soil fertility enforcement for best growing of crops, food crop pasture grasses for animals and other uses (Tilman, Cassman, Matson, Naylor and Polasky, 2002). The most common benefits of conventional land preparation for most crops are:

① Weed control,

② Fertilizers incorporation ease,

③ Porosity and aeration increase and

④ Fine tilth of soil to increase the adsorption of nutrients (De Datta, 1981).

Furthermore land planning and amendment positivity back to many years ago in the past in developed countries (USA, Canada, UE), in some Asian countries on their main crops (De Datta Surajit 1933 "Principles and practices of rice production"). But in developing countries like in Africa these techniques were under exploited by authorities by ignorance and/or by their expensiveness or by land availability (extensive agriculture). However, now our days, according to world conjuncture; boom demographic, successive crisis, natural disasters, global warming and other factors, circumstances do not leave any country the choice of ignorance or to bypass them whatever their costliness (Africa rice, 2011). However practices vary according crop from the land tillage (land plowing and land harrowing), land

leveling to land drainage. For the rice, land preparation varies according the planting systems (direct or transplanting sowing), soil texture and topography, availability of the financial resources of farmers, water availability and others social aspects (IRRI). And their tolerance margin is lower on rice production.

Land must be well prepared to make a good seedbed with high productivity subject to the crop requirement. In Senegal for maize, the common planting system is the tie-ridging and ridging one because of its shallow root and to improve more weed control by landfill. This system eases water infiltration into the soil and protects plants against erosion and runoff (ISRA).

If livestock manure is used, plowing should take place as soon as possible after application. And a correct opening ridge should ensure that all the ground is plowed. Tillage should maintain a depth up of 15cm to 30 cm to bury the manure and crop residues. It is done to repair main factors affecting the quantity and the quality of land that decrease progressively agriculture sustainability according to the improvement and maintain of soil properties. Those factors are soil degradation by water and wind erosion and depletion of organic matter as well as related consequences including loss of nutrients in many circumstances (Cannell & Hawes, 1994; and Tilman, Cassman, Matson, Naylor and Polasky, 2002). And as cropland erosion rate is superior to the natural land erosion one (Tilman, Cassman, Matson, Naylor and Polasky, 2002) soil formation will depend highly on bulk density.

Land tillage (plowing) is subdivided in primary tillage and secondary tillage. The first is normally the most aggressive and deeper one. It must be done immediately after the last harvest or at the beginning of the next wet season. It needs basic soil moisture for more

effectiveness and equipments are moldboard, one way disc, offset disc and tine implement under animal or tractor traction. The secondary tillage is usually shallower and less aggressive than the primary one. The final works are then completed using peg tooth harrows to puddle (in flooded rice cultivation) the soil and leave the surface level apt and ready for planting. In fact tillage alone rarely leaves the ground in good enough condition to plant and then disking and harrowing will usually be necessary. The final disking or harrowing should be done just before planting to control early weed growth.

Minimum and zero tillage may ideally be applied but it may have certain problems in seed production (Africa Rice and IRRI). In hybrid seed production unimproved seed have low seedling vigor and under minimum tillage crop standing can be severely affected along the crop cycle with crop non uniformity growth. This can eventually cause poor nicking. Then it is advisable to go under conventional tillage in seed production.

Indeed in West and Central Africa the combination of best land preparation and improved seed use increased maize production by 2.5 fold (IITA, April 1997). For crop production, land tillage can be slowed down little bit if the first one was done correctly due to its huge cost (SAED, 2009). But there is a tradeoff between them depending on area (direct or indirect seeding for the rice) and the physical area characteristics. If less tillage or zero tillage involve high chemical or mechanical weeding method it will be better to undergo with basic tillage norms.

Even, it is a fundamental factor on crop yield, its expensiveness (Tilman, Cassman, Matson, Naylor and Polasky, 2002; Africa Rice 2011) involves that many family farming producers do not perform it correctly. However, professional producers are struggling on well doing tillage under the government support while semi mechanizing agricultural production.

This improvement is more effective in agricultural area managed by the government like in SRV and in Anambé basin where the first tillage is mostly done (without fertilizers incorporation (amendments)) by the government. To bypass tractors use, farmers in general use animal traction which is very productive in cash crops and cereals production (Huybens, 1990).

3.2.2 Land leveling and grading

Land leveling and grading are very important in irrigated agriculture, mainly in rice production which productivity depends highly on the quantity of water. Land grading and leveling needs are did according to land topography assessment and depends strongly on the techniques of irrigation which are chosen by farmers fallowing their financial capacity and water availability (Tilman, Cassman, Matson, Naylor and Polasky, 2002). Land leveling for irrigation depends especially on four topographic features: land slope, micro-relief, macro-relief and plant cover. If it is performed correctly subject to topographic evaluation and based on experience (skill) as well as equipments (total, semi mechanization or traditional), land leveling increases considerably rice yield and the maize one also. It allows also a better weed control, larger farming area, faster seeding with less work and mainly efficient and better use of water (Africa Rice). However its cost is neither negligible and its well done is the big matter in SRV for the consideration of efficient productivity of farmers.

3.2.3 Water management

Water is one of the most important inputs, essential, crucial in the production of crops. Plants need water continuously during their life and in huge quantity. For that, in agricultural

production water management is becoming increasingly important in developing countries like Senegal precisely in irrigated crops (IPTRID, 2004). Indeed, water management in agricultural production was developed in industrialized and advanced countries since far past years ago. But, the efficient management of water is still a challenge in all countries due to water scarcity, the objective of increasing agricultural productivity, other demands creating competition in water utilization (Tilman, Cassman, Matson, Naylor and Polasky, 2002) and other random factors. Water influences profoundly the photosynthesis, the respiration, the absorption, the translocation and utilization of mineral nutrients as well as cells division beside other processes (ISRA). Both, its shortage and excess affect the plant growth and development directly, thus consequently its yield (Fashola, Imolehin and Wakatsuki, 2007) as well as its quality (Africa rice, 2011 and AATF 2008-March 2011).

Water management takes into the control of water for optimum crop yield under high quality, the best use of a limited supply of water (Bayala et.al, 2011) and its management is crucial in the preservation and restoration of ecological environmental. A proper management of water and irrigation systems, especially those that rely on stored water, enables a water supply during the dry season where yields are generally high because of high solar radiation (SAED) and greater nitrogen fertilizers response (Tilman, Cassman, Matson, Naylor and Polasky, 2002) which are very necessary in rice and maize production (ISRA).

Rainfall is the cheapest natural source water-supply for crop plants. However its randomness in Sub Saharan Africa as in Senegal and mainly in the Northern part of Senegal (SRV) implies that producers cannot rely on rainfall for their entire production. Its frequency distribution and amount are not in accordance with needs of crops. Additional water-supply through irrigation (to provide necessary quantity of water) and removal of excess water

through drainage (to save water for future use which needs more infrastructures and only present in SRV) become therefore imperative if policy makers want to increase successfully domestic production. Water management includes irrigation (in Anambé basin and in the SRV) and drainage (SRV) for cereals production in Senegal and depends considerably on environmental conditions, soil, crops, and climate (De Datta, 1981 and Tilman, Cassman, Matson, Naylor and Polasky, 2002).

Water affects the performance of crops directly and indirectly by influencing on the available nutrients (chemical, organic and inorganic) (Seck et.al, 2010), the timing of agricultural practices (Bezelga and Keita, 2006) and giving to the plant the mechanical strength to its turgidity. As water and other inputs of production interact between them ((Fashola, Olaiyan, Aliyu and Wakatsuki, 2007), water management is neither by passable. In proper combinations, crop yield can be boosted by manifold under irrigated agriculture (IPTRID, 2004).

Nonetheless, water management is very expensive and then non realizable by most of traditional farmers. For that governments are managing many irrigation infrastructures in areas where there is permanently water availability trough the year (along SRV and in the country Southern part) in order to satisfy the local demand firstly and export the excess of output as declared Africa Rice Director in 1997. He said that “Too often, in our rush into the future to solve anticipated problems, we do not look back into the past to draw the lessons thereof. And no sooner, the tomorrows upon which our hopes were hinged become the yesteryears of the past and the lessons from today’s experiences are not retained”.

In fact the construction of dams and reservoirs, water conveying from storage points to fields as well as system of canals operation and maintenance involve huge expenses. And

the misuse of water leads to problems such as water-logging and salt-imbalance which are rendering agricultural land unproductive. This improper water irrigation is the main production barrier in areas of irrigation where technicians tried to decrease irrigation inefficiently by omitting land leaching. Salt concentration in certain soils before irrigation is sometimes so high that initial leaching is required before planting. The amount of water to be used in order to improve soil fertility by leaching saline root zone depends mainly on the initial degree of soil salinity and irrigation technology. Hence, a proper appreciation of the relationship between soils, crops, climate, and water resources for maximum crop production is imperative and considerable.

3.2.4 Fertilizers and pesticides management

Optimal crop production depends on fertilizers and herbicides used by farmers (Tilman, Cassman, Matson, Naylor and Polasky, 2002). Fertilizers and herbicides management is a challenge that producers are challenging in order to stay in business or feet their family members. To meet this challenge, it is necessary for them to provide to the plant all required nutrients to have high yield (Saito and Futakuchi, 2009), to protect crops against insects and diseases, pests and to reduce competition from unwanted plants (wild weed) (Krupnik et.al, 2012).

Fertilizers and animal manure are used to increase crop yields and to replace soil nutrients removed with harvested crops. Both have valuable impact in reversing the declining trend of soil productivity and soil nutrient tenor (Saito and Futakuchi, 2009). Many researchers showed clearly that fertilizer input increased crop yields, fixed soil organic matter when more crop residue and root matter are returned to the soil. The management and the use

of fertilizers, manure and pesticides vary widely across the country according to the planting season, soil variety and climatic conditions (Africa Rice, ISRA, and Saito & Futakuchi, 2009).

However fertilizers, livestock manure and herbicides became an increasing environmental concern over potential catalyst, contamination of soils as well as surface water and groundwater pollution (Krupnik et.al, 2012; Tilman, Cassman, Matson, Naylor and Polasky, 2002). Thus, there a huge necessity to out pass these issues trough researches under participative management of doses. Furthermore, as excessive dosage leads not only to yield decreasing but also to a low quality crop (Tilman, Cassman, Matson, Naylor and Polasky, 2002) and in long term toward a harsh neutralization of pests, insects and harmful birds to crops like now around the world and more especially in developing countries. Due to that, fertilizers, pesticides and insecticides should be periodically be revised to appropriate them to new characteristics resistance of current parasites (ISRA, and Tilman, Cassman, Matson, Naylor and Polasky, 2002). In Senegal, researches focused on abundant and accessible neutralizers to improve soil stress in order to increase crop yield.

In sodium and saline soil improvement, chemical amendments are often necessary to neutralize free sodium by providing cation which will take the sodium place in the exchangeable complex. Gypsum is by far the most commonly used amendment. Phosphorous gypsum, a byproduct of superphosphate, is relatively inexpensive in countries with superphosphate plants like Senegal. It can be effective even at low dosage due to the small size of its particles (ISRA). Agronomists and scientists showed that phosphorous gypsum has a very sensitive effect on repellent electrolytic properties of soils and it quickly improves the physical condition of the fraction of silt / clay. Other useful amendments are calcium chloride, calcium carbonate, and lime (a mixture of calcium alkaline) which are residual products of

sugar refineries. Some acidifying agents such as sulfuric acid, sulfur and iron sulfate are used to improve sodium soils because they neutralize the sodium carbonate and react with the lime of limestone soils to produce gypsum, which gives the rate of soluble calcium desired. Another way to dissolve sodium in the same soil is to increase the content of organic matter by growing green manure or applying organic manure. This practice reduces the pH by increasing the concentration of the dioxide carbon itself. The most effective way to improve saline and/or sodium soils after leaching is to practice farming improvement. Mulching with organic materials will also give spectacular results (ISRA).

In a system of crop rotation (DA), in order to avoid soil saturation, farmers should also apply fertilizers according to precedent crop nature and apply the minimum required dose. In that context if matter occurs; infestation or nutrients deficiency, farmers will have to add the necessary quantity of fertilizers, insecticides or fertilizers.

3.3 Harvest and post harvest activities

A crop with high quality is a highly valuable product. And special technology is required to preserve and conserve product quality from producers to consumers. Its genetic advantages might not be easily recognized by most consumers as its physical appearance during it marketing. Thus, appropriate materials and technologies should be used in harvest and post harvest activities to conserve crop quality which is related to best production system at non negligible cost, mainly in agribusiness (Bezelga and Keita, 2006).

3.3.1 Harvesting

Harvesting method has a considerable importance and crops should be harvested earlier as

possible when matured to avoid losses of output and post losses during product processing. Indeed, crops are constantly under birds and rodents attacks which decrease the harvestable quantity as long as crops are standing in farms. And the earlier harvest gives the opportunity to practice a double farming or others one crop farming. Then suitable technology is necessary to reduce harvesting time, time of crops storage at the farm and also to gain more revenue. It is proven that in developing countries first harvesters gain better than last ones because at that time supply is always inferior to demand.

Harvesting can be manual or mechanical according to socio-economic context and cultural believing of producers. In developed and advanced countries it is mainly mechanized with sophisticated reaper under tractors traction. For developing countries the semi mechanic and traditional system coexist simultaneously. The first one is mostly in use in irrigated zone under animal or tractor tractions. In subsistence agriculture, farmers harvest manually (by hand) using rudimental materials such as knife for the rice. And rice harvesting is harsher than the maize one as well as losses during harvest period is the highest. Maize harvesting is just cob broking and need less labor. During the harvesting time, harvesting crops are split into lots in farms before being transporting out of farms to be drying. In small farms, the drying can be taken there. But now with robbery risks, crops are mostly dried around compounds for more security.

3.3.2 Drying

The drying stage is necessary in order to dehydrate products until their involved metabolisms' and microorganisms' activities are strongly slowed down. As for the harvesting, the drying system can be natural (open air under the sun or without) or traditional as well as mechanical

(traditional or modern ovens). Traditionally, farmers let standing crops to dry up several weeks after reached maturity. If it allows pre-drying or full grain drying this technique extends the tenure of land by delaying land preparation for second farming, and contributes to various attacks and natural ginning.

The improvement of traditional drying methods is oriented towards a better use of solar radiation and winds. This work has resulted in elevated racks. They are oriented perpendicularly to the prevailing wind direction where ears are stored in bundles cross themselves to facilitate the flow of air inside the pile. For the rice, a pole of about 6o cm high of parrot is made based on stakes. Around this pole sheaves are covered by other sheaves in order to avoid the direct sunlight contact which causes grains cleavage. Such structures improved the speed and quality of drying while reducing pest attacks (ISRA/CNRA). Studies on new structures for cereal drying focus on crib-dryer using current natural air convection, and solar dryers.

Solar dryers gave satisfied technical results because they reduce the drying time by 50% and eliminate more the risk of infestation and retain substantially the initial proteins content. However they are not economically justified in the current context of rice and maize production in certain localities (subsistence agriculture). Indeed, the criteria of economical efficiency require a wide possible use of solar dryers. Due to that, a diversified range of solar dryers should be created and spread throughout the country for long term conservation of agricultural products.

3.3.3 Storage

The main factors of storing products degradation are humidity, temperature, interstitial air

and external agent attacks such as insects and rodents. A good conservation system which techniques have to act against these factors should be in place.

Spikes or panicles storage through vegetable fiber plaited granaries is most prevalent in rural areas. Losses due to insects and molds are low with this type of storage because grains are fairly well protected. Through glumes, husks, and the condensation of external exchange air as well as heat pockets which are favorable to mold growth is avoided. Traditional solid granaries walls can be used to store dry grain. Tests made by ISRA/CNRA Bambey showed that grains mixed with 500 grams/ton of bromophos during silage have little insect attacks after 18 months.

Several types of individual or collective silos were developed and tested in Senegal and gave satisfied technical results. Studies showed in general that principles and practices that ensure effective conservation of grains are to:

① Have a dry, healthy and clean gain,

② Have a watertight structure, capable of stopping the invasion of parasites and reduce temperature fluctuations and humidity,

③ Put in silo and to treat it as soon as possible after harvest and always before finding damage,

④ Ensiled at low temperature and isolate the structure from direct radiation to avoid the risk of condensation and

⑤ Make insecticide silage base and maintenance treatment of surface every two or three weeks.

However, investments required are often beyond farmers' financial capacity who

store only for their own consumption. And as ears storage in traditional granaries provide a fairly good preservation of grain it is therefore necessary to consider the use of these structures in the context of increasing production and a better organization of the marketing sector that can ensure economic viability of investments. In particular, the uniformity of producer prices is not conducive to search for better quality of product as sometimes some producers are sure to be able to sell their crop regardless agricultural product quality. However, with the government withdrawal policies and the agriculture sector liberalization, situations are changing very quickly mainly in the SRV which is suitable for double crop.

3.3.4 Processing

Grains undergo into a series of mechanical and physic-chemical transformations before being accommodated. The first step consists of grain shelling or husking which rid the grain from its skin, and grinding for reducing particles in more or less fine size.

Before, generally and mainly in rural areas, cereal milling and husking activities were performed traditionally using mortar, usually very wet, except in rice processing. The addition of water during the shelling prevents grains breakage. Product is then winnowed, washed, and then dried. The characteristics of cereal in daily use except rice are:

① Daily mandatory activities, due to the lack of stable products which must be moist and semi-fermented,

② Being sluggish as well as arduous and

③ Unsuitable to urban area socio-economic conditions where people are still attached to traditional dishes.

Thus, research focused in the early stage on the principles of shelling and milling of cereal to:

① Alleviate women daily home works,

② Obtain a stable, fermentable and accepted product by people,

③ Reduce nutritional losses arising from traditional methods and

④ Promote the consumption of local cereals in cities.

Today, there is at least in each village in the entire sectors of rice and maize in Senegal, necessary equipments for cereal treatment. The latter husker being designed by CIS (IDRC-MARSIS-ISRA) in pre-extension has created since 1987 and is currently manufactured in series by MARSIS. Thus, rice milling and husking are fairly and widely mechanized in rural and urban areas. This innovation in rice processing is not general in other cereals shelling. So there is a coexistence of the traditional method and the mixed method one, meaning the manual shelling and mechanical milling. This last method depicts objectively an evolution toward more complete mechanization of processing of local cereals. However like the first (traditional processing), the mechanical processing does not allow a long conservation and inhibits the extension of marketing possibilities in urban areas. Improvement of works in husking and milling systems created and stabilized local cereals market share as well as accepted flour by population. There for these results should be quickly transferred in rural and other urban areas in order to eliminate the increasing traditional ordeal of women and remove technical, economic, socio-psychological constraints, even political hinder of local cereals development in favor of imported cereals which are most of time transformed. The weakening of the consumption of imported products which is

an objective compatible with research on sustainable satisfaction of consumers involves activities intensification of food technology as well as their technical mechanization and industrialization.

But it is especially in artisanal and small-scale shelling and milling activities that effort should be focused at first to meet household needs. Indeed at industrial level the costs of procurement, storage and distribution are extremely high and make the marketing of semi-finished agricultural products title bit complex because of their high prices. There for small processing units begin being relatively profitable at a low utilization rates. However these transformation units encounter management and maintenance problems of equipments which resulted from inadequate training of operators as well as parts pieces unavailability in local markets.

3.4 Conclusion

Te improvement of farmers' average yield is the main concern of policy makers. To this score, many strategies were and are taken to enforce their capacities. Thus numerous R&D on fertilizers, pesticides, and insecticides in order to improvement them as well as appropriate agricultural practices and equipments (in the entire sector) were made to boost the domestic agricultural production.

Nonetheless, there is still a huge gap to fill mainly in rain fed agriculture. In the irrigated sector, for the rice and maize, non negligible results have been realized, mainly in SRV where the current yield gap are respectively 37.9% and 58.75% of the potential yield. These results are correlated to the perfection of agricultural production factors and innovation in agricultural practices. But some constraints are still persisting due to the less

mechanization factor in this century of technology boom.

The main principal handicap in crop production is the respect of conventional land preparation which includes land tillage, leveling, first fertilizers amendments and others due to its huge cost which is almost beyond farmers' financial capacity. And the minimum or zero tillage is not going to settle this matter for many reasons like:

① Unavailability of crop residues as all residues are used to fed cattle,

② Shortage of labor to deal with initial high weed infestation,

③ Unavailability of appropriate and necessary agricultural materials to realize some agricultural operation such as planting and weeding,

④ Leveling conservation, etc.

Furthermore, these constraints are increased by harvest and post harvest activities issues. Indeed if harvest and postharvest activities are not well done, grains quality will be affected physically (color, weight, broken...) and nutritionally (taste, nutrients composition). In SRV the main postharvest concern in rice production relies on the processing system. Most of machines in use are not appropriate to local rice varieties and caused heterogeneous milling rice in absent of grading machine. Due to that, population preferred and prefers the imported rice for it already to cook characteristic.

In order to boost sustainably cereals production, governments, NGO, farmers, communities and others organisms of development should focus efficiently in the improvement of post harvest technologies. The packaging must also be revised considerably even though some improvement are done in the SRV by using new bags instead of already used of imported cereals like rice or others plastics boxes.

IV. SENEGALESE AGRICULTURAL POLICY EVOLUTION

4.1 Introduction

In the early 1980s, after a series of very poor harvests, the agricultural sector experienced a steady decline with severe adverse effect on the socio-economic situation of rural areas. In a bid to revamp the agricultural production, the New Agricultural Policy (NAP) was adopted in 1986, but to no avail. The next move was to establish the Structural Adjustment Program (SAP) whereby the Structural Adjustment Program of Agricultural sector was implemented via the Agricultural Development Policy Letter (LPDA) in April 1995. It increased the withdrawal of the government that had been initiated through the NAP.

In 1984, during a special inter-ministerial meeting, the Government of Senegal defined the New Agricultural Policy (NAP) as one of the structural readjustment plans to implement in the country. The NAP targeted mainly the reduction of state expenditures. From this ideological point of view, NAP brought about a huge change, reducing the excessive involvement of the government in the economy of the country and it was felt to be a strongly needed financial and economic lever, especially in the sector of agriculture. State intervention was therefore reduced to the role of a catalyst and prime mover of economy activity.

The purpose of the New Agricultural Policy (NAP) was to achieve self-sufficiency in specified priority areas, especially that of cereal supplies. It was decided to implement the new policy through a series of five plans called Priority Action Programs. These programs were developed in accordance with the seventh Economic and Social Development Plan 1986-1989. The Grain Program was launched in May 1986 with the objective of specifying means to achieve a level of 80% in cereal self-sufficiency by 2000. It also aimed at

disengaging the State from various agricultural chains, strengthening organizations of producers in the advent of emergencies and liberalizing them while reducing their production costs as well as supporting production techniques that are respectful of the environment and implementing improved hydro-agricultural layouts for rain-fed and irrigated agriculture in the SRV.

The Structural Adjustment Program of Agricultural Sector was mainly aimed at restoring factors boosting productivity and production processes. To this effect, the World Bank, increased subsidies and assistance granted to Sub-Saharan countries, one of which was Senegal, for projects targeting particular sectors, like cash crop production (i.e. cotton, peanut….).

It should be mentioned hereby that the agriculture sector plays a major role in Sub-Saharan Africa, given that it accounts for about 80% of the labor force. This explains why the SAP of Agricultural Sector was expected to have a considerable impact on crucial areas such as employment, improvement of exports, and the comparative advantage enjoyed by Senegal. The action launched through PAS of Agricultural Sector was therefore supposed to ease farmers' access to factors of production, particularly to trainings, investments, fertilizers, new cultivars or improved seeds and others. In so doing, production and productivity were supposed to improve in such as extend as to subsequently enable achieving food self-sufficiency, mainly based on rice and cash crops. As part of the decentralization strategy, SAP was designed to give a new orientation and increased assistance to agricultural services. Its implementation was to be spread over twelve years, accompanied with programs like the Programme national d'infrastructures rurales (national program for rural infrastructure).

With the same objective of reinforcing agricultural production, the agricultural sector

was liberalized in 1996 but results were still inconclusive. In fact, the liberalization of the agricultural sector in Senegal required farmers to be highly autonomous while facing the global market. Nonetheless, Senegalese professional farmers were lacking in appropriate training to handle such as situation. For this reason, the National Strategy for Agricultural and Rural Training (SNFAR) was implemented in 1999 with objectives of reaching out self-sufficiency in food by 2015.

From 2000s onwards, Senegal entered into another circle of agricultural crises. Due to that, political leaders started looking for a new participative approach applicable at the national level, and aimed not only at solving agricultural issues but also at bringing about strong and sustainable economic growth. In those issues challenging, organizations gathering professional farmers like the National Council for Rural Dialogue Consulting (CNCR) also needed to define a new orientation for the agricultural sector. As a result, in 2004, the agricultural law called Loi d'Orientation Agro-Sylvo Pastoral (LOASP) was adopted and provided the overall strategic orientation of agriculture in Senegal over a period of twenty years. With its strategies, mainly based on family farming, LOASP superseded all the other sectional agricultural policies in Senegal. Moreover, LOASP's objectives shared similarities with the Common Agricultural Policy (UAP) implemented by the West Africa Economic and Monetary Union.

LOASP aimed mainly at reducing poverty, for that reason it was also supported by the two Poverty Reduction Strategy Papers, one going from 2003 to 2005 (PRSP I) and the other one from 2006 to 2015 (PRSP II). PRSPs entailed a direct participatory process which involved all professionals and actors working in the area of agriculture and were implemented through the 2006 REVA plan (Reversion to Agriculture). The stated goal of

REVA plan was to create incentives to massively attract the population into rural areas and to achieve sustainable land management as well as self-sufficiency in food.

Before 2008 the national GDP growth rate was established at 5%. Then in order to revamp growth and achieve a GDP of 7%, the government of Senegal launched the GOANA program. One of the stated objectives was to effectively and sustainably reduce the level of poverty. To this effect, the Accelerated Growth Strategy (AGS) was launched by the government in order to support key sectors, like the agricultural and agri-indystry sectors, which have a strong potential impact on the development of the country. In the same vein, it was decided to modernize the agricultural sector, so as to effectively reduce poverty and achieve food security, at the level of the farm as well as in the management of the entire agricultural sector by integrated agricultural systems. At its implementation, the AGS was also a strategy instrument of the REVA plan aimed at complementing and strengthening LOASP.

But the 2008 food crisis enabled to realize that all agricultural policies implemented till that time had failed to achieve food security. This brought about a major and sudden change in the approach to solve agricultural issues in Senegal. Consequently, in May 2008, a new participative agricultural policy was initiated, namely, the Great Agricultural Offensive for Food and Abundance (GOANA). This program represented a significant shift from previous policies because professional agricultural organizations were not fully involved in negotiations and decision making. Nevertheless, GOANA could be considered as a pending of LOASP targeting the achievement of food security and its strategic goods were crops like cereals (maize, rice) and other cash crops. From the point of view, many African economists, unlike compared to LOASP, GOANA is a major setback to agricultural liberalization because,

even though it provided a lot of subsidies to farmers, it also disempowered them. In fact, when LOASP was being implemented, in agricultural sector, producers were the sole responsible for their accounting charges and had to develop some skills for their own farm management. But through GOANA, the Government subsidized a lot of seeds and fertilizers, thereby reducing their charges and easing inputs accessibility to farmers. But the adverse effect was that farmers, bit by bit, tended to "forget" the value of all these aids and started relying too much on the government. This did not only burden the State but also reduced producers' competitiveness in an open market.

In generally, policy makers and the government were and are very aware about the severity of Senegal's dependency on imports mainly for cereals which domestic's demand can be hugely covered by the domestic production because of the country large potential (natural resources) in rice, maize and other cereals production. For that, agricultural policies are defined in long term (to boost sustainably agricultural production), medium term (rural people living conditions improvement, rural exodus regulation...) and short term (according national and international market conditions) according to each agricultural targeting objectives and instruments. However, no policy has been completed because of continuous change in strategy as well as political function instability.

4.2 Stratégie Nationale de Formation Agricole et Rurale (SNFAR)

The National strategy for agricultural and rural training, launched in 1999, was aimed at achieving a new agricultural and rural economy development as well as self-sufficiency in food by 2015. In fact, during that period, governments and policy makers had come to the realization that trainings offered by public and rural agricultural institutions did no longer

match with needs of the increasingly and deeply changing agricultural context of Senegal. Due to that, leaders from the ministry in charge of Agriculture and the ministry of Rural Education, heads of training institutions, NGOs and farmers' organizations conducted a prospective reflection on Agricultural and Rural Education (Training). The reflection focusing on the support of agricultural training and was carried out with the support of the interim project called Projet Sénégalo-Suisse (Senegal-Switzerland Project).

Areas considered as priorities were the training of seniors, middle managers and technicians highly needed within the new public administration and institutions. Their training was to be sanctioned by automatic recruitment into the public service, for offices to match the specific missions entrusted to them, namely: the training of rural population, the enforcement of regulations, the outreach of modern production practices to the population, the protection of natural resources, ensuring animal health, the organization and management of cash crop production sectors.

4.2.1 Objectives and priorities

The objectives of the SNFAR (national strategy for agricultural and rural training) were subdivided into three categories: short-term, long-term and political objectives. The main short-term objectives were based on the identified changes within the agricultural context which had to be considered and included into agricultural and rural training, namely:

① The growth of active rural population,

② The liberalization of the country’s agricultural economy,

③ State decentralization and the emergence of new private and associative actors, and

④ Improved technologies.

Needed policies guidelines were identified as follows:

① Income transfer policy in order to enable farmers to access real information of policy

② Training programs and advisory support for rural communities.

③ Investment policies in public services and rural infrastructures;

④ Planning strategy for policies, as well as

⑤ Land reform and farms restructuring.

These policies which were designed to encourage investments in rural areas, had to improve (mainly crops) productivity and create non-agricultural jobs. Long-term policy objectives for agriculture were defined based on the following priorities: the modernization of family farming, the development of rural economy around production activities and services, and the development of intensive-capital in agriculture areas and sectors having comparative advantages.

4.2.2 Instruments of SNFAR

To achieve the three main priorities of the SNFAR program, namely, the modernization of family farming, the effective emergence of rural economy and its integration into a national and international open economy, different instruments were identified. The program was also deemed to support the development of intensive-capital in agriculture. Based on these new missions and priorities, four orientations and strategies were defined.

4.2.2.1 Ensure greater access to basic education and education to all

Greater access to basic education and adult literacy were identified as prerequisite for effective training and the government wanted to achieve such objectives by 2008. But this required many efforts, some of them are, adapting the public school model to rural population in more than 13,000 villages, providing training first in literacy to girls and women before training them professionally, building synergies between literacy and professional training, and adapting the content of basic education to rural environment and concerns.

4.2.2.2 Needs of professional training in rural areas

In an increasingly liberalized world economy, in order to increase their productivity and competitiveness in the domestic as well as sub-regional and international markets, the vocational training of rural communities was considered as an unavoidable long-term investment. Such training was also essential for the development of non-agricultural activities in rural areas, in order to prevent farmers from having to leave the countryside, and not being absorbed by the sluggish urban economy. Three strategies were identified to achieve this purpose:

① Supporting rural people in formulating training demand through systematic mechanisms, which would allow them: to identify and articulate their own needs, to mobilize necessary resources and expertise, and to be engage and participative in their training. This approach would enable them to appropriate permanently their demand in training.

② Supporting the provision of training that meet rural communities' needs. Public,

private and associative training offers to rural communities and trainers had to be supported financially, in order to meet demand made by rural population in terms of the achievement of quantitative, qualitative and diversifying objectives.

③ Granting vocational training in rural areas through public service institutions. In fact, the State was unable to meet the huge demand of rural area, not only because of the costs, but also because of the inadequacy of the model which was used in public training institutions. The government had therefore to train private and associative operators based on how to establish private contracts with producers. According to such contracts, the government and local collectivities had to contribute to infrastructures, large equipments and initial training financing which are sometimes too expensive for producers. Some other training was related to the provision of direct or indirect services financed by beneficiaries.

4.2.2.3 Appropriate trainings for rural communities

There was within rural areas a better need to strengthen adapt and articulate the secondary and higher education system with rural requirement in order to help rural communities to upgrade their standard living. Such training was carried out by public secondary and higher education establishments. The strategies envisioned, aimed at improving the quality and the diversity of technical training education by developing a synergy between trainers and trained producers. The main axes were:

① Creating five centers offering short vocational training at secondary and higher levels: the proposition was made to split Senegal rural areas into five “regions”: the Senegal

River area; the Groundnut basin and Pasto-forestry area; the Niayes area; the Middle, low and high Casamance area; and the Eastern Senegal zone

② Diversifying vocational trainings,

③ Launching specialized trainings involving universities, colleges and research institutions, and

④ Widening the mission of training institutions from research, agricultural and technical advisory services for rural communities till the provision of private services.

4.2.2.4 Regulating public and private agricultural and rural training institutes

The following strategies were adopted to create mechanisms regulating the agricultural sector and to ensure its financial sustainability by:

① Creating a mechanism of inter ministerial regulation with the participation of all public and private actors. Activities relating to agriculture and rural training were distributed into four ministries, and trainings offered to rural communities were done through public service concession. Also, an intern ministerial mechanism for the development, follow up, evaluation and coordination of training policy was set up, with the involvement of regional councils, public, associative and private training institutions, as well as professional organizations for efficient training of involved actors. The system was regulated through decentralized poles where trainings were proposed, organized, and coordinated throughout the nation. Decentralized entities were organized from upstream to downstream as follow: Regional councils, rural councils, educational institutions, NGOs, peasant organizations and private sector

representatives. All those decentralized entities had to work in synergy between them. This also enables local collectivities to participate to different administration and pedagogic councils for publics and institutions better management by;

② Ensuring that institutions in charge of vocational training were well coordinated both vertically and horizontally: supervisory of authorities and administrative as well as pedagogical councils had to ensure consistency and complementarity between training structures.

③ Ensuring the sustainable financing of producers' training. To achieve such objective, it was decided that the government should financially support initial training. But, after the government support, local collectivities must gradually bring a financial contribution in other to appropriate progressively and sustainably the training of rural people. Beneficiaries had also to contribute in their training, either directly or indirectly by bearing some charges of their activities. Training institutions had to participate equally via diverse provision of service. Some training models were also designed in order to reduce the unit cost of training, namely, public service concessions or on-site training which does not require the use of infrastructure, and trainings were dispensed by professionals or trainers originating from agricultural institutions.

4.2.3 Impacts of the NSFAR

Right from its launching, the SNFAR (national strategy for agricultural and rural training) was aimed at accomplishing the lever mission of the agricultural sector in an increasingly

difficult context, in which:

① The production of major crops had been stagnated,

② Cereal imports had witnessed a rising sharp and

③ The pressure on natural resources had peaked to levels hardly unsustainable, while the rural population kept on increasing.

This increase of rural population had eventually resulted in the rise of people in need of training and thereafter in need of employment. Due to that, the informal rural sector was expected to absorb about two third of the need of employment and the remaining one's having no other choice than resorting to self-employment according SNFAR planning. The national impact of SNFAR on agricultural was more effectively felt in maize production which recorded a growth rate of 50.25%, contrary to the rice where a negative figure (-0.07%) was recorded. Yet, this program enabled to assess the importance of Senegal River valley as far as issues in food security and self-sufficient are concerned. Despite the slight increase in the production of maize and rice as experimented in Senegal River valley, amounting to 17.07% for the rice and 29.05% for maize, the share of agriculture in Senegal's GDP remained very low.

Table 2. SNFAR impact on rice and maize production as well as on the GDP

Years		2000	2001	2002	2003	2004	Growth (%)
National production	Rice	202293	206989	172395	231805	201744	- 0.07
	Maize	78593	108546	80372	400907	400555	50.25
SRV production	Rice	104433	141263	133655	154331	196157	17.07
	Maize	2678	4160	5443	16104	7428	29.05
Agricultural share on GDP (%)		10.7	10.6	6.8	8.3	7.2	
Primary sector share on the GDP (%)					15.1	13.7	

Source: SAED and MEF, 2012

4.3 Loi d'Orientation Agro-Sylvo-Pastoral (LOASP)

The main objectives of Agro-Forestry-breeding act (LOASP) were to reduce poverty and achieve food sovereignty. Adopted in June 2004, the LOASP sketched out the main principles and visions of leading the sectors of agriculture and rural development. It laid on a particular emphasis on the basics of land tenure, market regulations and the rights of famers as well as the status of their farming lands. LOASP thereby could be seen as a general framework oriented towards the development of the agricultural sector. Its registered sub sectional policies and development programs were also in line with its objectives, namely, securing

rural development by modernizing family farming and thereby promoting agricultural entrepreneurship. The scope of the Act covered all economic activities carried out in rural areas, including the processing and trade of services as well as goods. The program was also consistent with the principles aimed at refocusing the government on its regulatory functions. It also tried to reconcile the PRSP's objectives of fighting poverty under sub-regional integration (WAEMU and ECOWAS) as well as continental and international agreements (commitments) (NEPAD, WTO).

4.3.1 Objectives and priorities

The main objectives of LOASP consisted of reducing poverty, especially in rural areas, and achieving food safety in short term, which had to lead at its turn to country food sovereignty. Its specific objectives were to contribute to the reduction of inequalities between urban and rural areas, between genders, and to eradicate poverty, as follows:

① Reducing the impact of climate changes as well as economic, environmental and health hazards, so as to improve food security and ultimately achieve food sovereignty, meaning food self-sufficiency,

② Improving the living standards of rural population and establishing a system of social welfare to their benefit,

③ Improving of the living conditions and framework of rural areas,

④ Sustaining the management of environment and natural resources,

⑤ Encouraging private investments in agriculture thereby in rural area, and

⑥ Improving the environment and quality of production.

These objectives were in line with the following principles:

① Economic efficiency, social equity and environmental sustainability which are the three pillars of sustainable development,

② Economy of market,

③ Decentralization,

④ Empowerment of local communities, professional agricultural organizations and civil society,

⑤ The creation of a common market (WAEMU and ECOWAS) and

⑥ Solidarity and partnership between rural communities

4.3.2 Instruments of LOASP

One of the great innovations brought by LOASP program was the upgrading of professions related to the agricultural sector in Senegal. Through this program, professions related to agriculture were formally recognized, and attributed a legal status and also had access to social welfare. Therefore, professional agricultural organizations had enjoyed not only a recognized and protected status, but also benefited from the support of public entities. Family farming became valued as much as industrial and commercial farming. The legal statutes were attributed while considering the needs to modernize Senegalese's agriculture.

In addition to its economic recognition, the LOASP program also acknowledged the role of farming in the management of natural resources, the protection of the environment, and a balanced as well as coherent planning of projects of development. It went even further by providing a system of financial support.

4.3.2.1 Strategies of LOASP

One of the main perspectives opened up by LOASP was to announce land reforms within two years. For that, in an effort to modernize agriculture, individuals, farmers and communities rights were formalized on the ground to settle down some land conflicts. The deemed objectives and principles were for protecting the exploitation and landed rights of stakeholders and collectivities, increasing their estate accessibility, transferability and land using as collateral for credit. The diversification and control of supply chains, as well as market regulation were also part of LOASP's major concerns.

As a matter of facts, LOASP relied on the diversification of agricultural production as a lever to improve rural incomes and achieve the country food security by developing agricultural channels, promoting exports and reducing imports. LOASP acknowledged intra professional statutory organizations based on their agricultural zone of intervention, their products or group of products. Their acknowledgement has been extended to all other actors of agricultural sector. LOASP also had binding characters, contributions, and rules agreed upon by agricultural inter-professional organizations and WAEMU and ECOWAS.

Still, in LOASP, a policy to modernize the market was defined. A system of collecting information relating to markets was established and a national market was created on the outskirts of Dakar, the nation's capital. Also in order to ensure the control of products quality, a law was defined in line with the provisions of WAEMU and ECOWAS. Then, the government reserved for itself the right to take, when deemed, necessary protective measures or to apply subsidies in order to reduce or eliminate distortions in foreign trade within WAEMU and ECOWAS. This was in line with the elimination of unfair practices in trade and was in compliance with the WTO agreements.

Regarding agricultural and forestry, a management plan consistent with the Forest Code was developed with specified rules on clearing, grazing and bush fires. Concerning the sector of livestock, the pastoralism started being acknowledged as a mode of land improvement and appeared as a real political progress. In order to use water to achieve secured as well as sustainable agricultural production and to contribute to the well being of rural people, the government defined and implemented a rural hydraulic policy based on the principles of sustainable management.

The national policy and regional programs for the development of infrastructures and public services were defined and implemented, with priority given to rural areas. This was a sign of willingness to achieve social equity in rural areas, by establishing a balance between urban and rural areas, in terms of living conditions and accessibility to basic social services. This also entailed of achieving gender equity through the provision of equal rights to genders, facilitating women's accessibility to land and credit, supporting young people insertion into agriculture-related jobs by facilitating their accessibility to land and credit, and aiding all these actors to start up an agricultural activity. The Act was tried also to protect agricultural careers against natural disasters and risks, to secure investments made in agriculture through a policy of agricultural insurance support, as well as to create pre-basic seed reserve, calamities funds and guarantee... etc.

4.3.2.2 Institutionalization of dialogue and consulting

As part of the major achievements of the LOASP, dialogue and consulting between the government and all rural stakeholders was institutionalized through the creation of a High Council over LOASP program. This Council was chaired by the President of the Republic,

and regional committees were also established and chaired by Governors. LOASP effective follow up was carried out by the organization of an annual conference on agriculture.

4.3.2.3 Additional accompanying measures

The first interests of LOASP were to inform, educate, and train for agricultural jobs valorization and sustainability in rural areas. In this vein, an evaluation of agricultural information system was made for the strategic implementation of LOASP.

A national strategy for LOASP sensitization and training was defined and implemented, including the creation of training structures in each department within ten years. To strengthen and sustain agricultural production, structures and institutions of high education in science and technology for LOASP implementation were also defined.

The role of civil society organizations, farmers associations, and professional agricultural organizations in the development of agriculture as well as the implementation and the evaluation of public policies for agricultural sector were acknowledged. The government therefore defined and implemented a concerted program for the government and local collectivity capacity strengthening, a national policy and also a National Council for the LOASP. The LOASP council was implemented on a contractual basis with the ACP National Council, other public or private institutions and private individuals bestowed with a recognized expertise in agriculture or created for this purpose. A consultative committee of the ASP council composed of actors from the agricultural sector was created in each region.

The national strategy aimed at financing and supporting ASP activities was defined and implemented. The National Development Fund of LOASP was created to fund ASP council and support professional agricultural organizations.

The Act targeted the establishment of a fund within three years which had to support the modernization of farms by equipping them and helping young farmers who were trained in agriculture to settle up. Finally, a policy supporting financial institutes, mainly in rural areas, was elaborated and implemented to facilitate farmers' accessibility to finances.

4.3.3 Impacts of LOASP

The impacts of LOASP on agricultural production are similar to the previous implemented program. Even though the objectives of LOASP were well defined, the absence of government stability, that was, constantly changing authorities, hampered its effectiveness and led to the creation of a new policy, The Poverty Reduction Strategy Paper (PRSP).

4.4 Poverty Reduction Strategy Paper (PRSP)

The PRSP, established in September 1999 by the IMF and the World Bank which was applied in selected countries, was conducted in Senegal from 2003. It targeted the adoption of diverse general strategies in order to reduce poverty. These strategies provided a crucial link between actions implemented in the nation, public projects and donors' support, in order to achieve the Millennium Development Goals (MDGs) of the United Nations Organization. To halve poverty by 2015, the PRSP provided basic concessional loans and debts relief from the IMF and the World Bank framing; the Initiative of Heavily Indebted Poor Countries (HIPC).

Senegal developed its second PRSP (2006-2010) with the view of halving poverty by 2015 and achieving the Millennium Development Goals (MDGs). To this effect, the State put in place sustainable economic and social policies in order to significantly raise its socio-economic performance and put the country back on the path of sustainable human

development.

4.4.1 Objectives and priorities

Senegal established a development strategy to achieve economic growth and poverty reduction in order to improve sustainably the well-being of the population by:

① Reducing the incidence of poverty among the population below 30% by 2015 through an accelerated, a strong, a balanced and a better distributed growth (at least 7% in average in real terms over the period),

② Accelerating access to basic social services and improving population food security,

③ Protecting population particularly vulnerable people against social risks and disasters,

④ Reducing inequalities and eradicating all forms of discrimination within the country by introducing gender equality in all areas, and

⑤ Promoting good governance and the Rule of law.

In short term selected governments and policies makers who were subject to the non-occurrence of major exogenous shocks, had to be able to provide an average growth rate of 7% to 8% in real terms and trigger significant progress in social sectors so as to achieve the MDGs by 2015. Some of key factors were:

① A primary school enrollment rate of 100% ,

② An access rate of 78% of urban population to sanitation,

③ A specific drinking water consumption rate of at least 35 l per person / day,

④ Reducing maternal mortality by increasing the proportion of births attended by

trained personnel up to 75%,

⑤ Reducing the mortality of children under five years old by 56%,

⑥ Maintaining HIV prevalence AIDS below 3%,

⑦ Improving significantly the rate of social welfare and

⑧ Improving accessibility to energy services, with an objective of 66% of households having access to electricity, with at least 30% from rural areas.

These objectives took into account the identified profile of poverty of rural and urban people through the poverty diagnosis in different participatory frameworks, as well as the specification of objectives to be achieved through concerted efforts of all socio-economic actors. Specific and integrated instruments were defined and set up to achieve efficiently set priorities.

4.4.2 Instruments of PRSP

4.4.2.1 Strategy for growth and poverty reduction

The analysis of the causes, determinants and manifestations of poverty in Senegal showed that, there are prerequisites to achieve the high needed growth in order to reduce sustainably poverty in Senegal, namely, a sound of macroeconomic framework and transparent management of public resources, which are possible only through economic growth and legal good governance. But, the registered economic growth was not quit enough to achieve those objectives because the needed growth to be supplemented with decreasing revenue inequality, the reduction of discrimination between rural and urban areas in their access to social services as well as the building of human capital, increasing decentralization, and stakeholder

participation in the formulation and implementation of policies and strategies were not enough desirable. Moreover, previous experiences had questioned the possibilities of economic growth and human capital building, due to the occurrence of various natural disasters, accidents and the lack of protection against social risks. In order to harmoniously and coherently overcome these challenges, Senegal adopted a strategy which focused on four key levers.

4.4.2.1.1 Wealth creation

Data collected during two surveys (Senegalese Household Survey one and two) by Cheikh Anta Diop University of Dakar, Centre for Applied Economic Research showed that, subject to the assumption that income inequality does not change, the elasticity of poverty incidence compared to real income growth rate per capita was - 1.38. Consequently, a robust growth with better income distribution is a fundamental prerequisite to reduce significantly poverty in Senegal.

4.4.2.1.2 Rapid improvement of accessibility to basic social services

Establishing basic infrastructures with required quality, their appropriate geographical distribution, as well as the availability of essential social services to people are prerequisites for: the building of human capital stock and viable solutions for investments in social services such as education, training, health, transport, electricity in order to satisfy social demand...The willingness of the government to build a human capital stock, particularly by enhancing the educational system and improving sanitary situation, resulted in substantial allocation of resources to the sectors of education, training, and health. As a matter of fact,

budgets allocated to these sectors are increasing every year. And the four main keys of this strategy were:

① Education – Training,

② Health and Nutrition,

③ Access to drinkable water and

④ Access to Sanitation.

4.4.2.1.3 Social welfare, risks and disasters prevention and management

A diagnostic of social welfare in Senegal showed not only the existence of formal mechanism protecting civil servants and other employees against risks, but also the presence of private insurances, and other professional mutual. Such systems displayed serious problems and limitations in their performance as well as in their ability to answer the diversified needs of social welfare and risks management. They were undergoing a series of significant challenges because they needed to be adapted to an increasingly changing work atmosphere, with the associated new socio-professional structures, emerging families, and even the occurring changes in demographic.

4.4.2.1.4 Good governance and decentralized participative development

The strategy of the government, as stated in the National Good Governance Program and the actions of the Country Financial Accountability Assessment- Country Program Assessment Review (CFAA-CPAR) program, was aimed at strengthening the rule of law in a democratic society and enhancing efficiency and transparency in social and economic management.

Meaning that, the Government wanted to anchor in the mind of every citizen the values of a democratic society, the virtues of peace and stability, as well as transparent practices in the management of public and private sectors.

4.4.2.2 Accelerated Growth Strategy (AGS)

The analysis of the improvement of Senegal's economic growth induced by the devaluation of the CFAF led to two key findings:

① The average growth of 5% deriving from the 2005 model did not reduce to an acceptable level the poverty rate as expected by authorities

② After the local currency devaluation, competiveness was maintained in terms of price but problems persisted due to inflation and structural competitiveness. In fact, the cost of inputs became relatively high and difficulties related to land planning as well as to the accessibility of financial resources and the lack of sufficient information concerning foreign markets were major bottlenecks.

For the period going from 2005-2015, when the strategy of reducing poverty and achieving Millennium Development Goals (MDGs implementation) was being applied, the fundamental concern was to complete the implementation of a general framework. Such framework was a prerequisite to carry and maintain economic growth at a level consistent with an accelerated development process. The Accelerated Growth Strategy was therefore articulated around five clusters:

① Agriculture and Agro-Industries,

② Seafood and Aquaculture,

③ Tourism, cultural industries and crafts,

④ Textile and Clothing and

⑤ Information and Communication Technologies, and Teleservices.

The principal sub-objectives of this strategy were to accelerate the economic growth, by improving the quality of existing structure in order to make it more effective in the struggle against poverty and diversifying income resources for more security and sustainability. AGS was laid out based on a nationwide consultation with all involved stakeholders and was considered by most of them as a friendly alignment of the economic policies of the State. In reality, its general objective of achieving a strong growth and a better distribution of incomes federated all other policies and measures implemented to achieve good governance, namely the framework of the PRSP, Millennium Development Goals (MDGs), the Millennium Challenge Account (MCA) initiative, the Economic and Social Development plan, and also the strategy of development for the private sectors and sectional Policies.

The proposed institutional framework for the implementation of the AGS arose from consultations that gave birth to the private sector development strategy and also from the participative approach strategy of Poverty Reduction. AGS capitalized on transparency rules of good governance, as well as on the political willingness showed by highest authorities. It was based on three structures: the Steering of the AGS at national level, the technical community and cluster groups.

4.4.3 Impacts of AGS

Since AGS was adopted to alleviate poverty, its impacts were mixed with those of the PRSP. However, in terms of production, the expected results could not be evaluated because of its interruption by REVA plan. At that time, farmers acquired progressively more training, which made them more accountable and less dependent on the government, since their access to loans from few financial institutes was facilitated. Indeed, before this program, farmers had a hard time in getting loans due to the randomness of crop production and their lack of guarantee.

4.5 Reversion to Agriculture (REVA PLAN)

Reversion to Agriculture belongs to the initiatives of sustainable development launched in order to trigger by mass, sustainable and sustained national dynamic mechanism for the return of all categories of the population towards the earth. Such return was supposed to transform agricultural activities into a (jobs) base of the economy growth and an engine of development. This program revolved around the implementation of integrated emergence of clusters and the widespread promotion of private initiatives in the agri-industry sector, namely, in agriculture, forestry, fish farming, aquaculture, livestock, handicrafts, etc... At that period, such a tool, it was viewed as adapted to the technical and socio-economic context of the country. The REVA plan was managed at national and regional levels by the Minister of planning.

4.5.1 Objectives and priorities

The objective of REVA was to bring people, young people and women to settle in their lands.

This concept was particularly crucial for some migrants and repatriated Senegalese, who's settling had to raise significantly agricultural production, especially in the sector of horticulture, and also to contribute to the Accelerated Growth Strategy objectives meeting as well as poverty eradication. REVA is therefore the implementation instrument of the Poverty Reduction Strategy Paper and Accelerated Growth Strategy programs. Furthermore, the primary sector was considered as a unifying framework for all initiatives and interventions. The specific objectives of REVA Plan were:

① Fighting against rural exodus and emigration by creating sustainable conditions for voluntary return to land and allowing individuals to recover their dignity,

② Creating employment and agricultural jobs which can provide enough revenue to secure population, including youth and women, in their land,

③ Improving the productivity and the development of the agri-indystry,

④ Creating conditions for the promotion of agricultural production through short cycle of production, consumption, processing and marketing,

⑤ Supporting the creation of dynamic and ambitious productive groups,

⑥ Supporting and developing private initiatives in agriculture and livestock,

⑦ Promoting the protection of the environment and natural resources,

⑧ Improving the conditions and quality of life of rural population,

⑨ Ensuring water control as well as its accessibility,

⑩ Providing new techniques and technologies for researches in rural areas,

⑪ Accelerating the modernization of the agricultural sector, the training of farmers and

intensifying agricultural as well as rural activities, and

⑫ Improving the attractiveness of rural areas through incentive policies.

This plan was particularly aimed at enhancing the concept of "zero clandestine immigration", promoting a new type of farmer, improving food security to fight against poverty, ensuring food sovereignty, developing new crops with high added value and likely to increase exportable resources, increasing the share of agriculture in the national GDP, eliminating deficits of the balance of trade in the agribusiness sector, achieving mainly self-sufficiency in meat, dairy products, onions and potatoes as well as maintaining all rural areas activities through the year (none stop activities).

4.5.2 Instruments of REVA Plan

The REVA Plan was based on two main instruments: the emergence of integrated activities while promoting poles activities and promulgating the private initiative in the LOASP sectors.

4.5.2.1 Emergence of integrated activities of different areas

The emergence of integrated areas was generally associated to the primary sector, especially in large farms under diversified activities. Such areas had to be transformed to become pillars of the development. Traditional and new activities which were carried out by local population were classified into a broad area of activities, which were gathered into four major areas:

① Emergence of the Integrated area of "Excellent" type of activity, resulting from the agriculture merging and aquaculture activities,

② Emergence of the Integrated area of "modern village farm" type of activity,

③ Emergence of the Integrated area of mixed activities called "Agro fish farming" and

④ Emergence of Integrated area of activity "Agro-pastoral."

4.5.2.2 Private initiative promotion in ASP sectors

This initiative comprised four strategic “Poles of big producers”: Innovative poles of non-traditional crops in which bio-fuels included was included in; Small family farming mostly initiated by partners or Non-Governmental Organizations (NGOs) throughout the country; Micro and hydroponic gardens in urban areas; and the introduction and promotion of micro gardening in rural area schools.

4.5.3 Impacts of REVA Plan

The REVA plan was constantly criticized by farmers and rural people. From their point of view, funds were not attributed to professional agricultural producers but “Sunday farmers”, meaning politicians and other high income people. As a consequence, the initiative promoted and increased agribusiness rather than family farming which represented more than 50% of Senegalese population (ANSD). Therefore for policies makers, governments, and mainly rural population, expected results were annihilated and the program failure was confirmed by the 2008 crisis.

4.6 Great Offensive for Agriculture and Food Abundance (GOANA)

Following to the inflation of food prices, the declining stocks of agricultural products and difficulties of supplying local markets due to the food crisis, the President of the Republic

decided formally in 2008 to launch the Great Offensive for Agricultural, food and abundance (GOANA). The GOANA program initiative raised a lot of debates between policies makers and rural area specialists. It reopened the debate on the type of agriculture that the government ought to promote as well as concerns about land. In fact, GOANA was coupled with an order from the government authorities in charge of local committees. They were ordered to allocate land to potential individual producers and facilitate their exploitations. However land reallocation from rural population to newly coming people created many tensions and distortions wherever GOANA program was implemented.

4.6.1 GOANA objectives and priorities

The main objective of GOANA was to increase the agricultural production of major crops, mainly biggest cereals staple of Senegal, in order to speed up the achievement of food security, to reduce national dependency on imports and thus ensure food sovereignty. In this sense GOANA integrated and surpassed many existing special and rice self-sufficiency programs. It could be seen as a continuation of the LOASP, PRSP and AGS programs. The REVA plan was used to implement the new strategy of GOANA.

4.6.2 Instruments of GOANA

An information system was put in place to educate producers and GOANA program multiplied intervention strategies in the following areas:

① Water control,

② Soil regeneration,

③ Capital seed reconstitution,

④ modernization of the agricultural sector through the intensification of the production system,

⑤ Provision of extensive support to producers,

⑥ Promulgation of export crops,

⑦ Improvement of energy crops in order to counter the price soaring of the black gold,

⑧ Protection of crops and

⑨ Promotion of a healthy and sustainable agriculture.

However from the beginning of its implementation, GOANA was strongly criticized, especially by professional peasants' association because they were not consulted on the development of GOANA policy. Even though they shared with the government the desire to reach food security and food independency, they still criticized the implemented means to achieve it. They requested to be included in decision making process, so as to have the possibility to review beneficial policies to producers. From their point of view, multiplying supports, subsidies may disempowered farmers and gradually move producers from the market reality. Thus, they called for a reform of land policy that would efficiently secure producers.

4.6.3 Cereal production

Particular emphasis was placed on cereal production, namely, millet, maize, sorghum, rice and "fonio", given to their importance in the diet of Senegalese in general, and more especially in those who are living in rural areas. The context of global market production was

also considered to regulate prices. The target of GOANA program was to ensure food security, food self-sufficiency and create surpluses, meaning, stocks for export and future consumption. Indeed, the expected food security and self-sufficiency, mainly in rice, would bring eventually an increase in cereal consumption, thus farmers' income.

4.6.3.1 The rice sector

The adopted strategic to achieve rice self-sufficiency by 2012 stemmed from an analysis of the situation which was prevailing in the country as far as rice supplies were concerned. The rice sector was characterized by an international trade volatility and the country huge dependency on rice imports (80% of it local consumption a rounding 800 000 tons per year) which was and still is one of the major burden of the government. Ensuing threats and burdens were expected to increase gradually in coming years. Due to the huge potential in rice production within the country, the National program for rice self-sufficiency (PNAR) was adopted in order to boost the domestic production as well as to create new jobs, wealth and economic growth.

The overall objective of the program was to achieve self-sufficiency in rice by 2012 and increase the domestic production in white rice (milled rice) to 1 million tons which is equivalent to 1.5 million tons of paddy rice in 2012, for the needs of a population of about 13 million inhabitants. The expected contribution of irrigated rice to achieve this goal was 800 000 tons and that of upland rice production 200,000 tons milled rice. In order to achieve this goal, it was essential to:

① Rehabilitate and improve hydro-agricultural layouts: 35 000 ha in Senegal River

Valley and 4180 ha in Anambé basin

② Make new improved layouts,

③ Ensure the permanent maintenance of layouts,

④ Renew subsidies in fertilizers and pesticides,

⑤ Ensure crops production,

⑥ Facilitate the accessibility of financial resources for production, equipment and processing improvement,

⑦ Support rain fed layouts (facilities), improve agricultural practices with improved crops as well as their management,

⑧ Facilitate the commercialization of rice (paddy and white rice),

⑨ Enhance the capacity of farmers through training and coaching (close follow up) and

⑩ Promote R&D in rice sector.

4.6.3.2 The maize sector

Maize contributes highly to national food security, particularly by intensifying livestock production and improving producers' income. The high volatilities and uncertainties on maize imports due to the dynamic worldwide surrounding bio-fuel production, mainly in United States and Brazil, were and are gradually affecting maize prices. Those circumstances raised the hopes of the government in this sector given the huge potential of Senegal in maize production.

In order to reach the targeted objective of 2 million tons of maize by 2009 it was

necessary to consolidate the improvement of local varieties breeding programs, to continue hybrid seeds imports for high-potential areas, particularly for irrigated areas located in the southern part of Senegal River Valley. Another prerequisite to achieve the expected performances in maize sector was the provision of sufficient amount of fertilizers, pesticides, as well as tillage and processing equipments.

4.6.4 Impacts of GOANA

In the first year of its implementation the GOANA program had achieved only 16% and 29.28% of its perceived objectives, respectively in maize and rice productions. From its creation till 2011, the impacts of the program were more effectively felt in Senegal River Valley with a growth rate of 10.37% and 7.15% respectively in rice and in maize production. Because of the increasing dependency on imports (80% and 50% respectively for rice and maize), successive crises, the dropping of world stocks and price soaring in the international market, the government had a heavy burden and a hard time to achieve self-sufficiency. However, this challenge was not insurmountable given the huge comparative advantages of the country in terms of rice and maize production. Priorities had to be therefore focused on compulsory expenditures which were directly related to agricultural production. Actually in Senegal, like generally in Africa, payroll expenditures of development project (like agricultural production) weight heavily on the total charges incurred.

Table 3. GOANA impacts

Years		2009	2010	2011	Growth (%)
National production	Rice	391271	604043	439331.9	5.96
	Maize	211585	121235	178710.2	-6.02
SRV production	Rice	281733	336317	343172	10.37
	Maize	5459	6779	6267	7.15

Source: SAED, 2012

4.6.5 Conclusion

Senegalese agricultural policies have been constantly criticized for their lack of effectiveness and the continuous implementation of new policies. Actually, the debate on agricultural policy in Senegal is carried out by professional organizations, especially the CNCR which has been opposing the approach adopted by GOANA in handling agricultural issues. All actors involved in the sector of agriculture were and are still very well aware about the critical situation of the country as far as food security is concerned. If there is no doubt that all actors' share the same one objective, namely food self-sufficiency, they disagree however on strategies which were implemented to achieve it. For that, CNCR continue to underscore the urgent need of land reform announced in the LOASP. They agreed that the achievement of food self-sufficiency and food security cannot rely exclusively on the resurrection of family farming, but it requires also a real participation of professional agricultural groups and a strong policy device.

Concerning the possibility of land reforms, in order to attain sustainable agricultural activities, serious consultations between policies makers, authorities of rural local collectivities, and farmers should be held. That is the reason why LOASP has set up a commission to make proposals in designing a view of participative law. This principle of processing is still going on. But the CNCR is not involved in the consultations as well as in decisions making and the government seems doing its best to neutralize CNCR influence via the support of the Parliament. Indeed, for CNCR actors, the government has shown its willingness to solve existing problems by trying to organize actors of the new agriculture sector. Nonetheless, there still exist many rooms to fill. And as CNCR is one of the main active components in rural areas, the expected objectives of agricultural policies will be more delayed by their absence in decision planning and making.

The difference between past and current policies lies in the fact the new designed strategies are more participative and decentralized than the older one. Project beneficiaries (women, youth, rural people or groups) are involved in policies drafting and implementation. But there still is a huge gap to fill in the satisfaction of the domestic demand as agricultural production boosting needs great financial resources and technologies. Thus, internal and foreign investments entry in agriculture should be encouraged while creating favorable conditions as well as easing foreign capital entry in agricultural sector. Furthermore, Senegal must generalize its trade barriers allowed by African Union on agricultural products and eliminate subsidy on rice to boost local production and encourage local rice consumption.

V. EMPIRICAL ANALYSIS OF AGRICULTURAL POLICY IMPACTS

5.1 Introduction

For several decades, many strategies and programs have been adopted to boost agricultural production in Africa (Svanidze, 1968) to no avail. In Senegal, taken decisions, from the liberalization of agriculture to special programs, did not harmonize the domestic production with the demographic pace and the rapid growth of urbanization (IPAR, 2010 and Ferrer, 2011). Many criticisms continue to be expressed concerning the development of agriculture in African countries. Some of them are targeting the principles of transparent management of public institutes (Menocal, 2001 and Africa rice, 2011) and the other ones are implemented mechanisms and strategies (Raymond and Fok, 1995; Norman and Etoo; and Africa Rice, 2011) to boost agricultural production.

Many analysts noticed that Senegal, like many other Sub-Saharan African (SSA) countries, was and is still confronted to a host of challenges. The population of Senegal is currently amounted to about 13 567 338 inhabitants (ANSD, 2013) and is expected to reach approximately 20 million inhabitants by 2025 (IPAR, 2010). This increasing population essentially composed of young people is actually an asset of jobseekers in the labor market. For example, currently around 269,000 young people are entering the labor market annually, and this trend will increase to reach more than 350,000 within fifteen year (IPAR, 2012). Nonetheless, the economy of Senegal is not well prepared to receive all these young people in need of employment. Therefore, the problem of employment is triggered debates around the potential absorption (uptake) of job seekers of agricultural and non agricultural activities in rural areas in order to enhance sustainably the economy of Senegal.

However, structures of job providers in rural area as well as the government structures are little or almost not enough efficient in delivering many jobs. There is consequently a challenging need to revamp rural economy. Actually, even though a small level of diversification is going on in agricultural activities, there is still a huge gap to fill (DA, 2010) as this diversification is simply a manifestation of adjusted process, planning of difficulties which are facing rural people rather than a well defined or successful policy (Stads and Sene, July 2011). Therefore, it doesn't lead to a diversified employment carrier or creation.

Households with an income per day and per head lower than FCFA 500 can be amounted to 20% of the population. This shows that poverty is practically generalized, mainly in rural areas where the rural exodus of young people with no other job qualification except agricultural activities, enhances the degradation of agricultural sector. This poses major challenges because, like in a vicious circle, to learn and launch a remunerative activity there is a need of a source of income and a person without income cannot launch an activity and is trapped by poverty.

The barriers of the development of agricultural production cannot be tackled without addressing closely related issues such as the structural and the socio-economic problems that Senegal is facing. Moreover, such challenges involve all the actors who are directly and/or indirectly linked to agricultural sector activities. Since the rural areas perform a crucial role in the process of achieving food self-sufficiency in Senegal, agricultural policies (land reform, direct subsidies, etc.) should be in line with the realities of the rural environment.

5.2 Producer prices

Before the liberalization of the market system in 1985, local cereal prices were officially set

annually by a governmental decree at the all stages of marketing. Agricultural products were bought to producers by the government against credit coupons. At that period, farmers had no problem with raw crop trading. Nonetheless difficulties occurred when they wanted to exchange their coupons in cash. Due to that, they had problems with the government in debt recovery. Especially, producers were hampered by their low level and randomness income as most of them did and do not have the necessary financial support to transport their output in urban areas where prices were more incentive.

Producers' price is a very important component of cereals market. But in Senegal, the law does not specify clearly whether official fixed prices are mandatory or not during the distribution of production factors. This resulted to a high level of uncertainty on agricultural products prices. Mainly in cereals as far as rice transaction is concerned. Furthermore, the control of prices is almost nonexistent in urban markets and highly ineffective in rural areas. Consequently, prices are actually determined by the market law. And generally, official prices are only mandatory during transactions with the government agency, the Office of Food Security (OFS). The Office of Food Security is a regulatory body which supports producers' price. It generally intervenes when applied prices are below the official ones. However, in general such control remains ineffective because wholesale buyers and cereal transformers go directly to meet farmers who are living in landlocked areas, in order to collect cheaply their crops mainly during lean period. In fact, at that moment, producers are almost constrained to sell their crops at buyers given price. This practice was established by the liberal regime whereby prices were set during harvest time contrary to the outgoing social regime during which, prices were fixed during seed and factors of production distribution period.

5.2.1 Rice producer price

Over the period going from 1980 to 2011, the national producer price of rice varied between 37 FCFA/kg and 154 FCFA/kg with an average of 97 FCFA/kg. Between 1980 and 2011, the coefficient of variation of rice price was 36.21% which is higher than 33%. The value of the coefficient of variation underlines the huge non stability of rice producer price according to its mean. Producer price varied considerably between the two regimes (socialism and liberalism). During the 1980-2011, the producer price of rice experienced a growth rate of 4.08% with a moderate dispersion from the mean during the liberal regime. Furthermore, the early liberalization of the rice sector was characterized by a decrease of producer price (-1.68%) which led to farmers switch towards more remunerative agricultural activities in the valley, namely industrial tomato, green bean and other vegetables production.

Table 4. Evolution of rice producer price

REGIME	SOCIAL REGIME		LIBERAL REGIME	
	BEFORE LIBERALIZATION	AFTER LIBERALIZATION		
Years	1980-1995	1996-1999	2000-2011	1980-2011
Growth rate (%)	8.16	-1.68	9.01	4.08
Coefficient of variation (%)	28.61	4.06	13.67	36.21

Source: MA/DA/SAED, 2012

5.2.2 Maize producer price

From 1980 to 2011, the annual average of maize producer price has been fluctuating between 42 FCFA/kg and 159 FCFA/kg with an average price of 97 FCFA/kg. During the period going from 1980 to 2011, the national average price had a coefficient of variation of 28.48%, which is lower than 33%. This value of the coefficient of variation shows a non negligible dispersion from the mean of producer price of maize. The producer price of maize was influenced by 2007 crisis and the GOANA program before its stabilization around 100 FCFA/kg. Since then, its price has been slightly fluctuated in the neighborhood of 150 FCAF/kg.

This increase in producer price was also triggered by the development of urban livestock (poultry) and by bans on the importation of chicken which was consecutive to the avian flu epidemic. Nevertheless, producer price was more stable during the social regime (especially before the liberalization of the agricultural sector) as compared to the liberal one whereby taken decisions were more related to the prevailing economic climate when prices were set.

Table 5. Evolution of maize producer price

REGIME	REGIME SOCIAL		REGIME LIBERAL	
	BEFORE LIBERALIZATION	AFTER LIBERALIZATION		
Years	1980-1995	1996-1999	2000-2011	1980-2011
Growth rate (%)	6.67	3.92	4	4.28
Coefficient of variation (%)	24.37	5.66	2.1	29.48

Source: MA/DA/SAED, 2012

5.3 Seed prices

Even after the liberalization of the agricultural sector, the regulation and distribution of seeds have been generally organized around public programs belonging to the Ministry of Agriculture and Equipment which controls other professional producers' organizations (DAPS, 2011). But seed control and quality certification have been taken in charge by Senegal's seed department (DISEM). The combined effects of the liberalization of agricultural sector with those of agricultural policies which aimed at achieving food security and food self-sufficiency increased the number of improved seeds producers (companies and specialized farmers) (Stads and Sene, 2011). These policies entailed to seed improvement as well as to its appropriation within different eco-systems (WARDA report 2004-2005 and Rice Today, 2011) and led to an improvement of yields, especially in rice and maize production in SRV (Ndiaye, 2007 and DAPS, 2011). This enhance in seed sector had to increase potentially the economic growth since poultry and infantine industries are using increasingly a huge

quantity of imported maize (Stads and Sene, 2011). And the release of improved seed varieties is strictly under the control of the government. Considering the high cost of R&D in the agricultural sector, as well as its significant, potential impact in poverty eradication, West African countries, via the Committee for Drought Control in the Sahel (CILSS), worked together to harmonize the regulation of conventional and genetically modified seeds. These processes are increasingly being integrated into relevant operations and political goals in Senegal.

Before being released in local markets, new varieties of seed should be certified by ISRA and imported seeds must be authorized first by the government and controlled by ISRA. But the reality is different from stipulated texts. And illegally, unapproved or banned seed entry into Senegal is frequent and some critics blamed the weakness of the government in enforcing the law of competition. This situation may also be due to some amount of carelessness in the side of the government decision makers. In early 2000 years ISRA authorities introduced some maize seeds without any priory test and unfortunately for beneficiaries, the imported cultivars, distributed to farmers were forage seeds. This was an evidence of carelessness and absence of rigor from the government, where at the same time many Senegalese seed companies were paying large amount of money for compulsory tests and waited for a long time to the official approval of ISRA before being able to release their seeds in markets. There were also some complains about corrupt government officers who allowed cheap imitated seeds from China to bypass the rigorous test process and reach markets.

Cereal seeds price was generally subsidized by the government at more than 50% of their market prices. However, despite all government efforts, cash crops, like groundnuts,

were more cost effective than cereals. The northern part of the country has an early interest in cash crops, while farmers from the south used to keep the best part of their crops like seeds for next agricultural seasons.

Most of specialized producers complained and complain about the quantity of subsidized seed to not being enough (Sylla, 2009) as well as their unavailability in real time. Subsidized seed accessibility is particularly difficult to farmers who are living in lock land areas (Sylla, 2009 and Africa Rice, 2011). However seed producers proclaim always their capacity of recovering the national seed demand while complaining about the delay of the government in paying them back their credit coupons. But for the Government, it considers that producers are responsible of the delay in seed distribution through their systems of retention for requiring payment from the government (CNCR, 2009).

Some farmers also reported that they couldn't acquire subsidized seed (Africa Rice, 2011) for many socio-economic conditions. For the above mentioned reasons, the policy of subsidized seeds remains less productive than expected outcomes, especially for cereals like rice and maize, or for groundnut seed subsidy programs which have been questioned (Ndiaye 2009).

5.3.1 Rice seed prices

Over the period 1980-2011, the price of rice seed was between 100 and 226 FCFA/kg with an average seed price neighboring FCFA173. The period 1980-2011 is characterized by a growth rate of -0.7% (0.7% decreasing seed price) and a coefficient of variation of 22.13%, lower than 33% (price instability).

The social regime is characterized by an increasing seed price (3.83% and 3.04%

before and after agricultural liberalization) while the liberal regime, is characterized by a decreasing seed price (-6.18%). However price dispersion from the mean is higher during the last regime, compared to the social one. This can be explained by the increasing dependency of the country on imported rice. Due to that situation authorities are trying to alleviate this dependency by improving local rice production and by making improved seed more accessible to farmers. At the same time the government encouraged some farmers to stick on rice seed production to accompany their instruments on self-sufficiency in rice.

Table 6. Evolution of seed price

REGIME	SOCIAL REGIME		LIBERAL REGIME	
	BEFORE LIBERALIZATION	AFTER LIBERALIZATION		
Years	1980-1995	1996-1999	2000-2011	1980-2011
Growth rate (%)	3.83	3.04	-6.19	-0.7
Coefficient of variation (%)	19.51	3.86	25.91	22.13

Source: MA/DA/SAED, 2012

Table 7. Rice seed production in SRV

YEARS	ALL VARIETIES	
	AREAS (ha)	OUTPUT (ton)
1999-2000	692.28	2373.029
2000-2001	641.59	1938.983
2001-2002	385.66	905.404
2002-2003	269.48	1316.83
2003-2004	501.33	1784.288
2004-2005	552.01	3177.06
2005-2006	830.13	3153.82
2006-2007	402.76	953.91
2007-2008	855.97	2530.16
2008-2009	1370.16	3014.49

Source: Saint-Louis DRDR, 2011

5.3.2 Maize seed prices

From 1980 to 2011, the price of maize seed varied between 125 FCFA/kg and 185 FCFA/kg with an average seed price neighboring 169 FCFA/kg. In this period, price experienced a drop of 0.89% with a coefficient of variation of 7.89, which is lower than 16%. This value of coefficient of variation shows a moderated dispersion from the mean. Unlike rice, maize seed price is an incentive price, its price was more stable throughout both regimes (all coefficient of variation are less than 16%).

Table 8. Evolution of maize seed price

REGIME	SOCIAL REGIME		LIBERAL REGIME	
	BEFORE LIBERALIZATION	AFTER LIBERALIZATION		
Years	1980-1995	1996-1999	2000-2011	1980-2011
Growth rate (%)	0.28	-0.78	-3.16	-0.89
Coefficient of variation (%)	2.5	1.07	12.68	7.89

Source: MA/DA/SAED, 2012

5.4 Direct subsidy on seed prices

Direct subsidies on seeds were always included in Senegalese agricultural policies in order to support lower income farmers and enhance agricultural production. In the literature, policies makers qualified the level of subvention which was around 50% of suppliers' price since long time ago, as a modest subvention of the government in agricultural production improvement. However, this pillar of crop production has been continuously in rise, due to many factors like the successive agricultural campaigns, short rainy season, locus invasion and other random elements.

Table 9. Evolution of maize and rice seed subsidy

Years	Seed nature	products	Suppliers price (A) (FCFA / Kg)	Producers price(B) (FCFA / Kg)	Subsidy (%) (1 – B/A)*100
2008	SEED PRICES	Rice	-	145	-
		Maize	600	180	70
2009		Rice	475	100	79
		Maize	600	180	70
2010		Rice	475	100	79
		Maize	600	125	79
2011		Rice	-	103	-
		Maize	375	125	67
2012		Rice	-	-	-
		Maize	425	125	71
2008	HYBRID SEED PRICES	Rice	-	-	-
		Maize	3500	1050	70
2009		Rice	-	-	-
		Maize	3500	1050	70
2010		Rice	-	-	-
		Maize	3500	1050	70
2011		Rice	-	-	-
		Maize	3350	500	85

Note: FCFA, CFA franc is a monetary unit used in West Africa and FCFA 1 = $ 501.312

Source: MA/DA, 2012

5.5 Direct subsidy on fertilizers prices

Fertilizer subsidy policy was adopted to improve crop yield and quality. But despite all government efforts there is still a long way to go, because of some attitudes displayed by farmers. For that in order to get subsidized fertilizers at a minimum of 50% discount, farmers have to show documents justifying their ownership of the land in order to get the quantity of fertilizers related to their farming acreage. Indeed, when the period of fertilizers distribution coincide with the welding period, farmers sell them on the black markets of neighboring countries or to non eligible producers (agribusiness men) instead of using their seeds and fertilizers which the government provided them.,. Moreover, even many campaigns have been carried out by authorities on the respect of standards norm of fertilizers utilization, for a better and higher quality as well as high yield in areas of production; some farmers are still not using required norms. Sometime, after getting the necessary quantity for their fields, some use too much fertilizer, caused overdose by one application instead of twice.

Table 10. Price evolution of subsidized fertilizers

Formula / Years	NPK 18-46-0 (FCFA / Kg)	NPK 9-23-30 (FCFA / Kg)	NPK 15-15-15(FCFA/Kg)	Urea (FCFA / Kg)	Subsidy level (%)
2005	205	196	157	250	50
2006	216	221	195	250	50
2007	378	262.7	270	256.3	50
2008	398	420	380	280	50
2009	205	398	340.466	260	50
2010	245	437.8	374.512	286	50
2011	250	437.8	374.5	286	50
2012	255	412	362.25	385	
2012 Subsidy	50%	52.43%	55.83%	68.83%	

Note: FCFA, CFA franc is a monetary unit used in West Africa and FCFA 1 = $ 501.312

Source: MA/DA/SAED, 2012

5.6 Empirical analysis

5.6.1 Model

The production function defines the relationship between the output and used inputs for its realization. Used inputs act directly on production, except for those due to random shocks which are highly over farmers' control. The implemented model relies on stochastic frontier production function with focus on subsidized seed price and producers' price. The frontier production function model is based on efficient stochastic model which is increasingly in use in farmers' efficiency analysis since 1977 with Aigner, Lovell & Schmidt, and Meeusen &

Broeck research results.

$$(1) \quad Y_{it} = f((X_{itn}, \beta)\, e_{it}(u_{it}, v_{it})) + \alpha_{1it}P_{Farmit} + \alpha_{2it}P_{Seedit},$$

where:

$f((X_{itn}, \beta)\, \varepsilon_{it}(u_{it}, v_{it}))$: Cobb-Douglas function

i: rice or maize production (i= 1 or 2),

t: time (yearly observation starting from 1980 to 2011),

Y_{it}: rice or maize production at time t in ton,

X: vector of input (land (ha), fertilizers (ton), seed (ton), labor (person), investment (FCFA)),

P_{Farmit} : rice and maize producer price at time t (yearly farmer price),

P_{Seedit} : rice and maize seed price at time t (yearly seed price),

β: parameters to be estimated,

n: number of parameters

$e_{it} = u_{it} + v_{it}$ stochastic disturbance error term consisting of two independents error terms,

v: a symmetric component randomness error term which accounts for random variation in output due to factors outside farmers' control, such as weather and disease. It is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$,

u: one-sided component, where $u \leq 0$ reflects technical inefficiency relative to the stochastic frontier, $f(X; \beta)\exp(e)$.

Then $u = 0$ for a farm output which lies on the frontier production and $u < 0$ for one whose output is below the frontier production function at an individual level. U is independently and identically distributed and is a half-normal distribution function.

This approach has an advantage as it accounts for the presence of measurement error

in the specification and the estimation of parameters of the production function. The stochastic frontier function differs from the traditional production function. For that, the former consists of two error terms (u and v). The first error term (u) accounts for the existence of technical efficiency and the second accounts for factors such as measurement error in the output variable, weather and combined effects of unobserved inputs on the production.

To ease the procedure of estimation, the frontier production function will be estimated under its logarithm form. Then the function (1) becomes:

$$(2)\quad \ln Y_{it} = \beta_{0i} + \beta_{1i}\ln land_{it} + \beta_{2i}\ln lab_{it} + \beta_{3i}\ln fert_{it} + \beta_{4i}\ln seed_{it} + \beta_{5i}\ln inves_{it} + \alpha_{1i}\ln P_{Farmit} + \alpha_{2i}\ln P_{Seedit} + e_{it}$$

The annual amount of investment in rice and maize production is expected to include the amount of land layout and direct investment in rice and maize sectors. However, there are many amalgams and contractions in the amount of layout per hectare between service providers of private and public sectors, mainly between public policies makers and agricultural actors. Indeed main of land layout are make by private or semi-public foreign companies and prices vary between 3,000,000 FCFA/ha to 5,000,000 FCFA/ha according to agents of agricultural sector. Furthermore, the government bills in land preparation are always calculated on the base of the last amount which is very expensive in the opinion of many regulators of efficient agricultural production. For that agronomists think that land preparation service should be given to Asian service providers (China, Thai and Japan) instead of European and American companies as their provision of services are cheapest with

the higher local labor hiring level. Then, because of imprecise details on the amount of land effectively concerned (improved land), the layout amount is excluded for efficient estimation of parameters.

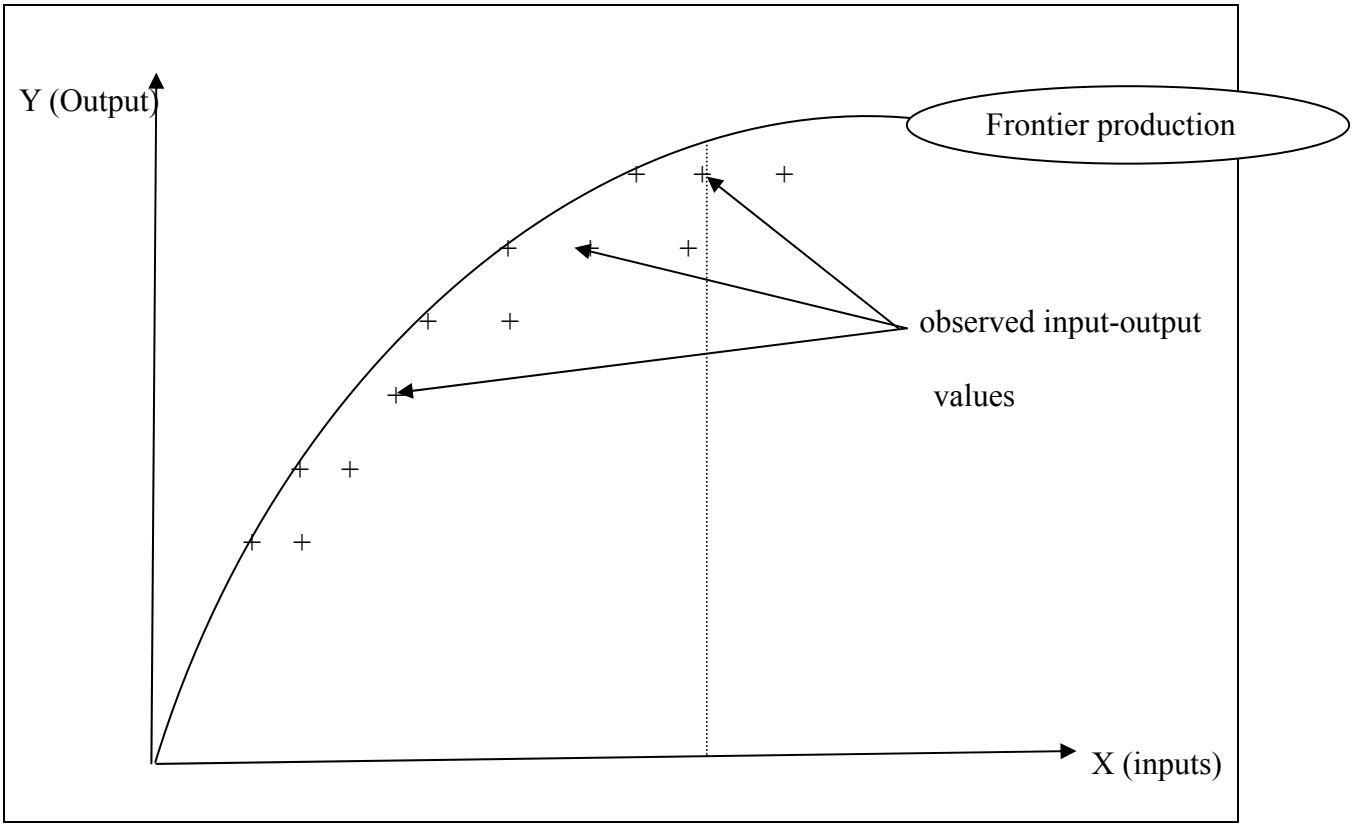
The seeds price is a subsidized price which is determined by the government and there is also no detail on seed varieties. The level of the subsidy varies considerable among years from 50% to over 75% per year based on socio-economic conditions of each year. Thus, as direct investment on agricultural production incitement, subsidized seed prices will be used in the model instead of suppliers' prices. Then the model becomes:

(3) $\ln Y_{it} = \beta_{0i} + \beta_{1i}\ln land_{it} + \beta_{2i}\ln lab_{it} + \beta_{3i}\ln fert_{it} + \beta_{4i}\ln seed_{it} + \alpha_{1i}\ln P_{Farmit} + \alpha_{2i}\ln P'_{Seedit} + e_{it}$,

where P'_{seedit} is subsidized price of rice and maize seed.

If there was more detail on collected data, for example age, gender, credit accessibility, schooling...etc, their technical efficiency could be tested to determine their impacts on rice and maize production in Senegal River Valley. The Figure 11 shows stochastic production function structure.

Figure 11. Stochastic frontier production



Below the stochastic frontier production line, the inefficient error term (u) is inferior to zero. And the variance of the model σ^2 and the ratio of the two standard errors are given by:

(4) $\sigma^2 = \sigma_u^2 + \sigma_v^2$

(5) $\lambda = \sigma_u / \sigma_v$

And if there is more information on different farmers in rice and maize production in Senegal River Valley, farmers efficiency at the individual level can be obtained from the error term ε which is given by the sum of the two error terms of the model ($\varepsilon = u + v$) and the technical efficiency of each farm can be evaluated as follow:

(6) TE = Exp (E(u/ε)) where $E(u/\varepsilon) = (\sigma_u \sigma_v) / \sigma$

5.6.2 Estimation results and discussions

5.6.2.1 The rice sector

Estimated coefficients of the stochastic frontier production function of rice in Senegal River Valley are represented in the above table. All the coefficients in the model have expected priori signs except the seed factor (lnseed). Estimates are all significant at 1% level of significance. This level of significance confirms their huge impact in rice production.

Table 11. Maximum likelihood estimates of parameters of the stochastic frontier production of rice

Variables	Descriptions	Parameters	Coefficients	St. errors
Cons	Constant	β_{10}	3.2762***	0.0002
lnland	Log of land	β_{11}	.7785***	0.0001
Lnlab	Log of labor	β_{12}	.0004***	3.83e-06
lnfert	Log of fertilizers	β_{13}	.2258***	0.0001
lnseed	Log of seed	β_{14}	-.0619***	0.0000
Lnpf	Log of producer price	α_{11}	.0619***	0.000
Lnps	Log of seed price	α_{12}	-.2059***	0.000
sigma_v			7.38e-09	1.54e-06
sigma_u			.2861	.0357
Log likelihood = 16.8167				

*** 1% level of significance

The 0.7785 elasticity of land implies that a 1 percent increase in cultivated land area, while holding all other factors fixed would lead to an increase of 0.7785 percent in the output of rice and vice versa . This suggests that land is a significant factor associated with changes in rice output. Same positive impact is also observed in labor and fertilizers inputs. Then an increase of 1percent of their quantity, while holding fixed all other factors would increase rice output by 0.004 and 0.2258 percent respectively and vice versa.

Contrary to the expected result, production elasticity with respect to seed factor input is negative. This significance of seed in rice production for example diverts from the fact that seed, more precisely its quality, is an important factor in rice yield improvement. Indeed, improved and certified seed use provides better quality of output than withheld seeds. However as farmers are almost low income producers, there is a tendency to withhold seed from present crop year for the next one. This negative estimated coefficient may refer to a high quantity use of uncertified seeds which is usually frequent in subsistence rice farming. Then 1 percent increase in seed quantity while holding fixed all other factors would decrease rice output by 0.0619 percent and vice versus.

For producer price and subsidized seed price, their elasticity's to the production are respectively positive and negative like expected. It means that an increase (decrease) of 1 percent of producer price (subsidized seed price) while holding fixed all other factors would increase rice output by 0.0619 percent (0.2059percent) and vice versus.

5.6.2.2 The maize sector

Estimated coefficients of the stochastic frontier production function of maize in Senegal River Valley are represented in the above table. The model coefficients do not have expected

priori signs. Among them only seed factor and producer price are significant respectively at 5% and 1% level of significance.

Table 12. Maximum likelihood estimates of the stochastic frontier production function of maize

Variables	Descriptions	Parameters	Coefficients	St errors
Cons	Constant	β_0	-7.5751	28.4374
lnland	Log of land	β_1	-6.8846	23.829
Lnlab	Log of labor	β_2	6.6417	22.8712
lnfert	Log of fertilizers	β_3	1.0155	2.8469
lnseed	Log of seed	β_4	.5641**	.2295
Lnpf	Log of producer price	α_1	.4243***	.0869
Lnps	Log of seed price	α_2	-.05454	.2384
sigma_v			.0773	.0358
sigma_u			.1206	.0715
Log likelihood = 26.669552				

***1% level of significance; **5% level of significance

However, unlike in rice sector, maize production elasticity with respect to seed is positive like expected. This positive impact can be explained by the professionalization of maize production in Senegal River Valley. Therefore, its positive elasticity of 0.5641 involves that a 1 percent increase in its used quantity while holding fixed all other factors would increase maize output by 0.5641 percent and vice versa.

The coefficient of maize producer price is positive as expected. This suggests that, the increase of producer price will induce farmers to enhance their production to gain more income at the farm gate. Thus 1 percent increase in producer price of maize while holding fixed all other inputs would lead to an increase of 0.4243 percent in maize production and vice versa.

5.7 Conclusion

The analysis of rice and maize model shows that land factor is the higher factor associated with changes among inputs in rice sector. Contrary to the maize sector in Senegal River Valley, in rice sector all parameters influence positively rice output except the seed factor. The impact of seed in rice and maize production is negative and positive respectively in rice and maize farming as well as respectively significant at 1 percent and 5 percent level of significance. Then the quality of seed should be improved in order to use less quantity of high yielding seed by strengthening established seed policy. Due to seed production complexity and requirement, the production of certified and improved seed must be encouraged and supported for policy sustainability and efficiency.

Fertilizers utilization has a major impact on sustainable and improved crop production. But for better result it should be used efficiently by respecting recommended norms by hectare as well as by applying them at real-time. Then subsidized fertilizers must be distributed on time to producers.

In rice sector, the estimate of labor input factor is positive and statistically significant at 1%. But its value is approximately nil. Therefore farmers training should be reinforced to increase their skill. And as young rural people desert rural areas to cities, sustainable policy

for young reverse to agriculture should be implemented to slow down rural exodus as well as to build up a strong and skilled labor.

Production elasticity with respect to producer prices (rice and maize) and subsidized price of seed (rice) show that they are main factors of output improvement. Then, even though producers can sold sometimes their output in daily or weekly markets at a price higher than the guaranteed price of the government, leaders should set up more incentive price to motivate farmers to increase their productions.

Thus, according the results of analysis of rice and maize models, we can say that food sufficiency in rice is reachable in Senegal if all necessary conditions are gathering. Leaders and farmers should seize these two crops opportunities, huge comparative advantages, to boost efficiently and sustainably rice and maize production in the extent of the country. Then in order to solve the country huge dependency on rice and maize imports and match the increasing demand of the population to the domestic production, it must have an efficient use of inputs and more appropriate measures to incentive and sustain crop production. Furthermore with an ascendant population growth rate which is combined to a rapid urbanization, agriculture intensification is imperative to satisfy the local demand. For that, priorities should be made on efficient use of inputs (mainly for fertilizers and improved seeds), plant protection and activities mechanization. And as Senegal River Valley area is suitable to double crop due to the availability of water along year, irrigation systems must be also improved and generalized for continual crop production in order to increase farmers' income and reverse people toward land cultivation.

VI. MARKETS, COMPETITIVENESS OF RICE AND MAIZE ANALYSIS AND EMPIRICAL IMPACTS OF PRICE POLICIES

6.1 Introduction

Right after its independence, Senegal promoted and developed from upstream to downstream public and semi-public institutions of agricultural production to enhance agricultural production. In the early years of its sovereignty, Senegalese economy had experimented contrasting trends. It was characterized by a prosperous period of five consecutive years of strong growth. And in order to strengthen and sustain agricultural performance, the National Office of Cooperation and Assistance for Development (ONCAD) was created in 1968 for the purpose of reorganizing and merging the existing institutions. The National Office of Cooperation and Assistance for Development controlled all agricultural cooperatives and had a general commercial monopoly on agricultural products. This trend continued till 1970s with the intervention of foreign lenders and the promotion of large projects of development which were managed by semi-public (para-public) companies.

Nonetheless, the end of 70s was characterized by the stagnation of domestic agricultural production, the degradation of internal finances as well as the external debt increase. This period marked the beginning of the implementation of the stabilization policy in 1978. And under the World Bank instructions follow up, 1980 years were dominated by the withdrawal idea of the government. At the beginning of the concept of government withdrawal, authorities were very enthusiastic about the idea of the liberalization in order to alleviate government charges. Indeed, the general economic conditions and agricultural conditions in particular were characterized by severe reducing in available resources of

supporting government spending. One of the first effects of government austerity was ONCAD suppression in 1980 because of the considerable debts of cooperatives under its charge. But the severity of the situation persisted in the main leviers of the economy (MEF) such as: the GDP growth rate in real term was 2.1% and lower than the population growth rate (2.7%); Very high rate of final consumption (exceeding 100%); Investment rate relatively low (around 15%); Huge budget deficit (representing nearly 12% of the GDP with workers salaries (payroll) absorbing over 50% of the current revenue); Heavy external debt representing 32% of exports in 1979/80; Unbearable trade deficit (FCFA 125 billion in 1981) and High inflation due to oil crisis and expansionary policies of credit.

Thereby, the stabilization reform was followed by the implementation of the Economic and Financial Recovery Plan and the Short and Long term Structural Adjustment Program from 1985 to 1992. Thereafter, the change of CFA currency parity in 1994, the changing was immediately followed by the signature of an arrangement with the International Monetary Fund. It turned into to a three-year agreement to facilitate the implementation of the Structural Adjustment Program. And since 2000 years, many programs and projects have been run to adapt Senegalese agriculture to the permanent international changes.

6.2. Price stabilization and price liberalization policies

There were generally two steps in the reform of economic policies which led to the structural adjustment. The first step was related to the stabilization of the economy in order to lead to a better balance of main national accounts. The stabilization program was followed by a so-called Structural Adjustment program for a sustainable economic growth. These two steps corresponded to two different types of programs; short term stabilization (one to three years)

and a long term programs (over three years) of the Structural Adjustment programs. The difference in targeted objectives (short and long term objectives) led also to the stabilization programs building by acting more on money supply and demand, while oriented Adjustment Programs more towards supply and production of goods.

6.2.1 Price stabilization policy

Before the liberalization of the agricultural sector, pricing policies were widely used in agriculture. Those pricing policies were interventionist as well as priority instruments of the government to incentive agricultural production and to shape the social and economic development of the country. Beyond the protectionist appearance, the ultimate goal of those measures was to bring the official exchange rate to its real equilibrium level and redistribute income between the various economic operators, particularly in the public sector. For that, four options of responses were implemented: tariff barriers, non-tariff barriers (or quotas), pricing policies and macroeconomic internal barriers.

In 1980's those regulation concerned mainly the rice sector because the imported maize was not very important comparing to the rice weight in cereal import balance. Policy makers and regulators were more stressed by the country increasing dependency on rice import and the high preference that Senegalese attributed to the imported rice. The main strategies used to stabilize price involved (Henner, 1996):

① Internal imbalance correction (between expenditures and consumption, investments and savings),

② Tax revenues increasing: necessary in public expenditures recovery;

③ Public spending reduction and

④ External imbalance correction: imports regulation and exports improvement as well as cash flows (outflows and inflows) regulation.

6.2.1.1 Tariff barriers

These trade restrictions were in force before the liberalization of agricultural markets and focused on variable taxes (MT) to limit the quantities of broken imported rice to encourage local production. At the national level, these restrictions relied on the payment of implicit tax by imported rice consumers as well as an implicit subsidy to cereal producers mainly rice farmers and the creation of reliable source of revenue for the treasury to support investment in agricultural sector. And, like in general in a well structured system this politic was accompanied by a policy of exports promotion.

In the practice this policy was hampered by the unavailability of funds, equipments, knowledge and skills of efficient and sustainable agricultural production. Indeed, exports promotion could be achieved by dumping, which is in practice by some Asian and Eastern European countries. But these practices are not acceptable in the "Washington Institutions" and do not belong to the "black box" politically correct instruments of economic policy (World Bank).

6.2.1.2 Non-tariff barriers

These trade restrictions relied on dictated quantitative restrictions on the maximum quantity of rice which was tolerated to be imported. Presumably, the considered superfluous goods by

policies makers and regulators were virtually impossible to import, while allocated available reserves to the purchase of inputs for domestic production and other indispensable foods for the survival of the population. Before the dissolution of the Funds of price Equalization and stabilization (CPSP: caisse de Péréquation et de Stabilisation des Prix), CPSP granted quota on imports of 340,000 tons per year in rice: 280 000 tons of broken rice, 20 000 tons of whole grain and 40 000 tons of intermediate rice. The CPSP had the monopoly on broken rice import.

Before the liberalization of the agricultural sector, the government bought the entire paddy from farmers without any regardless on quality and replaced it in markets through the CPSP. This system allowed a total sale of the local rice production (the CPSP acting as distributor) and prices were set by the government. If by that mechanism, local production was protected, consumers were taxed indirectly trough imported rice price. In addition, it should be noted that non-tariff barriers are more discriminatory trade than tariff barriers insofar as they allow benefits to quotas beneficiaries through a supplementary pension. However as import authorizations were not distributed according to the economy needs but on other criteria, quotas involved an additional cost of production. This cost increase therefore led to price competitiveness reduction for firms using imported inputs, or even to a complete inability to produce when spare parts, inputs, or machinery shortage become an absolute constraint.

6.2.1.3 Macroeconomic pricing policies

Macroeconomic pricing policies have been used for long time by the government in its guidelines in agricultural sector to modulate policies. These restrictions which are related to

exchange, interest and inflation rates resulted from a set of internal forces of economical operation. Indeed exchange rates have a direct impact on different economic agents to incentive productions or exports. For that, the government motivated financial institutes to apply incentive interest rates in agricultural input loan to encourage agriculture intensification, mechanization as well as efficient fertilizers, pesticides and insecticides use. Due to that, policy makers and regulators worked also in symbiosis with agents of development to achieve designed objectives. The inflation by cons permitted to regulate shocks induced by the increasing prices of products in the market via the government social balance policy. But the government did not apply the increasing price of some cereals through the CPSP and made prices more accessible to vulnerable people, mainly in rice marketing.

6.2.1.4 Internal barriers

Internal barriers are some forms of interventions adopted by the public sector to regulate consumers, producers and wholesalers prices. Regarding consumers prices, from 1991 to 1993 broken rice prices were fixed by the government regardless to transport subsidies. Differences in prices mainly in cereal, at the regional level were related only to products transport cost inside the country.

Those barriers were held to support consumers in their main staples while improving local production mainly in agricultural sector. In maize sector as preference is given to the local one, the concern was more present in rice pricing. And this pricing policy had to incentive local rice production and consumption.

6.2.2 Price liberalization policy

During 1980's, the government and its partners of development realized the failure of all previous policies which were judged too interventionist. Indeed, strategic policies designed for food security and self-sufficiency led to the failure of public agencies in charge of agricultural production as well as to a dual market development. The dual market was and is composed by a narrow administered market and an ample private market which was and is however fragmented and less efficient. These dysfunctions contributed to agricultural production stagnation and food imports growth in order to satisfy the domestic demand.

The examination of agricultural policy led to a complete liberalization of agricultural sector in 1996 and to the implementation of sub-regional communal integration policies in 2001. The total liberalization of agricultural sector came from a work of several years in collaboration with various financial partners of development and was named Structural Adjustment policies of Agricultural Sector. At its implementation, it led to the government withdrawal in agricultural sector. The government withdrawal in the agricultural sector entailed the abolition of subsidies on goods transport (mainly in imported rice). The administrated prices were also suppressed in 1995. And the disappearance of the CPSP involved a full liberalization of rice imports in February 1996. This government withdrawal was in effect at that period in agricultural production, agricultural products processing and domestic crops marketing as well as in the distribution of imported cereals (rice, maize, wheat). Imports were therefore only subject to customs and port duties payment. And normally tax benefits had to be orientated toward the support of local producers and in researches to enhance and sustain the local production. The market liberalization relied on some principles and was accompanied by many measures:

① Real price policy,

② Competitiveness improvement,

③ Infrastructures improvement and building as well as

④ Sub regional cooperation.

In 2001 the trade regime was characterized by:

① An average tariff rate of 14%,

② Around 7% to 18% dispersion tariff rate,

③ 42% tariff picks,

④ Quotas and licenses on import suppression,

⑤ No taxes and subsidies on exports and

⑥ The decrease of customs clearance duration period.

Taxes on international trade accounted about 22% of the government revenue in 1998 (MEF) and tariffs as well as import surcharges constituted the only significant trade barriers. In the context of the Sectional Adjustment Program for competitiveness, the government eliminated prior authorization imports of certain products that hampered the production improvement of their local homologue. Furthermore, national strategies for agricultural liberalization were strengthened by regional and WTO agreements on agriculture and ACP-EU relation principles.

6.3 Common trade liberalization and regional integration policies

6.3.1 Regional agreements

6.3.1.1 West African Economic and Monetary Union (WAEMU)

West African Economic and Monetary Union adopted a convergence, sustainable growth as well as a solidarity pact to harmonize macroeconomic and sectional policies. Policies included agricultural policies as well as tax laws of different member countries of WAEMU. It aimed also to regulate the flow of goods and services within the Community. WAEMU Agricultural policy (UAP) was designed to satisfy population needs in food, to promote social and economic development of member countries and to reduce poverty. The general objectives of the UAP included:

① The achievement of food security by reducing food dependency and improving the marketing systems of agricultural products,

② The improvement of producers living conditions through rural economy development and their social status as well as income enhancement and

③ Productivity improvement and sustainable agricultural production.

Due to that, WAEMU established an External Common Tax (TEC) which was completed by a policy of protection against unfair competition (Cyclical Tax on Import and reference values). Nonetheless, TEC is still less efficient. And agricultural sector has been affected by the harmonization of tax policies. That harmonization permitted the convergence of mechanism of taxation and equal treatment between all economic operators of the country.

Agricultural equipments and inputs were subject to 18% AVT (added value tax) and unprocessed agricultural products were exempt from added value tax. However, a paradox

remained because unlike other economic actors' farmers did not have a way to recover AVT and were then unfairly penalized.

6.3.1.2 Economic Community of West African States (ECOWAS)

The Economic Community of West African States (ECOWAS) modeled on European Economic Community (EEC) aimed to harmonize markets of its 16 member countries. The principle of free movement of goods, services and people allow them to trade by consensus agreement on communities' port duties. Nevertheless it was clear that this principle was strongly penalized by erected taxes of different members. And ECOWAS members' technical and trade dependency led to the development of strategies in order to harmonize their policies. Since its inception, ECOWAS aimed also to establish a monetary union in the image of WAEMU customs union.

6.3.1.3 Africa-Caribbean-Pacific –European-Union (ACP-EU) relations

Relations between the European Union (EU) and African, Caribbean and Pacific (ACP) countries were created in order to straighten ACP developing countries' economies by incentivizing their local production. Indeed ACP countries are exonerated from taxes on imports toward EU countries. The Lome (1975) and Cotonou (2000) conventions devoted an expansion of trade and economic partnership in a political cooperation. Today, these relations have evolved toward to the conclusions of economic partnership agreements which are based on a principle of free trade and reciprocity.

6.3.2 WTO agreements on agriculture

Agricultural products have been integrated in the conclusions of multilateral trading system rules which were adopted during Uruguay negotiations in 1994. Uruguay agreement on agriculture established disciplines and rules for WTO members in order to involve agricultural products in a more open world trade and service-oriented markets. These disciplines and rules focused on market accessibility, domestic support and subsidies on export. These mechanisms aimed to establish an equitable trading system based on market to correct and prevent restrictions as well as distortions in the international marketing of agricultural products.

Agreements on sanitary as well as phytosanitary measures and intellectual property rights on trade and trade technical barriers were some agreements related to agricultural products which were applied to ease the exchange flow of goods. However under the agreement on agriculture, African countries opportunities are limited by the liberalization measures adopted before the Uruguay meeting, mainly in the context of Structural Adjustment program on agriculture. These unilateral trade liberalization measures focused on tariffs reduction, input subsidies and price control elimination. And as it coincided with a context socio-economic less favorable, decisions application were lukewarm in Senegal. The taken decisions were not well prepared and very abrupt to rural people. Thus instead of improving farmers living conditions they worsened them. Furthermore, the majority of Sub-Saharan African countries as Senegal expressed less supports in agriculture to accompany agreements on green revolution measures. There was a little coherence and follow up on agriculture supports, including research, agricultural training and plants protection.

Moreover, if taxes exemption in specialized and differentiated treatments had to

allow developing countries to enjoy greater flexibility to support agricultural sector, only few countries have resorted to these provisions. As in most developing countries, in Senegal, almost of farmers have low income and needed inputs and investment subsidy to improve and sustain their productions. Then Senegal as the majority of sub-Saharan Africa countries opted ceiling tariff for rates consolidation. The government applied generally high and consistent tariffs rates in all imported agricultural products (30% to 150%) to incentive local production and support producers for sustainable agriculture.

These restrictive measures, only reserved to developing countries for greater flexibility on their policies management were held to ease their involvements in the Structural Adjustment Policies and Agricultural Sector Adjustment Program. However the common external tax level applied in WAEMU community limited the use of its advantages. Nevertheless Senegal agreements with WTO allowed the government to establish theoretically duties and taxes on imported agricultural products at levels rate up to 180%.

6.4 Rice and maize balance sheet analysis

Food security is a global preserving issue. Africa was and is experiencing a shortfall in production while facing a rapid population growth. In Senegal, local cereals marketing has a bright future according to their comparative advantages in production sided by research which led to a quality greatly improved, especially in terms of conservation, productivity and agricultural products nutritional components improvement. And according to the present state of the global and national economy, policy makers should focus on higher levels of productivity while working on the quality and quantity improvement as well as consumers requirements meeting.

Rice, millet, sorghum and maize are successively the main staple of households in Senegal. Imported rice is daily consumed by a large majority of households, especially in urban areas and very highly in the capital, Dakar. The local traded rice is mainly produced in the Senegal River Valley and is generally consumed in its production area. And the largest market of Senegal River Valley rice is the Saint Louis market.

Maize, produced and consumed in areas around Kaolack, Tambacounda and in Senegal River Valley is highly appreciated by Senegalese contrarily to local rice, labeled as poor quality since many years go. And even though the quality is quit improved now, consumers complained about its cooking style as they are more familiar with the imported rice. Generally, the imported maize from the international market is used in poultry and agri-indystry activities. There is a strong demand of rice and maize in Touba and Dakar areas. And Senegal relies more on imports from international markets, especially for rice, rather than cross-border trade in cereal and other staples (dairy, meat, etc).

6.4.1 Rice sector

The availability of cereal decreased overall in Senegal, from 174 kg per capita in late 1980s to 162 kg in 2008 (Baris, 2009) because of production constraints, rural exodus and no appropriation of agricultural policies to food producers expectations. The official standard norm of 185 kg (FAO) per capita was reached in 1989/90 and 2003/20004 (World Bank) in Senegal, where 54% of the population lives with less than one dollar per day. The production of cereals changed little bit since agricultural sector liberalization despite all established policies to improve and sustain agricultural production. The domestic agricultural production covered just 39% of domestic consumption in 2007 (OFS, 2010). Then the share of imports

in food security has tended to increase, increasing thereby Senegal food dependency on imports.

Rice share in cereals consumption was 42% before 2000s and since its share is increasing annually and attained 50% of overall cereals consumption in 2008 with only 28.6% coverage of the local consumption in rice (OFS, 2010). In urban areas, the consumption in rice of households accounts about 54% of cereals consumption. However, in rural areas, one quarter of cereals consumption is comprised by rice which represents now two-thirds of food imports.

6.4.1.1 Self-sufficiency ratio of rice

The rate of self-sufficiency can be measured by the available supplies of domestic production. Thus it shows to what extent a country covers its needs of food by its own productive resources. More a country self-sufficiency ratio is high, more that country is close to it self-sufficiency. However, if a country exports a significant part of its production, its food-sufficiency (coverage) rate can be high. But nevertheless, it will depend heavily on imports. This situation occurs where local output quality is very high in developing countries like Senegal (peanut oil produced in Senegal). But this phenomenon is not generally the case of a country which exports very few quantities of its outputs.

The ratio of Senegal self-sufficiency in rice in 2011 is 22.3%. It means that local rice production covers only this percentage of the national demand. During 1990-2011 periods, Senegal self-sufficiency ratio in rice varied between 15.29% (2007) and 33.44% (1993). These ratios show and confirm the weakness of local rice production. Furthermore during the period 1990-1999 and 2000-2011, Senegal self-sufficiency in rice decreased respectively by

1.5% and 1.8%. And, in the overall period 1990-2011 it dwindled by 1.7%.

The ratio of rice self-sufficiency varies considerably from one year to another with an average of 24.47%. However in early 1990 years, the self-sufficiency ratio in rice was around 31% and it started decreasing progressively after the FCFA currency devaluation and the agricultural sector liberalization. This situation confirms the high volatility of rice production and the serious enough dependency of the county on imports. These imports are mainly from Asian countries which are Thailand, India and Philippine (ANSD). But there is a light amelioration during these two last years through government struggling in the improvement of rice production mainly in Senegal River valley and in the Basin of Anambé.

Table 13. Evolution of rice self-sufficiency ratio

	SOCIAL REGIME	LIBERAL REGIME	
PERIOD	1990-1999	2000-2011	1990-2011
GROWTH RATE	-1.5%	-1.8%	-1.7%

Source: FAO, 2012

6.4.1.2 Import dependency ratio of rice

The import dependency ratio measures the degree of dependency of Senegal on imported rice. Then it is the proportion of available supplies coming from imports. Generally Senegal has always covered its cereals demand since some years ago from imports especially in consumed rice and wheat.

A country is continually dependent on imports from other countries as long as its import dependency ration is high. In 2011, the import dependency ratio is around 77.7% due

to a high local demand and low domestic production in rice. Thus, more efforts should be focused in the improvement of rice production in order to satisfy the increasing demand of Senegal in rice.

From 1990 to 2011, rice import has increased by 3.7% while varying between 348,380 tons (1994) and 1,071,680 tons (2007) with an average of 642,982 tons. During the social (1990-1999) and liberal (2000-2011) regimes, rice import increased respectively by 5.4% and 3.1%. This last low percentage during the liberal regime can be related to REVA and GOANA programs in which some special projects were defined to enhance and boost local rice production in strategic areas (Anambé Basin and SRV) where rice is suitable to double. Senegal import dependency ratio in rice has increased by 0.62% and fluctuated in the period 1990-2011 between 66.56% (1993) and 84.71% (2007). This tendency of ascendant evolution of the country dependency accentuated from 2002 to 2011year with an average of 800,000 tons imported rice per year.

Table 14. Evolution of rice import dependency ratio

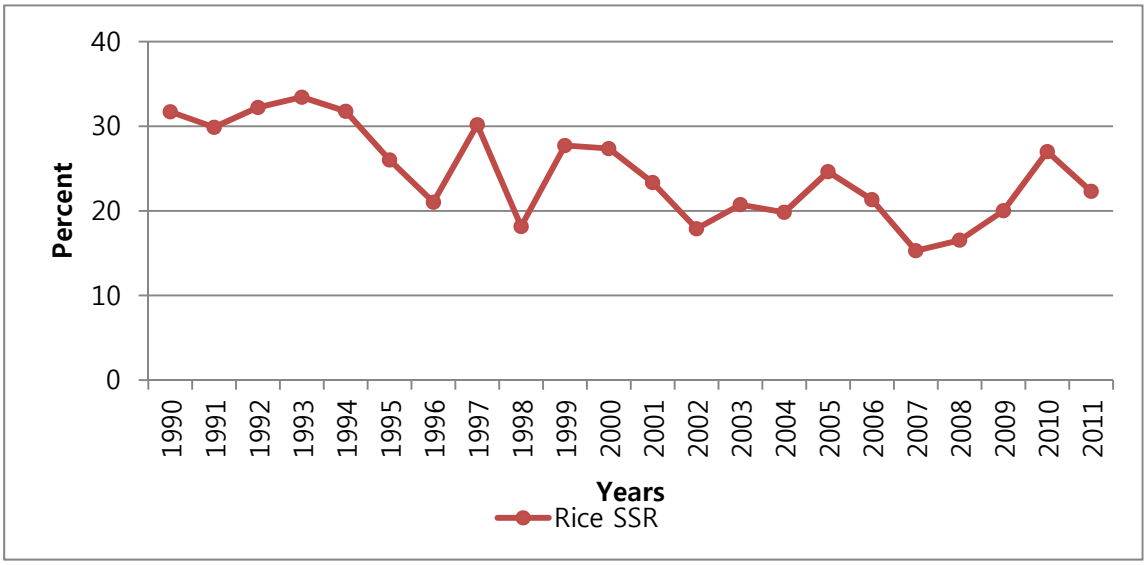
	SOCIAL REGIME	LIBERAL REGIME	
PERIOD	1990-1999	2000-2011	1990-2011
GROWTH RATE	0.63%	0.62%	0.62%
IMPORT GROWTH	5.4%	3.1%	3.2%

Source: FAO, 2012

The gap between rice import dependency and self-sufficiency ratios curves (Annex. 17) exhibits the vulnerability of the country in a context of international rice market which is

characterized by price soaring. It shows once again the much effort that Senegal, governments should make in agriculture to satisfy its domestic demand in rice.

Figure 12. Ratio of rice self-sufficiency



Source FAO, 2012

6.4.2 Maize sector

Maize is the second most produced cereal in the country after millet. Its production represents 22% of the national cereal production (Niang and Ndiaye, 2010) and it is produced in the entire territory of the country. The main producing and emerging regions are respectively Kolda, Kaolack and Tambacounda and is considered in these areas as traditional performed crop (MA/DA). These three areas alone produce 89% of harvested maize in Senegal. And the production repartition is as follow: Kolda (39%), Kaolack (29%) and Tambacounda (21%) (MA/ANSD, 2009). From 1990 to 2002, maize production was characterized by a low and quasi constant output with an average of 100,000 tons per year. But since the maize program,

initiated by the government, the annual output of maize improved considerably. Thus during the period 2003-2005, maize yearly production neighbored 400,000 tons per year. This output increase is related to policies of improved seeds and fertilizers distribution at real time. However, in 2006 and 2007 years, rainfall deficit dwindle the annual crop output under 50% of its previous level. But following the 2008 good rainfall and the Great Agricultural Offensive for Food and Abundance (GOANA) maize production enhanced significantly to 397,326 tons.

6.4.2.1 Self-sufficiency ratio of maize

Senegal self-sufficiency ratio in maize in 2010 was about 64.26% and is greater than the cereal one which was 50%. Then exception to the rice, maize production covers a high share of its local demand. The evolution of maize self-sufficiency ratio analysis from 1990 to 2010 shows that domestic maize output covers 74.13% of Senegalese maize demand in average. The higher ratio is observed in 1994 (93.11%) and the lower one in 1998 (37.47), which belong both to the social regime period. The period 1990-1996 registered the more important self-sufficiency rate with an average of 84.92%. And during the period 1990-2010, the self-sufficiency ratio of maize decreased by 1.6% due to the increasing domestic demand majored by infantine products and agri-industries as well as poultry emergence. During the social (1990-1999) and liberal regimes (2000-2010) maize self-sufficiency ratio decreased respectively by 2% and 1.3%. These results are different of Diallo and Sylla (2011) results who stipulated a ratio of 114% and 100% respectively in 2004 and 2009 due to maize programs positive effectiveness.

Table 15. Evolution of maize self-sufficiency ratio

	SOCIAL REGIME	LIBERAL REGIME	
PERIOD	1990-1999	2000-2010	1990-2010
GROWTH RATE	-2%	-1.3%	-1.6%

Source: FAO, 2012

6.4.2.2 Import dependency ratio of maize

In 2010, the import dependency ration of maize is about 35.74%, meaning that the domestic production has decreased comparing to the two previous years in which the dependency rate was respectively 20.9% (2008) and 26.3% (2009). From 1990 to 2010, imported maize increased by 9.8% between 8,000 (1994) tons and 117,121 tons (2009) with an average of 57,953 tons. In the social (1990-1999) and liberal (2000-2010) regimes maize imports increased respectively by 4.1% and 17.9%. This ascendant evolution of maize imports despite domestic production amelioration is due to urban livestock enhance mainly in poultry (Ndiaye, 2007). Indeed, imported maize is mainly consecrated to animals as for the direct consumption (human consumption) preference is given to domestic varieties.

Maize import dependency ratio increased by 6.2% in the period 2009-2010 with respectively in the social and liberal regimes 10.2% and 5.85%. It shows statistically that, liberal policies impacts on maize crop improvement were more effective than the social one's.

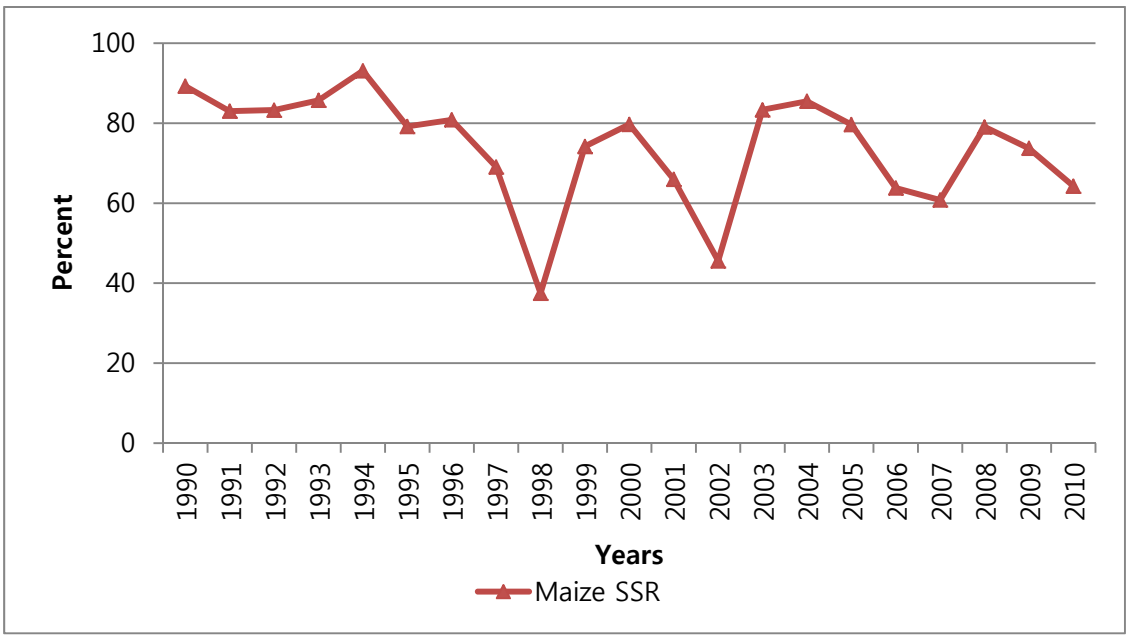
Table 16. Evolution of maize import dependency ratio

	SOCIAL REGIME	LIBERAL REGIME	
PERIOD	1990-1999	2000-2010	1990-2010
GROWTH RATE	10.2%	5.85%	6.2%
IMPORT GROWTH	4.1%	17.9%	9.8%

Source: FAO, 2012

In the annex number 18, we can see that the self-sufficiency curve of maize is strictly above the import dependency one except in 1998 and 2002 characterized by poor domestic production, 44,339 tons and 80,372 tons respectively. Then local production of maize covers nearly three four of the Senegalese demand.

Figure 13. Ratio of maize self-sufficiency ratio



Source: FAO, 2012

6.5 Markets analysis

Senegal imports almost all its entire main consumed staple in the country. This situation that jeopardized a stable accessibility of agricultural products is aggravated by the shortage and the weakness of the domestic production. Since 2006, there is a continued high bullish trend in cereal prices principally in rice, wheat and maize prices. The increasing prices of agricultural products in 2007 year and in the beginning of 2008 can be justified by an inflation rate of 5.9% (ANSD, 2009). Indeed, imported cereals prices increased by 19.25% in 2007 and by 92.25% in 2008. And for consumers, prices of unprocessed cereal increased by 16.7% in 2007 and 42.5% in early 2008. This phenomenon is not exceptional to Senegal only as rice price soaring was general in the world and had been explained by many economists as the fact of green gold emergence in main cereal producers' countries in order to overcome the increasing price of the black gold.

6.5.1 The system of distribution

Agricultural products are distributed under different systems according places (rural and urban areas) and the income level of population.

6.5.1.1 Supermarkets and groceries

Markets of big surface areas such as supermarkets, large grocery stores, some "price leader" stores and hospitals are significant niche of distribution. This circuit of distribution which is used for the distribution of products may give to the local rice and maize (mainly transformed) the opportunity to reach more solvent highest market share. Exhibited agricultural products are characterized by a positive image of reliability and quality. But, a limited share of the

population has the financial support to acquire them in those stores. On the other hand, payment terms, with delays up to sixty days involve essentially a good cash flow which is not always the case of small businesses that have difficulty of obtaining credit (OFS, 2008). However, the main handicap of these large surfaces is the difficulties of renewing their stocks and of ensuring a permanent availability of products in their stores, such difficulties represent the risk of their customers' loyalty. Indeed for the maize, most of their products are provided by organizations of women and other kind of organizations which have generally low fund and usually without credible guarantee to financial institutes.

6.5.1.2 Dynamic circuit of neighborhood shops

This circuit seems to be more appropriate to smaller producers. Some farmers, transformers and farmer-transformers rely on neighborhood organizations, including women's groups to promote their products. However this distribution system has some limits. It needs many trips to monitor actions and for following up the procurement of groups and shops throughout strategic areas. Neighborhood shops in rural areas distribute generally local and imported rice. However the percentage of transformed maize distributed at this level is very low.

6.5.1.3 Wholesaler circuit

They generally supply neighborhoods shops and this circuit is generally used by all units of producers and transformers. Conservation issues which are related to their very small scale and artisanal technical manufacturing as well as packaging lead sometime to wholesalers' withholding in marketing semi-final and final agricultural products. Indeed, they avoid damage of product if storage is prolonged. Entrepreneurs who want to increase their market

share have to follow this circuit as it can reach a large number of shops and therefore scattered consumers throughout urban areas. However before of embarking in this phase of growth, they must ensure that they will be able to ensure a steady supply and ensure that their products are sufficiently stable and well-protected.

The study of supply circuits in Dakar and secondary cities (MT and OFS) highlighted the existence of a range of craft activities related to the processing, preparation and distribution of agricultural products. This craft plays an important role in urban areas food supply. Beyond its nourishing function, this sector appears as a source of activity and income of a large segment of impoverished urban population, especially women.

The system of craft service provision is represented by small private entities located mainly in urban and extra-urban areas. In rural areas is represented mainly by milling activities. Such activities are most often held by men. Merchant craft system which is production and marketing of processing products under micro companies, mostly female, is represented by traditional activities in rural areas and snacks in urban areas.

There is some information about the improvement of cereals transformation in recent studies but they provide a little quantitative data in their analysis. However its importance is visible, especially in Dakar, as a source of income for poor families and as a response to a request of fresh transformed products or not essentially urban. Rural activities include also the production of maize couscous and “sankhal” (fine broken cereal) in the proximities of urban areas. And crafts merchant in city is represented mainly by husked maize, flour, semolina, couscous, and others (Broutin, July 2004).

6.5.2 Daily and weekly rural and urban markets

In this part of the chain of the distribution, it exits simultaneously wholesalers, semi-wholesalers and retailers. These markets are characterized by their huge varieties of products and affordable prices to customers. The liberalization of the Market sector p led to actors reframing along the chain of distribution. The development of this market segment is accompanied by the emergence of new semi-wholesalers actors named “bana-bana”, “baol-baol” and “coxeurs”. They usually ensure the interconnection between actors as well as between rural and urban markets. Their presence extended the chain of distribution in different markets. And their market behavior is determined by their favorite position and by their mastery of information. These new actors’ transactions are based on community sociability, values and norms. Their environment is characterized by the complementarity and interdependency between them and others actors. Thus, they have a direct influence on supply and agricultural products prices. Furthermore, there is no legal norm on prices and credits granted. Specific rates vary from case to case depending on the degree of belonging network.

The distribution chain of rice is relatively dominated by privileged relationship that exists between actors. This opacity between different actors (traders) makes the market very difficult to control and regulate by authorities. It turns out that the rice market is characterized by imports monopoly and a situation of cohesion along the network of distribution. These situations do not favor the market transparency as it distorts the rules of the market game. The main actors can by collusive influence the entire distribution chain. Then in order to regulate efficiently and sustainably imported rice market, there must be a smart and efficient intervention methods from rulers by taking account all different characters of the distributors.

6.6 Markets price statistics

Market volatility and prices soaring of international food, particularly for cereal, did not spared Senegal which imports 60 percent (ANSD, 2009) of its needed food. This overall situation is mainly due until June -July 2008 to an eventual rising speculation in oil prices which affected agricultural production sector, the strong demand in cereal for bio-fuels and the increasing demand of cereal in livestock in developed countries (mainly in USA and Europe for maize crop) as well as the increasing consumption in emerging countries (Brasilia, East part of Asia,...) and climate changes.

In Senegal, the high level of basic imported food prices hampered their accessibility, mainly for the rice which is the basic Senegalese staple. In late 2007 and early 2008 importers faced harsh difficulties due to the high volatility of food prices in the international markets, supply shortage and lack of available funds. Thus, to alleviate Senegalese daily charges, the government subsidized activities of rice importers in order to make prices more affordable to consumers.

6.6.1Tilene market

Tilene market is located in Dakar downtown and very close to the International port of Dakar. It is the main entrance point of imported agricultural products and the main source of supply of other regions of the country as well as most of Dakar region markets through Thiaroye market. Thiaroye market, at its turn ensures the supply of those of the suburbs areas where there is a large share of the population. Traders who are operating in Tilene market have sufficient storage facilities and direct contacts with the main importers. Prices in this market are generally relatively moderated.

Given the poor performance of 2007-2008 agricultural seasons, high energy costs which increased the cost of transport and the international rising of food prices, the monthly market prices of the ordinary imported broken rice fluctuated between 211 FCFA/kg and 256 FCFA/kg with an average of 238 FCFA/kg. For the maize, prices fluctuated between 165 FCFA/kg and 200 FCFA/kg for the imported maize and between 175 FCFA/kg and 200 FCFA/kg for the local one with an average of 182 FCFA/kg and 191 FCFA/kg respectively.

Many studies on consumer prices of imported broken rice, mainly the one of M. Ndiaye and M. Niang showed a quasi constant evolution rate between the FOB and consumer prices. Thus, in their study they found out a huge coefficient rate of correlation of 0.85 between these two prices in the period 200-2010. But the parallelism of price trends ended in 2008 with the event of financial crisis.

And since 2008 crisis which was characterized by a surge in food prices, particularly in imported rice among cereal in Senegal, an important disturbance was noted in prices behavior. From 2008, the FOB prices started soaring over and exceeded those of consumer prices of imported rice from April 2008. This situation is due to the direct (suspension of customs duties (10%)) and indirect subsidies applied by the government to support the purchasing power of consumers and to stabilize a social peace. But the speculative behavior of traders, led to the scarcity of subsidized imported rice and to an excessive increase of broken rice prices. However with the intervention of the government and the massive recovery of imports, consumer prices of imported broken rice declined significantly.

Figure 14. International (FOB) and consumer prices of rice in Dakar at Tilene market

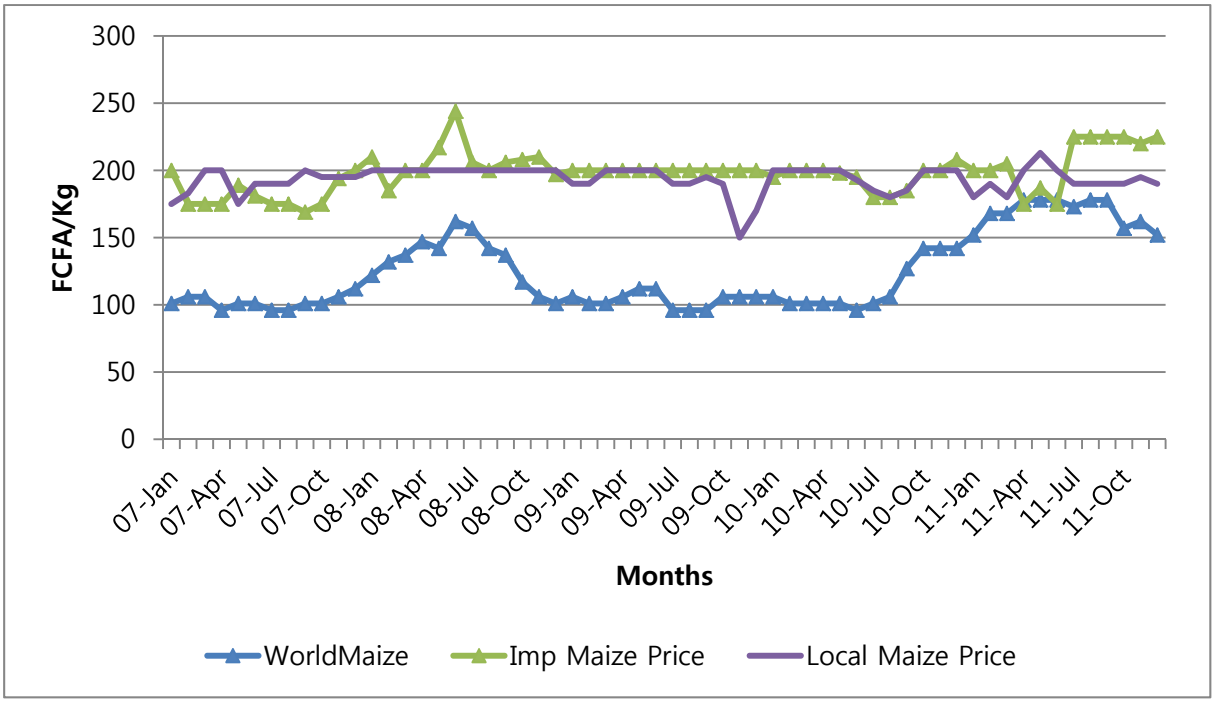
Source: OFS, 2012

This permanent presence of the government in the rice market in order to regulate it and to support population purchasing power induced to low correlation rate between international the FOB price and consumer prices in Senegal. Indeed, the period 2007-2011 was characterized by a weak rate of correlation relationship of 0.3189 between these two prices.

In the maize sector, consumer price of imported maize was less correlated to the FOB price from 2007 to 2011 with a rate of 0.4436 relationship and for the local one, the correlation relationship was very light (0.1633). Nonetheless, the 2008 crisis influenced shortly the price of imported maize due to the shortage of domestic production and the

development of urban livestock (poultry). But, the increase of the FOB price of maize at the end of 2010 and 2011 years did not also affect the local market prices because of the improvement of the domestic production.

Figure 15. International (FOB) and consumer prices of maize in Dakar at Tilene market



Source: OFS, 2012

Contrary to the rice sector, the domestic maize prices were and are less dependent on the FOB prices of imports. And imported maize as well as local maize prices are very weakly correlated (0.0209). This is due to the difference of purpose of their use by two groups of customers (direct consumption and animals feeding).

6.6.2 Senegal River Valley markets price statistics

Senegal River Valley is the only area where local rice and maize are present in the markets along the year and its biggest urban and rural markets are respectively Saint-Louis market and Mpal market.

6.6.2.1 Mpal Market

The rural market of Mpal is the major center of agricultural products (cereals, beans, onions...), and livestock trading. Large quantities of husked rice are sold in this local market and transferred after towards neighboring regions like Louga and Thies.

During 2007, local husked rice price fluctuated between 185 FCFA/kg and 232 FCFA/kg with a coefficient of variation of 7.13% with an increasing trend price. This price increase continued in 2008 until October and dropped down significantly during the two following months before restarted increasing again under the domino effects of government and traders actions. In 2008, local husked rice price fluctuated in the range 180FCFA/kg and 350 FCFA/kg with a coefficient of variation of 17.83%. Then price instability was less during the period of 2008 crisis. This price stability can be explained by price soaring of imported rice and its substitution to the local one.

During 2007-2011 periods, Mpal market is characterized by price instability of local husked rice, imported broken rice and local maize. This instability is justified by their low coefficients of variation which are respectively 12.95%, 13.52% and 18.22%. Furthermore, local husked rice price is highly correlated to the imported broken rice one and to the local maize one with 0.6174 and 0.6852 coefficients of correlation respectively. But the correlation between the local maize and imported broken rice is relatively weak (0.2567).

Figure 16. Local maize, local husked rice and imported broken rice consumer prices in the market of Mpal

Source: OFS, 2012

6.6.2.2 Saint-Louis market

Saint-Louis market is a large grouping market. The market of Saint-Louis is regularly well supplied both in local cereals (maize, millet, rice) and in imported cereal (maize, rice).

As the largest markets of Dakar, Tilene and Thiaroye, the market of Saint-Louis is endowed by important infrastructures of stock and conservation. It represents also a sub-regional exchange market with neighboring countries like Mauritania and Mali. And the

market capacities were reinforced by different projects of development initiated by the Organization for the development of Senegal River (OMVS) and SAED.

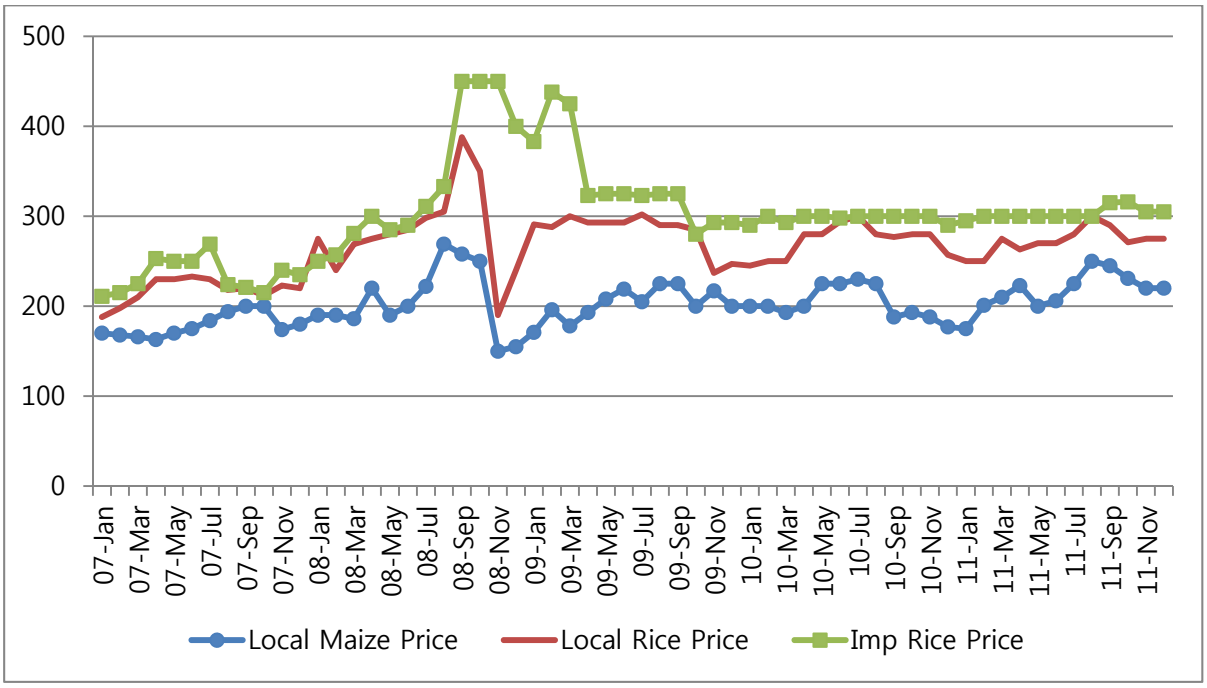
Market prices are relatively moderated in Saint-Louis market comparing to other inside regions of the country (Niang and Ndiaye, 2010). Ironically, prices of collected local husked rice in the urban market (Saint-Louis market) are similar to those practiced in the rural market (Mpal market). The market of Saint-Louis monthly prices in 2007 and 2008 oscillated in the range 188-233 FCFA/kg and 190-388 FCFA/kg respectively with coefficients of variation of 6.39% and 18.1% for the local husked rice. It shows then an aspect of price instability which is quasi identical in the two markets.

The quasi similarity of monthly prices of local husked rice between Saint-Louis market and the market of Mpal can be explained by the fact that Saint-Louis traders supply them self from localities throughout the Valley rather than in the rural market of Mpal or other reasons given the short distance between the two markets (35Km). Furthermore transportation costs are not so significant to generate significant margins. And M. Niang and M. Ndiaye research proved that Saint-Louis and Mpal markets are highly correlated with a coefficient relationship of 0.99.

From 2007 to 2009, Saint-Louis market as Mpal is characterized also by price instability for local husked rice, imported rice and local maize. These three cereals have coefficients of variation of 13.65%, 18.57% and 12.73% respectively. The correlation rate between local maize prices and imported broken rice in Saint-Louis market is similar to the one of Mpal market (0.2567) and shows that imported rice prices do not influence really the local maize one. However, the correlation rate between the two local crops is high (0.7025) and greater than the rural one. Moreover, the correlation relationship between the local

husked rice prices and imported broken rice prices is also important (0.6127).

Figure 17. Local husked rice, local maize and imported broken rice consumer prices in Saint-Louis market



Source: OFS, 2012

6.7 Local maize and rice competitiveness in Senegal River Valley

A product can be competitive if it its quality is improved sustainably overall its entire production. This quality notion depends on the perspective of the person to whom it is addressed whether than on producer, processor and trader. The qualification of quality of finished and semi-finished products by distributors (retailers, semi and wholesalers) relies on its well or better selling character.

A good quality product is a product which can be sold well or better, therefore a

product corresponding to consumers' desires. Nonetheless, the well to sell notion will depend on the quality-price ratio perceived by the final consumer. Then product competitiveness depends simultaneously on its price and quality. And higher the quality is, as perceived by the consumer; greater will be the consumer willing to pay, a significant price. But the consumer willingness to pay is within its reasonable limits defined by the level of it financial resources.

Generally a product with good quality can be sold quicker with a better price than a low quality product. According to the study done on SRV rice competitiveness (Baris, 2009), there is a 10% gap price between the imported rice (ordinary varieties) and local husked rice which is related to a difference of 40 FCFA /Kg between imported retail price and local paddy rice. But milled and sorted local rice price is comparable or just little bit below the imported price one. Then, orientations towards improved quality of rice and maize must be the first priority of all actors of these two sectors; producers, transporters, transformers and traders. And benefits of a better quality will be shared among all the country population through mutual satisfaction and higher willingness to pay to acquire desired finished product.

6.7.1 Quality definition

Quality of cereals (rice and maize) can be defined as something better or which has a good taste (according to the consumer taste), easy to cook and which gives the expected results after cooking, attractive (color, cleanness, shape (grading), smell, packaging) as well as a product which has a constant quality. It must also be easy to find permanently by consumers.

If for the local rice, scientists were and are researching on varieties improvement to achieve consumers' requirement in taste, for the maize, priorities rely on crop management and processing. The widely demanded rice varieties in Senegal are the broken aromatic ones.

As such, new short cycle (90 days) aromatic varieties appeared in Senegal (Sahel 328, Sahel 329 and Sahel 177) with a potential yield of 10 t/ha (SAED). And due to that for SCPRL, with the coexistence of preference of these new scented varieties and old unscented varieties, consumers must be differentiated by ecological zone for special production and farmers' specialization depending on their area demand specification. Then a system of Information must be conducted to assess preferences for different varieties (blind taste tests) in order to:

① Adjust production towards consumers preferred varieties and

② Orientate rice destination according differences on taste of different regions

The expected result of Cooking is closely related to the homogeneity of the product. A mixture of whole, large broken, medium broken and fine broken rice or maize is almost difficult to cook. It is less commercial to consider that Senegalese housewife must sort cereal before cooking especially when addressing to urban consumers. Therefore standardized products must be prioritized in terms of grain size. Urban consumers are accustomed to imported rice and there is less or significant difference in the methods of preparation between the local and imported rice. But, unfortunately, usually most Senegalese women demand explanatory notes for the local rice cooking style when they always adapt them self to all imported varieties.

The physical presentation of a product is often the most important point to attract new consumer. A good rice or maize must first be clean. This means no dust, no foreign elements such as rocks or weed seeds. Predominant urban housewife must not be constrained to wash much time in cereal cleaning before their preparation as is still often necessary.

Color is also an important factor to attract buyers. It must be completely uniform.

Dark grains (weed grain) and others grains having been harvested immature or fermented (stored too wet and / or too long) must be avoided.

Bad smell is often a prohibitive character that will remove the consumer from the trading product. For rice, grain shape seems less decisive in Senegal, where consumers is said to prefer the broken grain. Then broken grain must be well calibrated. Otherwise, this preference should not prevent research in markets niche, which can create large profitable volumes of exchanges (basmati (very fine whole rice), type rice risotto etc.).

The packaging may have a very important and attractive rule. It must first be beautiful and attractive. It must also show visibly, the rice or maize origin (SRV, Anambé, etc.) in order to retain consumer fidelity. There must be also other information such as the weight which must be respected as much as possible, the variety name, the type of grains (whole, big break, half broken, small broken) and other information if it exists as the product name, advocated cooking and even recipe proposal. Packaging should be adapted to urban consumers and eventually categorized in different types of packaging or weight.

Consistent quality is a key element for the gain of customer loyalty. If a consumer has enjoyed a product highly, that product should be easy to find by looking just the marking color or packaging and must certainly not be disappointed with a purchase that does not match with their expectations. If SRV rice satisfies this quality consistency it will have a comparative advantage over the imported one which qualities are not constant.

6.7.2 Rice production competitiveness

Local rice production competitiveness analysis relays on PRESOA 2011 results analysis (annex 3 and 4). According to PRESAO 2011, in Senegal, rice production is competitive at

0.75 level (lower than 1) with a high level of variation between concerned agro-ecological zones. Nonetheless, the local rice is weakly protected. It is financially profitable and receives an efficient production subsidy from the government.

The study reported a profitability of 75 FCFA/kg which producers can make. It is also economically profitable for the paddy with a return of 42 FCFA/kg. As a whole, the rice sector receives from the rest of the economy a net transfer of 33 FCFA/kg. It shows that rice production is favored by existing policies and confirms the government option which is seeking to promote local rice sector (see annex 3 and 4).

It seems more profitable and sustainable for Senegal to invest in local production than imported rice. And it will be possible if the government pursues the objectives of GOANA and the National Program for Self-Sufficiency in Rice (PNAR). However, it should be noted that the government cannot continue definitely its subsidy policy. Then this policy efficiency will depend on the level of the professionalism of producer organizations to support themselves, their own production after subsidies removal and to rehabilitate facilities (land improvement after some years of use).

The analysis by agro-ecological zone shows that rice sector in Delta River, Middle Valley and Anambé Basin are competitive except in the Upper Valley where labor factor is more rare and expensive. In view of results, the competitiveness of local rice in the Middle Valley (0.50) is higher than the Delta river (0.55) one which is followed by Anambé (0.83). These results show differentiated performance in rice production among different areas. Then rice production competitiveness increase requires several efforts: productivity and production increase (yield increase, extension of double cropping of rice), efficient production system (efficient use of input) and better remunerative, incentive prices.

6.7.3 Price competitiveness of the local rice and maize

The analysis of Price competitiveness will be done in two different areas: in Senegal River Valley for the local rice and in Dakar for imported rice according respectively to their market price and the level of production.

6.7.3.1 Local rice price competitiveness in SRV

The comparison of the local rice price and imported rice price can be done at a significant level in the region of Saint-Louis. Indeed, local rice consumption is very low or even quasi inexistent in the city of Dakar. Therefore, only the city of Saint-Louis can be considered for local rice price competitiveness because both grains, local and imported rice, are abundantly present along the year in Saint-Louis urban market.

Price comparison of these two cereals shows that local rice prices were always lower than those of the imported broken rice. And this is due to several reasons, including:

① The dietary habits of people who are mainly interested by imported broken rice (more than 95% of the population (ANSD, 2009)),

② Low production of local husked rice as well as its seasonality,

③ Low quality of the local rice compared to imported rice,

④ Limited area of marketing of the local husked (Senegal River Valley, Louga and Thies) and

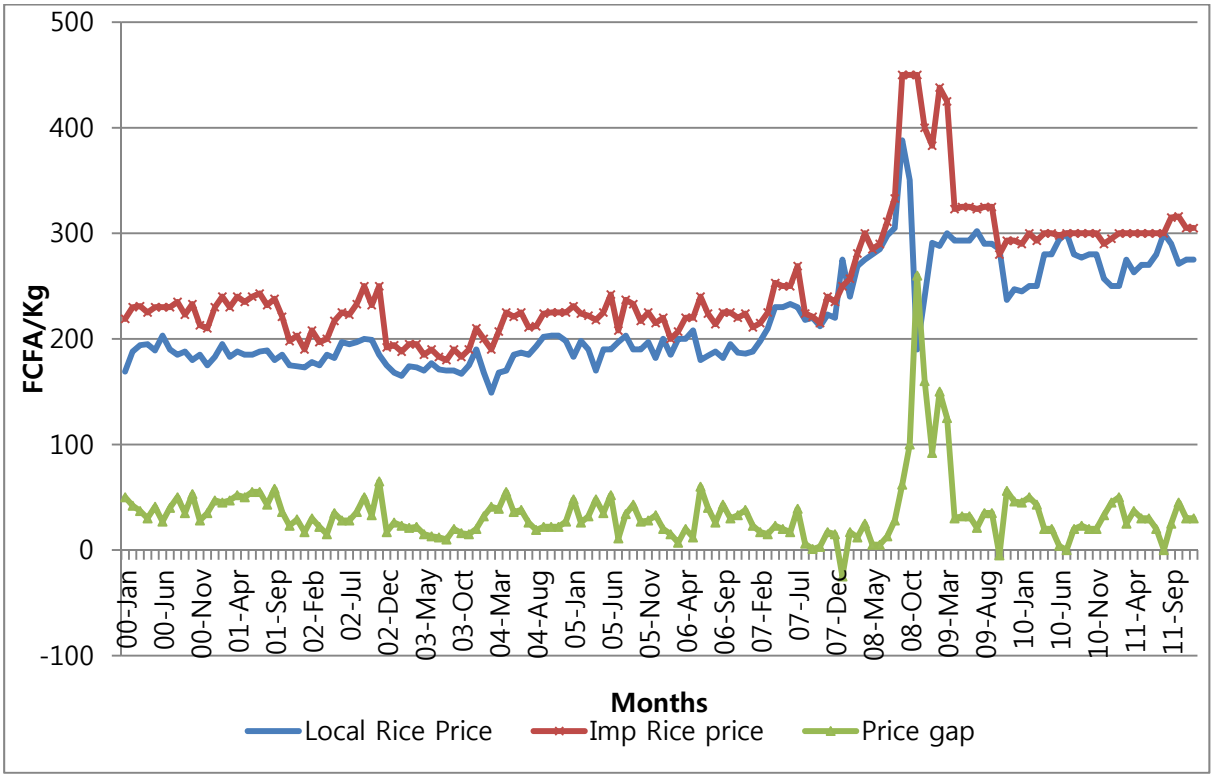
⑤ Increasing complex of the population towards local rice consumption: local rice consumption refers usually to a financial handicap (low income householders).

Thus, from 2000 until the end of 2007 year, monthly prices of local husked rice

fluctuated in the range of 149-233 FCFA/kg against 180-269 FCFA/kg for the imported broken rice. But since the beginning of the crisis in 2008 that has contributed greatly to overbid the price of imported rice, local husked rice was more valued. And with the domestic production boosting, the improvement of local husked rice as well as the high level of imported rice prices, local husked rice prices knew relatively high level values, while oscillating in the range of 240-298 FCFA/kg against 250-311 FCFA/kg for imported broken rice between January 2008 and July 2008. And the gap between prices was slightly moderated.

The graph below shows that in January 2008, local husked rice price exceeded the imported rice one by 25 FCFA/kg. However between August and October 2008 local rice price kept its increasing trend and the ascendant gap attaining 100 FCFA/kg in favor of imported one. Then even thought local rice monthly price improved significantly, price started increasing progressively and attained 260 FCFA and 160 FCFA/kg respectively in November and December 2008. This situation is due to the combined effect of imported rice traders speculation and the bad financial situation of producers which pushed them to pitch, dump their crops. But since April 2009, local rice price competiveness improved moderately and its prices fluctuated between 237 FCFA/kg and 302 FCFA/kg against 280 FCFA/kg and 325 FCFA/kg from there to December 2011.

Figure 18. Price comparison between imported broken rice and local husked rice



Source: OFS, 2012

6.7.3.2 Local maize price competitiveness in Tilene market

Maize production is far behind millet and rice and was mainly consumed by Tambacounda region, Kolda region and Kaolack region population. But since 2000, with the development of urban livestock (mainly poultry) and low cereal production, maize demand increased considerably. As the domestic production is deficient, demand satisfaction relies on imports like for the rice to meet the needs of human consumption, poultry and industries activities. Therefore maize marketing interested increasing number of private operators.

Comparison of prices since 2000 reveals that local maize price is higher than the imported one in the early years. And from March 2002 to October 2003 the price gap

fluctuated between 10 FCFA/kg and 44 FCFA/kg. There is also sometimes a quasi equality of prices between 2000 and 2011 with three main periods; December 2003 – May 2004, November 2005 – May 2006 and January 2010 – November 2010.

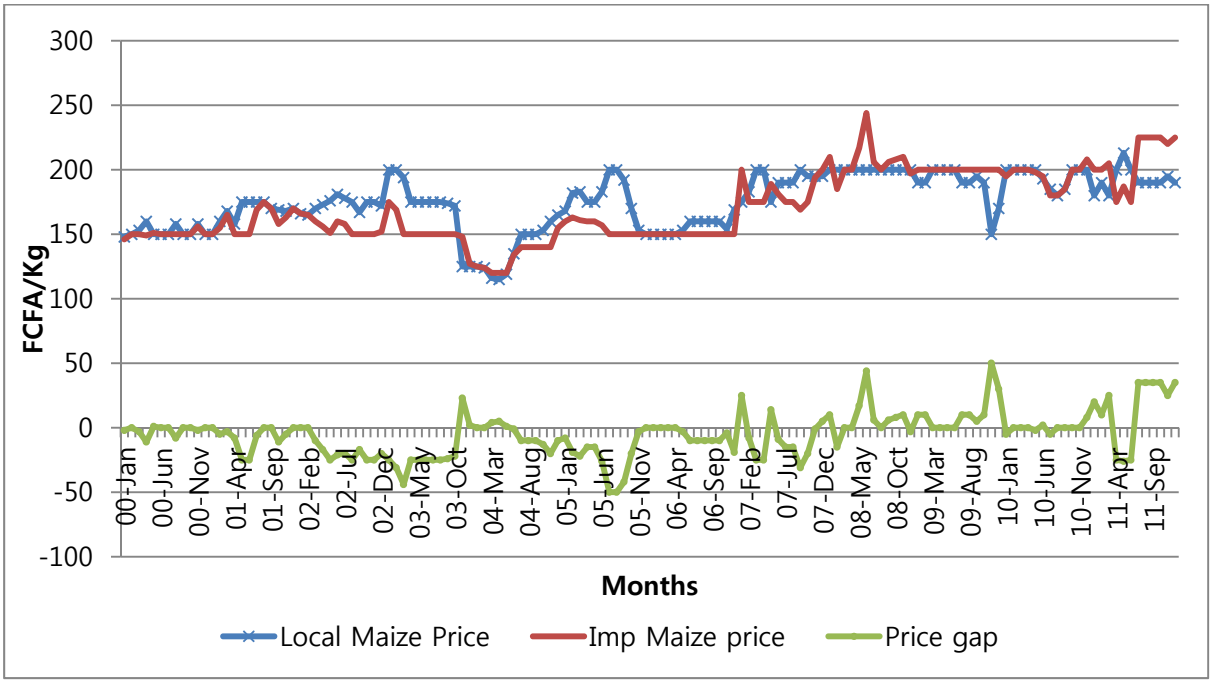
From July 2004 to October 2005, local maize monthly price outpaced the imported one and the gap varied between 10 FCFA/kg and 50 FCFA/kg. But in May 2008, there was shortly alternative price competitiveness (imported and local price competitiveness mixture). The high competiveness of local prices is mainly registered especially during welding periods. Indeed, during welding period, local maize supplies are very low and most of the available quantity of this grain is imported.

Furthermore, the last months of 2011 are characterized by imported maize price soaring due to the massive jobless youth orientation towards poultry and the increasing demand of agri-industries. This means that, despite all efforts made in recent years by the government to increase domestic production, maize is extensively imported.

Supplementary efforts should be done in maize sector to satisfy the national demand by boosting the local production. And as prices are very incentive, its improvement will lead simultaneously to family farming resurrection, people reverse towards agriculture as well as to a progressive decreasing of rural exodus.

Then private and public authorities must seize this local varieties preference to boost this grain production and invest more on its processing to overcome the huge dependency of the county on Asian rice through rice substitution by maize. The white maize production program which was based on maize rice (rice from maize crop after transformation) must be revived to support local rice production in order to satisfy the domestic demand.

Figure 19. Local maize competitiveness in Tilene market



Source: OFS, 2012

6.8 Empirical analysis: Market integration and price causation

This market analysis will rely on Saint-Louis and Mpal markets where price data is more available and reliable. The empirical analysis will rely on the integration of these two markets (urban and rural) through the Granger-Causality test in order to determine the direction of prices causation.

Market integration and price causation direction of agricultural products are very important in policy makers' decisions. Normally if they are well defined, conducted policies would absolutely lead to a sustainable agricultural production as well as to the improvement of the environment. Then there will be an improvement of the socio-economic conditions, situation of farmers' which depends also on the management of their own agricultural

revenues.

As agricultural sector is now liberalized, farmers should be aware about the notion of competitiveness and try to take off their activities efficiently. And since the government cannot continuously subsidize agricultural inputs, farmers and mainly family farming producers must have a notion of saving and not to expect always everything from the government or try to move into cities expecting better life without any qualification. The reorganization of farmers is necessary and imperative because they usually make the management of cities difficult to undertake, mainly in Dakar cities which are the main poles of convergence of rural people. Indeed most of them are usually homeless voluntary or not.

Then, as Saint-Louis market and Mpal market are highly correlated, price causation direction is a prominent element in the implementation of priorities. It will help in the improvement of the domestic production as well as the in the fixation of policies

The vector autoregressive model is as follow:

$$(7)\quad PU_{At} = \alpha_1 PR_{Bt} + \beta_{11} PU_{At-1} + \beta_{12} PU_{At-2} + \ldots\ldots\ldots\ldots + \beta_{1n} PU_{At-n} + v_{PUt}$$

$$PR_{Bt} = \alpha_2 PU_{At} + \beta_{21} PR_{Bt-1} + \beta_{22} PR_{Bt-2} + \ldots\ldots\ldots\ldots\ldots + \beta_{2n} PR_{Bt-n} + v_{PBt}$$

or

$$(8)\quad PU_{At} = \alpha_1 PR_{Bt} + \beta_{1p} PU_{At-p} + v_{Put}$$

$$PR_{Bt} = \alpha_2 PU_{At} + \beta_{2p} PU_{At-p} + v_{PRt}$$

where:

PU and PR are urban and rural market prices in Senegal River Valley,

A: represents Saint-Louis market,

B: represents Mpal market,

t: represents period, monthly price from January 2000 to December 2011,

v_{PUt} and v_{PRt} are error terms which are assumed to be uncorrelated,

α and β are some parameters,

p: is an integer , p=1,2,3, ..., N,

n: is an integer, n=3,4,5, ..., N.

Equations (7) and (8) have endogenous variables in their right hand side. Then, the VAR model is under a structural form. The structural form must be reduced. The transformation of the structural equation will lead to:

(9)

$$PU_{At} = \Phi_{11}PU_{At-1} + \Phi_{12}PU_{At-2} + \Phi_{1n}PU_{At-n} + \Phi_{21}PR_{Bt-1} + \Phi_{22}PR_{Bt-2} + \Phi_{2n}PR_{Bt-n} + \varepsilon_{1t}$$

$$PR_{Bt} = \varphi_{11}PR_{Bt-1} + \varphi_{12t-1}PR_{Bt-2} + \varphi_{1n}PR_{Bt-n} + \varphi_{21}PU_{At-1} + \varphi_{21}PU_{At-2} + \varphi_{2n}PU_{At-n} + \varepsilon_{2t}$$

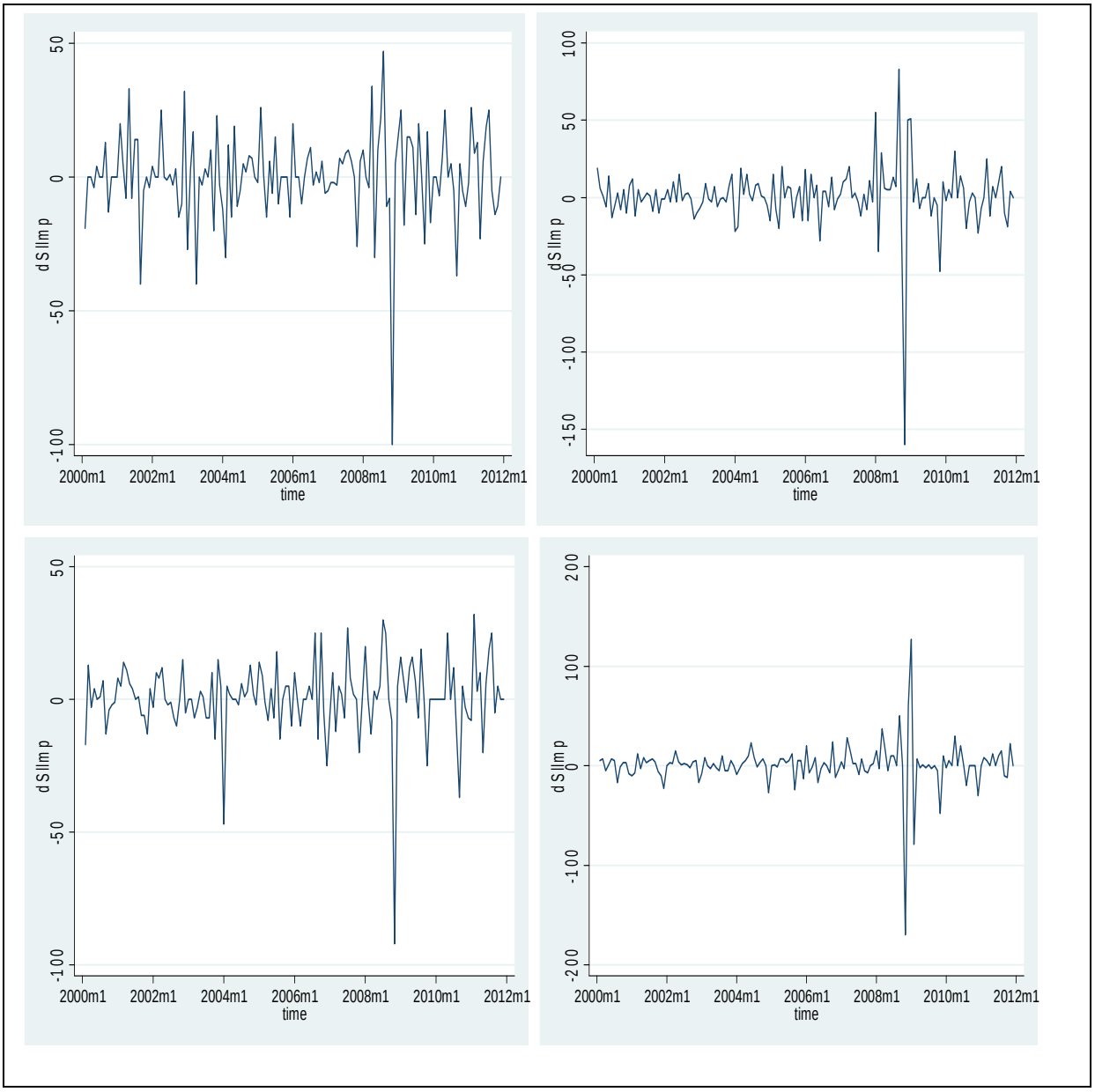
where:

Φ and φ are some parameters,

ε_{1t} and ε_{2t} are unobservable error term variables which are serially uncorrelated.

To estimate the VAR model properly, there is a need of data stationary. And the above trends of prices in Saint-Louis and Mpal markets show that prices are not stationary. Furthermore, the unit root test by Dickey Fuller test confirms that data is a non stationary time series data. Then the time series should be differentiated to make it stationary. After the first differencing, the Phillips Peron test shows that data is now stationary as represented in the below graph.

Figure 20. Differenced price



And from here, the VAR model lag-length can be estimated to determine the number of lags. The optimal lag length estimated is two. Thus, the equation (9) can be rewritten with a lag length of two-period as follow:

(10) $PU_{At} = \Phi_{11}PU_{At-1} + \Phi_{12}PU_{At-2} + \Phi_{21}\,PR_{Bt-1} + \Phi_{22}PR_{Bt-2} + \varepsilon_{1t}$

$PR_{Bt} = \varphi_{11}PR_{Bt-1} + \varphi_{12}PR_{Bt-2} + \varphi_{21}PU_{At-1} + \varphi_{22}PU_{At-2} + \varepsilon_{2t}$

The Granger causality test will be done with differentiated variables of the data, first differences. And the null hypothesis is:

H_{01}: $\Phi_{21} = \Phi_{22} = 0$: Mpal market price fails to Granger-cause Saint-Louis market price,

H_{02}: $\varphi_{21} = \varphi_{22} = 0$: Saint-Louis market price fails to Granger-cause Mpal market price.

Granger causality tests utilize test statistics computed from the VARs. A variable X_t is said to fail, to Granger-cause another variable Y_t, relative to an information set consisting of past values of X_t and Y_t if:

(11) $\hat{E}\,[Y_t \mid Y_{t-1}, X_{t-1}, Y_{t-2}, ...] = \hat{E}[Y_t \mid Y_{t-1}, Y_{t-2}, ...]$

where $\hat{E}$ denotes a linear projection of the dependent variable. In this case, this means that Saint-Louis market price does not Granger-cause Mpal market price relative to an information set consisting of past values of Saint-Louis and Mpal markets if and only if the estimates of φ_{21} and φ_{22} are equal to zero. The results of these Granger causality tests are summarized in the table 17.

Table 17. Granger-Causality tests of local maize and local husked rice prices

Crops	Causality test	R^2	Prob>chi2	Comments
Rice	Saint-Louis → Mpal	0.8461	0.009	One-way
	Mpal → Saint-Louis	0.8351	0.364	causation
Maize	Saint-Louis → Mpal	0.8141	0.667	One-way
	Mpal → Saint-louis	0.7343	0.000	causation

The Granger causality test shows that markets are integrated between them for rice and maize crops in one-way causation. For the rice, the hypothesis, Mpal market price Granger causes Saint-Louis market price, is rejected and the opposite sense of causality direction is accepted. In maize market, Mpal market price Granger-causes Saint-Louis market. However, Saint-Louis market price does not Granger- cause the price of Mpal market in one-way.

For the husked rice, the causality direction between Saint-Louis market and Mpal market is from Saint-Louis market to Mpal market. It means that rural price is highly driven by the urban market price at one percent level of significance. Then the increase of urban price will also lead to the increase of rural price in rice sector. But for the maize, the direction of causality is from Mpal market to Saint-Louis market. So if subsidy on imported rice is limited or stopped, urban price of rice will obviously increase and that will encourage farmers to produce more to satisfy domestic demand as well as to improve their incomes. Furthermore, as imported and husked local rice are highly correlated in Saint-Louis market (0.6027), the imported one will be substituted by the domestic rice. Then, the demand of the local husked rice will increase considerably as well as its price also. This increasing price of

rice in Saint-Louis market will at its turn drive up Mpal's price and motivate farmers more in rice production. And as Senegal is highly dependent on imports from Asian countries mainly, the improvement of rice production as well as its sustainability can be a huge source of revenue for rural people (farmers and traders). Moreover, it will lead to family farming resurrection and can solve the rural exodus matter. And, if subsidy amount is oriented in agricultural infrastructure building, production can be boosted sustainably while creating job for young people in rural areas and moderating rural exodus.

Then, with an efficient improvement of rice production, farmers' revenues will be improved obviously and the volume of imported rice can be reduced significantly. In addition, if this dynamism is sustained in the country in a long period, self sufficiency in rice may be achieved in short term.

In maize sector, the Granger-causality direction is from Mpal market to Saint-Louis market. Then rural maize price drives entirely the urban one at one percent significance level. And since the price of rice in Saint-Louis market affects strongly the one of Mpal market, the government should revised and reduced the amount of subsidy on rice import to motivate highly rice and maize production. The amount of subsidy must be oriented toward production infrastructure building to sustain the production of rice and maize in SRV. Then, if production competitiveness of local rice is harmonized by a scale of production, it will improve the security of supply and reduce Senegal's import dependency considerably.

For maize, as preference is given to local varieties, efforts should be on efficient production to compete sustainably with the imported maize. Indeed, according to the socio-economic conditions, if local maize price increases considerably, people will substitute it to the imported one if its price becomes more affordable than the price of domestic maize.

Furthermore, agri-indystry must be improved for maize processing in order to adapt its sub-products to the increasing urban areas needs. This appropriation can lead to rice demand decrease as rice is one of popular cereals easier to use in Senegal with less preparation and less cooking time. Furthermore, in the maize sector, as imported and local maize prices are now nearly close to each other because of the increasing demand of maize (poultry and agri-industry emergence), priorities should be on scale of production for farmers to produce at less cost to compete sustainably with imported maize.

6.9 Conclusion

The weakness domestic production of cereals and the quasi dependency of the country on imports, 77.9% (2011) and 35.7% (2010) for rice and maize respectively, do not show a best image of Senegal's agricultural sector. Thus, efficient and sustainable rice and maize production are and will remain for long time a crucial business opportunities, niche of employment as well as wealth creation mainly in areas suitable to double crop.

However silos structures for the support of agricultural production, the lack of strategy in the elaboration of programs, the different types of interventions implemented and applied, which are added some time by the groping vision status of the government to support agricultural institutions in order to reduce the country dependency on imports do not allow the achievement of expected results, agriculture development. Indeed, even though some industries are promoted the consumption of local cereals through the transformation of agricultural products to adapt them to Senegalese's current needs, there is a particular and permanent need of promotional support to increase their market share.

It is unrealistic to expect to reverse the dominant trend of rice consumption in

Senegalese diet if it remains that rice and maize production improvement can validly regulate the system significantly and reduce Senegal dependency on imports. Self-sufficiency in rice can be realized if previous malfunctions are considered and if challenges for food security and sovereignty are really well defined based on efficient development of policies and programs. A strong political willingness, sustained by local products consumption marketing boosting and strategic complicities between partners are the key factors to achieve expected changes in maize and rice sectors particularly and Senegalese agriculture in general.

Farmers are generally price takers for rice and as imported and local husked rice are highly correlated these last years due to the soaring prices of imported rice, the government should invest more efficiently in agriculture sector for sustainable macroeconomic stability rather than on import subsidy. And in maize sector, realized efforts should be maintained and improved to avoid the increase of its dependency and to expect a future self-sufficiency in maize.

VII. PROJECT OF INTERNATIONAL COOPERATION

7.1 Introduction

Actually, there is many type of international cooperation in Senegal in agriculture sector. The mains one are agricultural production and agricultural service cooperative. Some cooperation process and/or trade directly products and services of their members. Other sells to their members the necessary inputs for continuing their activities. This is the case of agricultural supply cooperatives.

Furthermore, as ACP country member and by its geographic position, Senegal still has potential possibilities in joint venture project success. The free export advantage of Senegal towards EU as well as political stability (comparing to neighboring countries) bring into many foreign investors from developed and emerging countries.

7.2 South Korea agriculture and Korean agricultural cooperation policy objectives

South Korea agriculture has improved significantly and sustainably since 1992 under the combined effects of the Uruguay Round negotiations ongoing and the great major decisions initiated by Korean government to strengthen the competitiveness of agricultural industry. Trade restrictions (Minimum Market access provisions for rice) and agricultural products tariff alleviation boosted domestic production and improved farmers' income. The improvement of Korean agricultural sector was backed by the government. Several programs were implemented to deepen agricultural from downstream to upstream in order to support farmers, to innovate irrigation systems, to mechanize agriculture and consolidate marketing

systems. Korean Agrarian reforms and policy of farmers' income stabilization were not done vainly as in many current developing countries because South Korea is actually fully self-sufficient in rice (Park, 2011). However, the drastic decrease of cultivable land due to climatic factors as well as the population growth, cash crop or fruits emergence (The Hankyoreh 2009, September 11), and "also by changing zoning laws and changes in priorities in land use policies favoring urbanization and industrial zoning rather than agricultural production" (Lee and Muller, 2012) restrict the satisfaction of other Korean grain demand by its domestic production.

Indeed, according to Sungwoo Park (2011) South Korea is the third biggest maize importer in the world and imports almost its consumed wheat. And for that the government relies on oversea farmland securitization to cultivate crops such as grain (maize and wheat) in order to match the domestic demand and stabilize the increasing price of cereals (Lee and Muller, 2012). Then in order to achieve the objectives of self-sufficiency and food security, Korean government stipulated its willingness to support Korean investors to "lease arable land or buy stakes in overseas firm" (Park, 2011). This increasing interest of Korean investors and policy makers in oversea land has been motivated by the successful action of Daewoo Logistics Company in Madagascar. In 2008, The Korean company, Daewoo logistics leased 1.3 ha arable land in Madagascar (BBC, April 17 2012). And since that event, Korean government is supported Koreans toward the exploitation of oversea farmland under international cooperation and/or joint venture action (Park, 2011).

This kind of collaboration between South Korea and developing countries, in priority Philippines, Cambodia, Ukraine, Indonesia and Russia (Park, 2011) as well as potential African countries relies in a win-win relationships between partners (Kim et.al, 2010). And

the opportunities for developing countries are their agriculture modernization as well as their sustainability through a large and appropriate cooperation which includes infrastructure building, training and transfer of technology (Lee and Muller, 2012). Furthermore for South Korea, it will help the country to overcome its production shortage because as said Professor Cherl-ho Lee "without actions taken, there is a possibility that Korea will face a serious supply crunch within two or three years". Thus many objectives in oversea land exploitation have been set by the government. Among them there is according to Shin Hyon-hee, (2011):

- Safeguard against price volatility and secure of stable supply,
- Food security by having a distribution structure at home and abroad as well as,
- Acquirement of maximum potential arable land in developing countries mainly.

7.3 The international cooperation impacts

Agriculture improvement relies on the development of agriculture research in which Senegal is vainly keeping in activity since many years ago to alleviate its dependency on imports. This increasing dependency of Senegal on imports in cereals, mainly in rice, maize and wheat, is related to the socio-economic conditions of farmers, to agricultural policies less effectiveness and to the shortage of financial resources of public and private structures. For this, cooperation with emerging countries like South Korea may be a cornerstone of technological improvement and development of Senegalese agriculture.

Technological advances in agriculture would be the primary factors influencing the direction of agricultural policies and economic growth. They shall participate to strengthen food security as well as to reduce poverty. Indeed, the international agricultural cooperation between Senegal and South Korea may be a win-win partnership in a near future as well as in

long term. South Korea is known by its dynamic rapid growth supported by technological innovation in key sectors of economy such us agricultural and industrial sectors. And, as any kind of cooperation between developing country and emerging or/and developed country, it means implicitly and explicitly transfer of technology, knowledge and financial means for sustainable welfare.

Senegal has in fact the necessary natural resources (arable land, water, labor, climatic conditions and other) to overcome its agricultural production shortage and be in a near future exporter. However, its potential progresses are crippled by its status of underdeveloped country. Then through the improvement of productivity, the project will contribute directly to the improvement of farmers' agricultural revenue as well as indirectly not only in the market to the decrease of agricultural products price but also to the improvement of Senegalese's food quality.

In terms of environmental impacts through agriculture intensification, the project shall assist to improve natural resources management by identifying potential technologies and practices.

7.4 The international agricultural cooperation

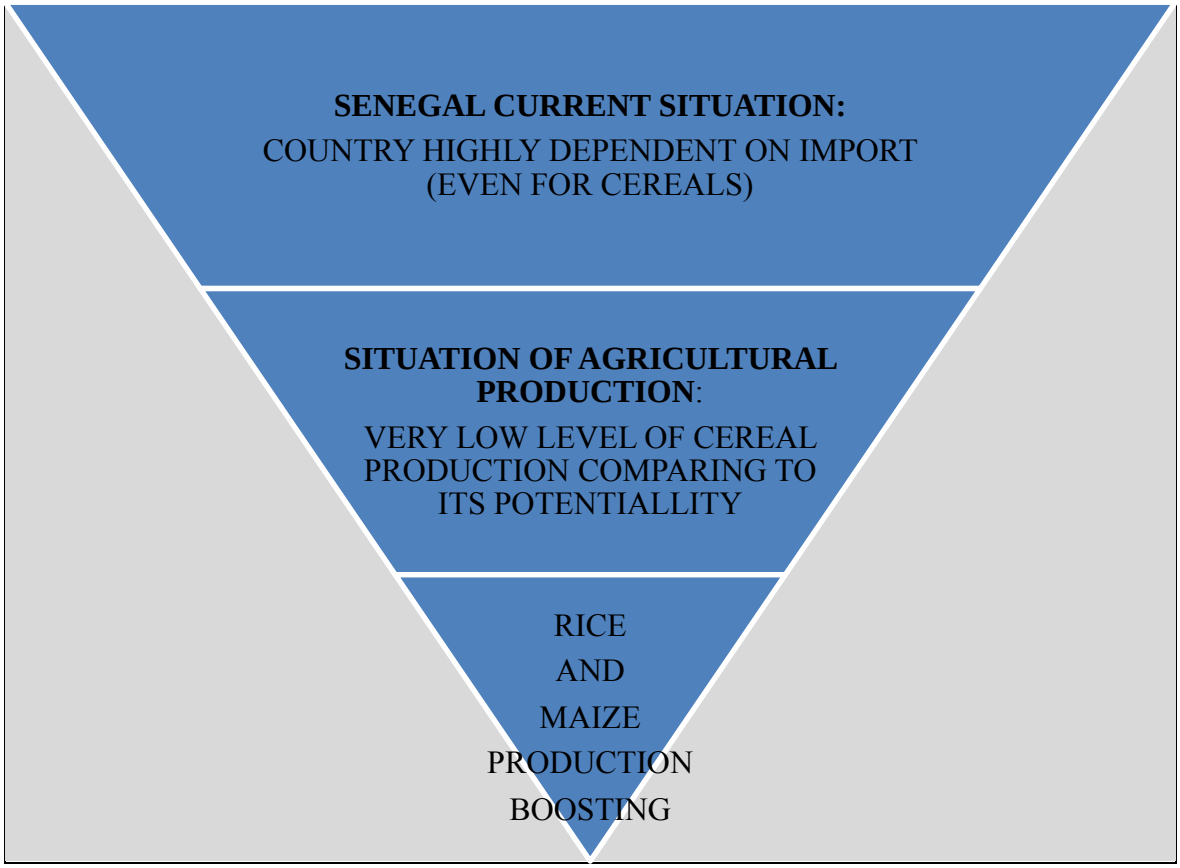
7.4.1 Evaluation of the initial situation of Senegal

The 2010 Paper on Human Development classified Senegal at the 144th over 169 countries. Despite all reducing poverty program and projects as well as economic growth challenges involved by the government and by other organisms (IMF, WB, ABD (African Bank of Development)), Senegal Gross National Income per capita was estimated at $ 770 and ranked the country in the group of Least Developed Countries. And the evaluation of the Strategy of

Reducing Poverty of 2006-2010 periods and the one of MDGs exhibited huge regional poverty disparities between rural and urban areas. This disparity can be explained by low domestic agricultural production and productivity, lack of employment opportunities in rural areas and credits inaccessibility as well as energy to farmers and to other vulnerable people mainly in rural area. These differences are also due to the limited access of women to productive resources and the limited participation of people in the prioritization of objectives of local development.

Agriculture is the major component of the country, primary sector which furnishes the population bulk of food mainly in rural areas as well as in the rest of the country. However domestic production is limited by many random variables and socio-economic constraints. In 2011, the population growth rate is estimated about 2.56% while, the one of the rice consumption which represents 50% of cereals attained 3.5% in 2008 (Baris, 2009).

During these four last years, domestic rice and maize production increased and decreased about 1.85% and 13.25% respectively and cover just 20% and 50% of rice and maize demand. At this rate of production growth, the dependency will never be swallowed down. Then, the country huge natural potential of production (in Senegal River Valley and the Anambé) should be exploited for sustainable production and future self-sufficiency in rice and maize. Nonetheless, there is a lack of funding and technology to make use of comparative advantages of production. So then, Senegal must find means to resolve its low domestic production by exploring potential bi-lateral cooperation. Such cooperation can help to boost agricultural production by exploring the country opportunities in agricultural development (Kim et.al, 2010) in order to satisfy progressively the local demand, mainly in rice and maize production.



7.4.2 Problematic

Through the financial support of the International Community, countries bordering the Senegal River Valley and Senegal had implemented an extensive program of development (planning) of the Senegal River Valley. The program led as first step to the realization of two Diama (1987) and Manantali (1989) dams. Their implementation created new prospect achievements in the Northern part of the country. Important irrigated units of improved hydro agricultural enabled people of Senegal River Valley to face drought by pursuing their main activity, agriculture. It aimed also to power and incentive local people to remain in their land as well as to promote food security sustainability through increasing and diversifying

agricultural production. However, despite all efforts, Senegal depends hugely on imports even on agricultural products which are highly and comparatively producible in the country.

Many programs for the training of farmers had been set by the government to improve producers' skills. But the lack of financial resources hampers always there effectiveness due to rural low income and their disability to get advantages from financial institutes. Then as developing country, Senegal must bet on emerging countries like South Korea to take advantage of their dynamic models and technologies in a context of win-win cooperation.

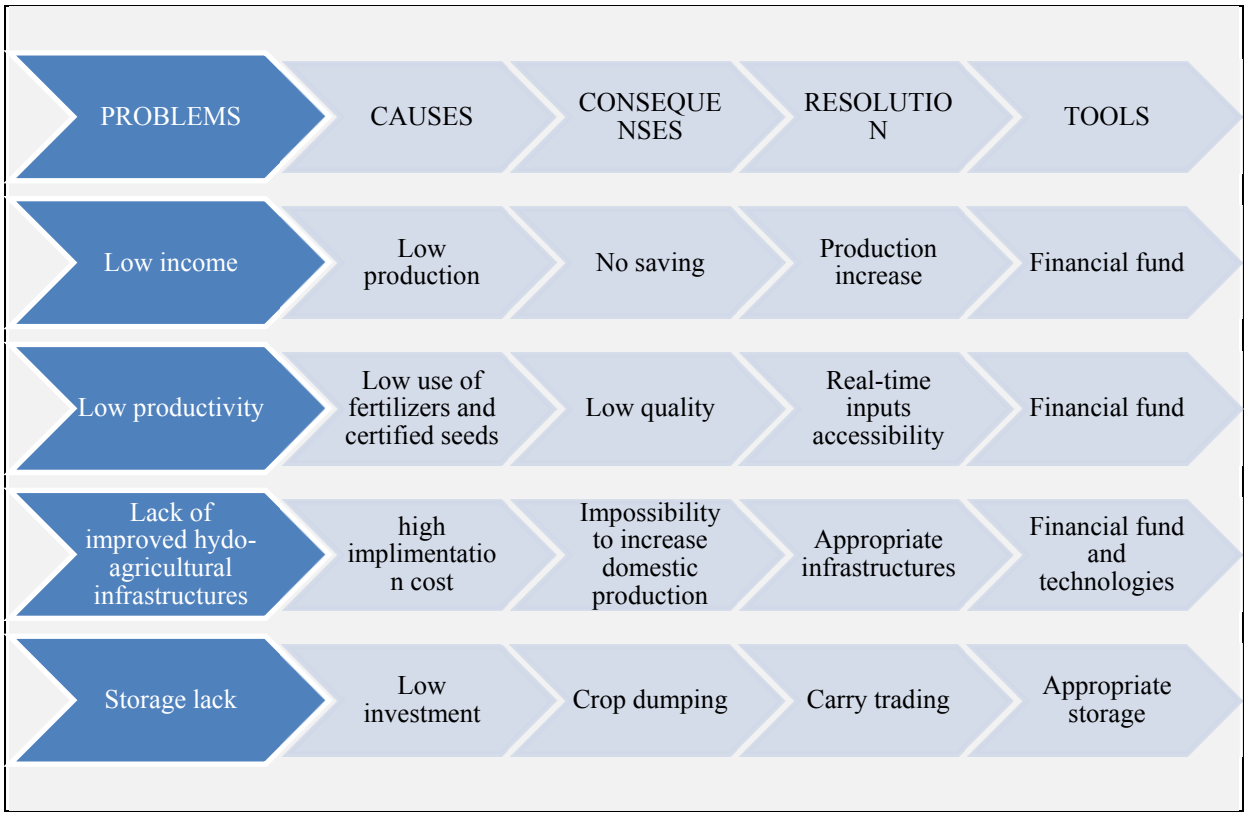
This cooperation will contribute to cereals production improvement by acting efficiently upstream and downstream of agricultural activities. And the productivity strengthening must take account all factors which limit domestic supply such as:

① Post-agricultural activities

② Agricultural activities

③ Agricultural products storage

④ As well as their transformation



7.4.3 Objectives

The overall objective of this cooperation is to increase agricultural production to achieve sustainable self-sufficiency in food by creating and supporting opportunities for rural areas economic and social development. It will focus mainly on sustainable production of rice as main targeted output and maize (complementary crop) in Senegal River Valley.

Objective achievement is based on the exploitation of 2,500 ha in Senegal River Valley. Selected perimeters are localized in Saint-Louis region and Matam region. Rice has been farming in these two zones since many years ago as auto consumption and commercial crop. However for the maize, its large-scale production is a new phenomenon in SRV. This step was motivated by the policies of agricultural production diversification. Selected areas

are:

Denominated	Object	Area	Location in SRV
Casiers Italien de Matam	Improved hydro-agricultural infrastructure	2500 ha	Matam
Casiers de Thiologne	Improved hydro-agricultural infrastructure	1200 ha	Matam
Casiers de Nabadji	Improved hydro-agricultural infrastructure	1300 ha	Saint-Louis

The potential beneficiaries of this program will be rural population, farmers, women, youth, groups, associations, decentralized structures, rural communities, etc... Furthermore, the specific objectives of this cooperation include:

① Improved hydro-agricultural infrastructures building

② Modern store building

③ Implementation of processing unit of agricultural products

④ Producers income increase

⑤ And the decreasing of rural poverty

7.4.4 Framework

The framework execution will depend on many internal and external factors. For internal

factors, most of parameters are already defined by governments under self-sufficient policies. These factors included all conditions to be fulfilled by any kind of agricultural project holding in Senegal. They concern mainly:

① Biodiversity conservation (wildlife),

② Landscape quality and character maintaining and enhancing,

③ Environment and natural resources protection, and others.

As for external factors, that not dependent directly on Senegalese leaders, possible and necessary modalities will be defined according partnership characteristics as well as required financial resources and technological capacity of investors and service providers.

7.4.5 Results indicators and means of verification

As main objectives are to improve sustainably rice and maize output as well as import dependency decrease while enhancing farmers' level revenue, indicators will be aligned on output growth, productivity and producers income improvement. So results will be based on the project share on the satisfaction of the future demand of milling rice. The future demand estimation relied on population growth and rice consumption ex-post norm (80.23kg/pers/year).

For the maize a standards share of exploited area will be allocated to its farming to alleviate the increasing dependency on imports. As emergency rely exclusively more one rice sector for cereals, 350 ha will be dedicated to rice farming. Then, the 150 ha left will be for maize farming.

As Senegal River Valley is highly suitable to double crop, expected results are based

under this aspect. Then annual production will be the sum of seasonal agricultural production. Thus, the project completion will increase constantly the domestic production of rice and maize respectively by 3,749 tons and 1,500 tons per year.

Years	Population	Rice	Targeted paddy		Milling	Maize output	
		Demand	Season	Annual	rice/year	Season	Annual
		(ton)	(ton)	(ton)	(ton)	(ton)	(ton)
2013	1,3215,540	1,060,283	-	-	-	-	-
2014	13,572,360	1,088,910	3,150	6,300	3,749	750	1,500
2015	13,938,814	1,118,311	3,150	6,300	3,749	750	1,500
2016	14,315,162	1,148,505	3,150	6,300	3,749	750	1,500
2017	14,701,671	1,179,515	3,150	6,300	3,749	750	1,500
2018	15,098,616	1,211,362	3,150	6,300	3,749	750	1,500
2019	15,506,279	1,244,069	3,150	6,300	3,749	750	1,500
2020	15,924,948	1,277,659	3,150	6,300	3,749	750	1,500
2021	16,354,922	1,312,155	3,150	6,300	3,749	7,50	1,500
2022	16,796,505	1,347,584	3,150	6,300	3,749	750	1,500
2023	17,250,010	1383968	3,150	6,300	3,749	750	1,500

7.4.6 Budget

Improved hydro-agricultural infrastructure costs include earthwork (land tillage, leveling and flattening) and civil engineering cost as well as irrigation and drainage network cost, pumping station equipment cost (mechanical appliance and electronic equipment). The

budget includes also production factors and costs of storage building.

Section	Earthworks/ha (€)	Equipments/ha (€)	Control/ha (€)	Average cost/ha (€)	Total cost/ha (€)	
C.I Matam	6,252	906	540	7,698	12,245,000	
C. Thilogne	6,252	906	540	7,698	9,237,600	
C. Nabadji	6,252	906	540	7,698	10,007,400	
Subtotal					**38,490,000**	**A**
Storage	Unit price (€)	Capacity	Number	Double crop (€)	Total cost (€)	
	5,145	100 m^2	2		**10,290**	**B**
Rice	764	350 ha	2	1,528	**534,800**	**C**
Maize	659	150	2	1,318	**197,700**	**D**
Milling husker	1,425	225-275 kg/h	1		**1,425**	**E**
Cereal husker	1,775	400-500 kg/h	1		**1,775**	**F**
Maize Sheller	1,235	1800-2000kg/h	1		**1,235**	**G**
Computer	492		1		**492**	**H**
Payroll	2,290/month		3	12 months	**27,480**	**I**
Office equipments	306/year				**306**	**J**
Other charges	310/month			12 months	**3,720**	**K**
Other equipments	7,634				**7,634**	**L**

The table below gives the minimum sum of amount necessary for the realization of the project. The budget is calculated under the supposition that its execution will be incorporated in any local agricultural institute. The procedure is intended to minimize the operating funds of the project

Heading	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Fix Charges	3.4%of inflatio
A	38,490,000										**38,490,000**	**41,151,814**
B	10,290										**10,290**	**11,002**
C	534,800	534,800	534,800	534,800	534,800	534,800	534,800	534,800	534,800	534,800		
D	197,700	197,700	197,700	197,700	197,700	197,700	197,700	197,700	197,700	197,700		
E	1,425										**1,425**	**1,524**
F	1,775										**1,775**	**1,898**
G	1,235										**1,235**	
H	492	0	0	0	0	492	0	0	0	0		
I	27,480	27,480	27,480	27,480	27,480	27,480	27,480	27,480	27,480	27,480	**274,800**	**274,800**
J	306	306	306	306	306	306	306	306	306	306		
K	3,720	3,720	3,720	3,720	3,720	3,720	3,720	3,720	3,720	3,720		
L	7,634	0	0	7,634	0	0	7,634	0	0	7,634		
Variable charges	744,652	736,526	736,526	744,160	736,526	737,018	744,160	736,526	736,526	744,160		
3.4% of inflation	796,149	814,235	841,919	879,567	900,143	931,369	972,368	995,114	1,028,948	1,074,960		

10% Unexpected expenses	79,615	81,423	84,192	87.957	90,014	93,137	97,237	99,511	102,895	107,496
Charge/year	875,764	895,658	926,111	967,524	990,157	1,024,506	1,069,605	1,094,626	1,131,843	1,182,456

Total variable charges (10 years)	10,158,249
Total fix charges	41,442,358
Total project	51,600,607

7.5 Conclusion

The project of international cooperation and its budget implementation will allow the exploitation of 5,000 additional hectares in Senegal River Valley. This funding will lead to the construction of sustainable agricultural infrastructure to alleviate rice import dependency. Indeed improved hydro-agricultural infrastructures create double (semi-irrigated (rain-fed farming by irrigation) and irrigated systems) cropping possibility. In addition storage building is very prospective in the conservation of agricultural products and carries trade for future sale more remunerative. Since during harvest period, demand is below the supply level and as most of farmers, mainly those of family farming do not have appropriate storage equipments, they usually dump their products to avoid future loss and to pay their loans also.

The project implementation can ease input accessibility on time; thereby increase output productivity and quality. And if the marketing system is well organized, output increase would normally upgrade farmers' agricultural revenues. Moreover, in a scale of production, producers can moderate their costs while producing more important quantity of output at less cost. Then they will be able to save one part of their revenue for their future self-financing.

VIII. CONCLUSION AND POLICY RECOMMENDATIONS

8.1 Conclusion

Many R&D projects and programs have been conducted by Senegalese government, public sector, foreign organizations and NGO to improve agricultural production. Those researches included the improvement of all production factors (inputs) such as fertilizers, pesticides, insecticides, agricultural practices and equipments (machines). There by, yield gap decreased mainly in SRV and attained 37.9% and 58.75% respectively in rice and maize production because of farming system innovations. But these staples production are still hampered but their lack of mechanization, credits access and farmers poverty (very low income and without any tangible guarantee for financial institutes).

Since the yield gap can also be increased by harvest and post harvest activities because crop productivity is highly related to crop farming systems as well as to harvest and post harvest activities efficiency. Furthermore, statistics show that many efforts should be done in productivity and quality improvement to meet consumers' needs and requirements. Due to that, appropriate and efficient technologies to local varieties must be in point for best conservation, processing and packaging of agricultural products.

The empirical analysis of rice and maize production exhibits the impacts of polices (labor training, seed and fertilizer subsidy as well as land improvement) on the improvement of output. Except land factor in rice production and producer price as well as seed factor in maize sector, which impacts are positive and statistically significant, other input impacts are very low and the seed one is negative in rice production. For rice production, all factors except seed input are positive and statistically significance at 1%. However for maize, all significant estimates are positive. Then according to estimated parameters, farmers training

should be further reinforced. And policies on fertilizers must be revised for their better effectiveness. Normally with 50% subsidy rate, fertilizers impact should be high in order to give farmers opportunities to increase their production and save money for their future own funding. Then, the distribution of subsidized fertilizers has to be regulated and oriented to necessitous farmers.

The effectiveness of subsidized price policy on seed must be also redressed like the fertilizers one. Producer price, farm gate price of maize and rice, should be more incentive to encourage highly farmers' production. For that, government should propose more interesting prices to farmers in order to motivate them or withdraw completely in the collect of agricultural products mainly in rice sector.

Senegal is hugely dependent on imports since many years. This dependency is about 72.9% for rice in 2010 and 35.7% for maize in 2010. However, local rice and maize competitiveness can address sustainably this dependency if necessary and efficient measures are taken in consultation with all concerned actors. Rice and maize production is in fact an important business opportunities, source of job creation, thus wealth building factor. And as Senegal River Valley is suitable to double crop production because of the annual availability of water in this zone, necessary infrastructures and institutions must be created and directed toward fundamental priorities of agriculture. If priorities are well defined and executed consistently, it is sure that Senegal can reverse this tendency considerably in few years. But addressed policies in domestic production boosting (productivity and quality amelioration) should be accompanied by smart marketing system to encourage and motivate Senegalese in the consumption of local products because most of Senegalese think that quality paces always with imported products.

Then, in order to secure and settle considerably and sustainably self-sufficiency in rice, supplementary efforts should be done in maize processing. Indeed, in 2000 ITA scientists demonstrated that, the white maize variety can be transformed likely to rice. And during the tasting ceremony, guests were not able to distinguish differences.

The junction of these two crops farming, by their importance and their factors of strategic products of stabilization, will not just reduce country financial deficit. It will improve rural area environment as well as the living condition of rural people. And if family farming is resurrected rural exodus will be alleviated while substituting imported rice and maize to the domestic production.

8.2 Policy recommendations

Previous and current agricultural policies were designed to improve the domestic production, decrease the country dependency on imports and to achieve food self-sufficiency in long term, mainly for cereals (rice). However, expected objectives were weakly attained and Senegal dependency on imports is increasing continually, particularly in staple food like rice, wheat, maize, dairy and others. In this context, with respectively 2.56% and 46.8% of population and urbanization growth rates, policy makers, economy regulators as well as other public and private agents and organisms have to redress the situation of agriculture sector as it is becoming more complex.

The estimates of the stochastic production of rice in SRV show that self sufficiency in rice can be achieved theoretically. However, practically there are a number of prior conditions that need to be met before the improvement of the domestic production and the achievement of self-sufficiency in rice. And the major factors in meeting these conditions

whether it is land, labor, fertilizer, seed or policy planning and management, is related to the accessibility and the availability of financial resources. Then, the straightening of cereal production relies firstly on the mobilization of necessary financial resources from both domestic and foreign institutes and secondly on factors of production and policy improvement.

The participative development concept initiated in developing countries such as in Sub-Saharan African countries, to upgrade rural farmers' financial situation was welcomed by projects and programs of development beneficiaries. Projects and programs allowed the training of many producers in rural and urban areas. But, the main obstacles of their sustainability and effectiveness still remain in the existence of appropriate infrastructures as well as the no-permanency of financial resources. Then, the government, Development Partners as well as stakeholders in agriculture sector should work together to increase the effectiveness of cooperation of development. And agricultural policies must be implemented through harmonization and alignment of activities and procedures. The need to work together and to adopt common approaches has become critical against the backdrop of international and national agenda in order to adopt comprehensive development strategies as well as to harmonize and align foreign investments to country development frameworks and processes. As defined in GOANA program, Senegalese government confirmed its commitment to a modernized agriculture culminating in a structurally transformed economy and evident in food security, employment opportunities and reduced poverty. For that it was necessary, imperative to ensure a maximum efficiency and effectiveness of the use of natural resources as well as the one of production factors in agriculture sector through the improvement of the sector of monitoring and evaluation of frameworks (to increase farmers' skill and

productivity) as well as systems in order to meet the broader efforts to strengthen the management of public finance. Nonetheless, significant efforts should be done in public and private financial institutes to increase their enthusiasm towards cereal production and other agricultural activities because of agricultural production randomness and farmers' socio-economic conditions (loan guarantee problem).

Nationally, it must have incentive instruments to incite financial institutes in agricultural production, mainly in cereal production in which farmers have less loan guarantee with high random of production. Indeed, the primary sector which includes agriculture, livestock and fishery is receiving less than one percent of local institutes' total loans (FAO, 2012). And as practical evidence shows that Senegal cannot currently provide adequate financial resources to boost cereal production, authorities should ease the entry of foreign capital in all areas of the agricultural sector. Foreign capital is imperative in agriculture modernization as well as productivity and quality improvement. Most of foreign direct investment (FDI) in Senegal's agriculture is oriented toward agribusiness (annex 15). In Senegal River Valley, where much of this agribusiness is concentrated, activities include mainly tomato and fresh green bean production and in other parts of the country, mainly mango production has benefited (annex 16).

Foreign direct investment in Senegal's agriculture was initiated by France and strengthened by the strategic position of the country to the seaports and airports of America and main developed countries of Europe. However as there is still a huge potential stock of land to be exploited in Senegal, mainly in Senegal River Valley and in Anambé Basin, the increase of foreign capital inflow in cereal production is crucial in the achievement of self-sufficiency in rice and maize. For instance, in Senegal River Valley, among its 240 000 ha of

irrigable lands, only 114 000ha are managed and cultivated. The availability of this land is evident to the fact that, the achievement of self-sufficiency is possible. Nonetheless, the exploitation of land depends on the increase of foreign capital inflow. The inflow of foreign capital would not only help extending useable land but the implementation of a feasible and consistent restructuring plan and action to mobilize the necessary fund to boost cereal production viability in long term. Then, the achievement of the conditional self-sufficiency includes the availability and accessibility of financial resources as well as the improvement of production factors.

Even progress has been made during the last decade in Senegal River Valley and in Anambé Basin in cereal production, mainly in rice and maize production by adapting agricultural policies to the ever changing needs of urbanized population, results are far below the expectations of development agents and the productivity capacity of the country. Thus policies should be oriented to reap benefits of more market orientation as well as to open trading, while simultaneously addressing a broader range of domestic policy objectives. Generally designed objectives of agricultural policies fall into two categories. Either they address issues relating to equity and income distribution, or are related to the correction of market failures. Market failures are often believed to be more frequent in agriculture than elsewhere in the economy due to the many functions of agriculture as providers of both positive and negative externalities, and public goods.

In order to emphasize positive and sustainable policies for Senegalese agricultural production, issues relating to market failures should be imperatively identified, analyzed and solved as well as subsidy on agricultural products. So then, other issues related to farmers' income improvement can be addressed efficiently. Policies that address market failures also

have an impact on producers' incomes and can be sometimes positive as well as negative. The optimal level of intervention of each policy instruments, production and market improvement, should be considered together and not separately. This consideration may get out the country, Senegal, from its present vicious circle to a virtuous circle.

Indeed, in order to increase rural communities' incomes and increase their savings for future investments as well as the improvement of their productivity and their aggregate agricultural output sustainably, direct and indirect subsidies on imported agricultural products should be revised considerably. And the orientation of subsidy amount towards cereal production, especially in rice and maize sector can enhance at least significantly the domestic production. However, this measure, even though it might boost domestic production, targets of foreign investment should be deemed to sustain government efforts. Thus, as post agricultural production infrastructures building is too expensive to establish by the government and other private local institutes or groups, potential cooperation with developed countries as well as emerging countries must be find out. The creation of a win-win partnership can considerably enhance agricultural sector, farmers' living standards, reduce rural exodus and decrease progressively and significantly Senegal's dependency on imports. For that, objectives should be set in three unavoidable groups of persons for the economy to evaluate in a virtuous circle. Policies must take account:

① Objectives related to farmers:

- Regulate farmers' incomes volatility
- Increase farmers' agricultural revenues to an affordable level and
- Enhance the competitiveness of agricultural products in domestic markets in

order to expect future competitiveness abroad.

② Objectives related to consumers:

- Assure provision of safe and high quality food at affordable price to consumers and
- Assure permanent availability of products in quantity as well as necessary nutrients for consumers well being

③ Objectives related to the society:

- Preserve environment and biodiversity and
- Sustain agricultural activities

Even though land factor is a significant factor associated with changes in rice output, the accent should be on intensive agriculture rather than on extensive agricultural production in a context of sustainable management of natural resources. Policy makers and authorities should establish and ensure continuity in the creation and the rehabilitation of improved hydro-agricultural planning (layouts) in order to maintain soil fertility and manage soil acidity and salinity as well as soil erosion. Thus, agricultural plots must be equipped with sophisticated irrigation and draining systems. This investment in land improvement, soil fertility restoration, agricultural productivity increasing as well as efficient use of inputs of production, is necessary to overcome positively changes in weather conditions and address the decreasing self-sufficiency of Senegal.

Labor factor elasticity in rice production is close to zero. This slack, close to zero impact of labor factor is due to the excessive number of people working in agriculture and to the rudimentary quality of the stock of capital fix. Then, the quality of labor factor must be

improved while mechanizing agricultural production. For this reason training of farmers should be general and consistent with targeted objectives and producers' education level. In that sense, there is a necessity of efficient training of monitors in order to satisfy adequately the improvement of farmers' skill according to their culture and believing. Indeed during the World Conference on Agrarian Reform and Rural Development in 1979, many analysis and training methods were elaborated to support projects of development in developing countries where the percent of the illiterate is usually very high. However, those methods were neglected by policy makers and authorities. And since year 2000, rural institutes and sub-regional organization like AfricaRice are activated in the same direction positively. Among them, the leading used one in West Africa, mainly in Senegal is the MARP (Methode Accelérée de Recherche Participative: Rapid Rural Appraisal) diagram. The MARP diagram methods of dealing with farmers are easy as it just designs or characterizes each component of the training by using things which are very familiar to farmers. For example, in agricultural production the tree diagram is highly in use in the improvement of agricultural practices. The importance of agricultural practices is graduated from tree roots to its leaves. Roots represent all sine qua non (prerequisite) conditions and factors or actions in agricultural production. After roots comes successively the stem, branches and leaves. This method improved obviously farmers' skill and productivity in many local specific training programs. Then, the government should focus on this method while encouraging children enroll and stay at school as rural children stop their study earlier than urban children.

The positive elasticity of fertilizer factor in rice production confirms its importance in rice production. But its availability and accessibility is not enough desirable even it is subsidized at a rate of 50% of the market price. And as subsidy policy cannot be continuous

in a system of open market, incentive policies on fertilizers should be formulated to make farmers progressively less dependent on government credits. Policy makers must work on the empowerment of farmers to help them to ensure their future expenditure in agricultural production. Furthermore, as most of them have volatile income related to the nature of farming activities, farmers should work on their own credibility building toward financial institutes. As financial institutes are just intermediate between savers and borrowers, producers should support the sustainability of their activities by saving their money in those institutes. Indeed most of rural people don't want to save their resources in banks and keep them in their houses.

In term of fertilizers use, subsidized fertilizers must be distributed on time in all agro-ecological zones and applied appropriately at real time according crop needs to increase efficiently crop productivity and quality. Farmers should also be aware of the toxicity of fertilizers and take the necessary measures for livestock, environment and human being protection.

The estimate of seed factor is respectively negative and positive in rice and maize production in Senegal River Valley. It emphasizes that seed issues in rice sector are more severe than in maize one. This negative impact of seed in rice production can be highly related to the quality or to the quantity of seed used per hectare (overuse of seed). As seed productivity is also highly related to the density of plants per hectare (AfricaRice, 2011), the appropriate quantity of seed per hectare as well as the required space between seedling according seed variety should be respected to ease plant growth. Then, in order to address the impacts of seed in rice production and improve its productivity as well as to boost its positive effect in maize sector, farmers should use improved and certified seed to increase

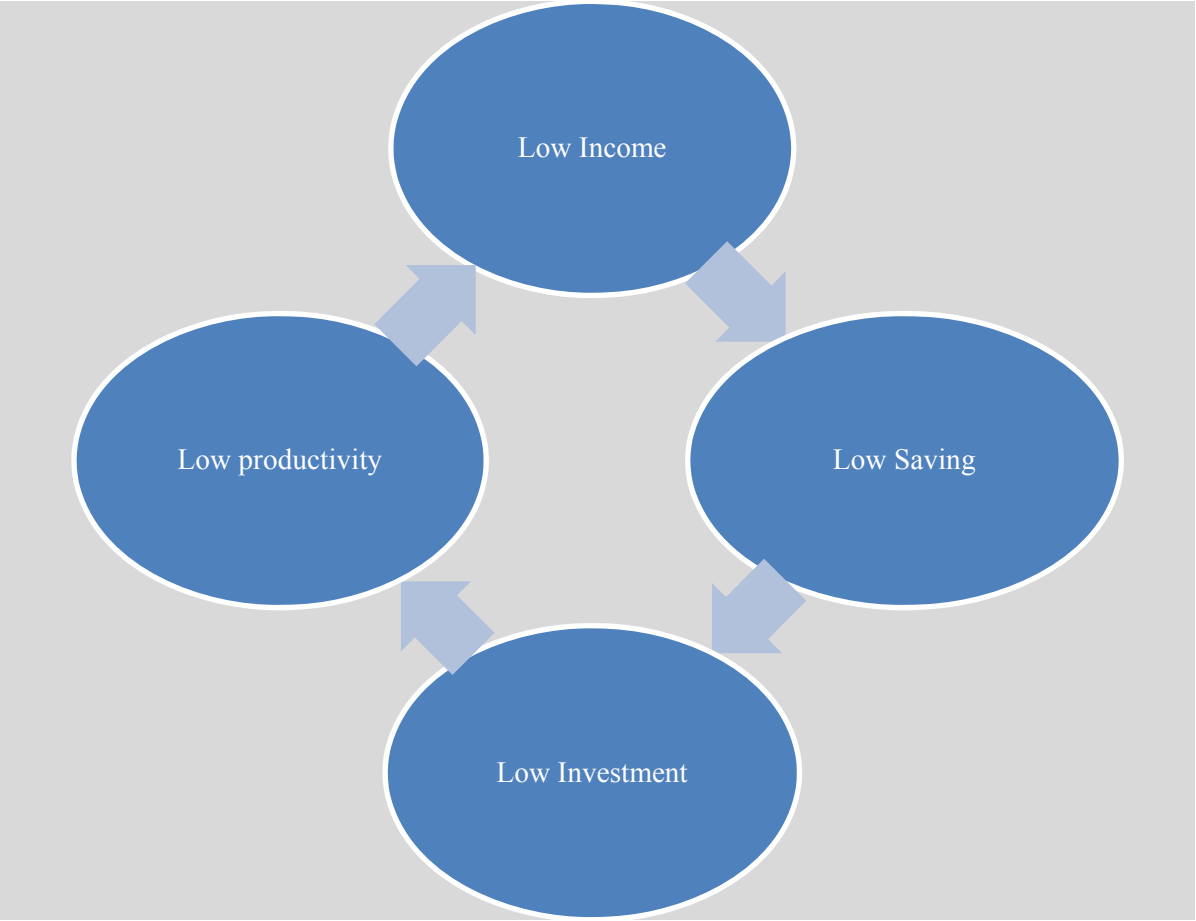
quantitatively and qualitatively their output. For that, some farmers must be specialized in improved and certified seed production. And as improved and certified seed yield and resistance to parasitic infestation and climate changing are higher than the withheld seed ones, the use of improved and certified seed must be generalized to increase progressively domestic production in order to achieve self-sufficiency in cereal in a near future.

Furthermore, the negative price elasticity of subsidized seed in rice production emphasizes the importance of certified and improved seed use in rice sector. This negative estimate supports the necessity of scale of production of rice seed to cut down seed price. Seed production should be totally liberalized and boosted to drive down its price. Indeed, the decrease of seed price should provide an opportunity to support small farmers as well as to strengthen family farming. And if the productivity and the production of family farming farmers are boosted, rice import will decrease considerably.

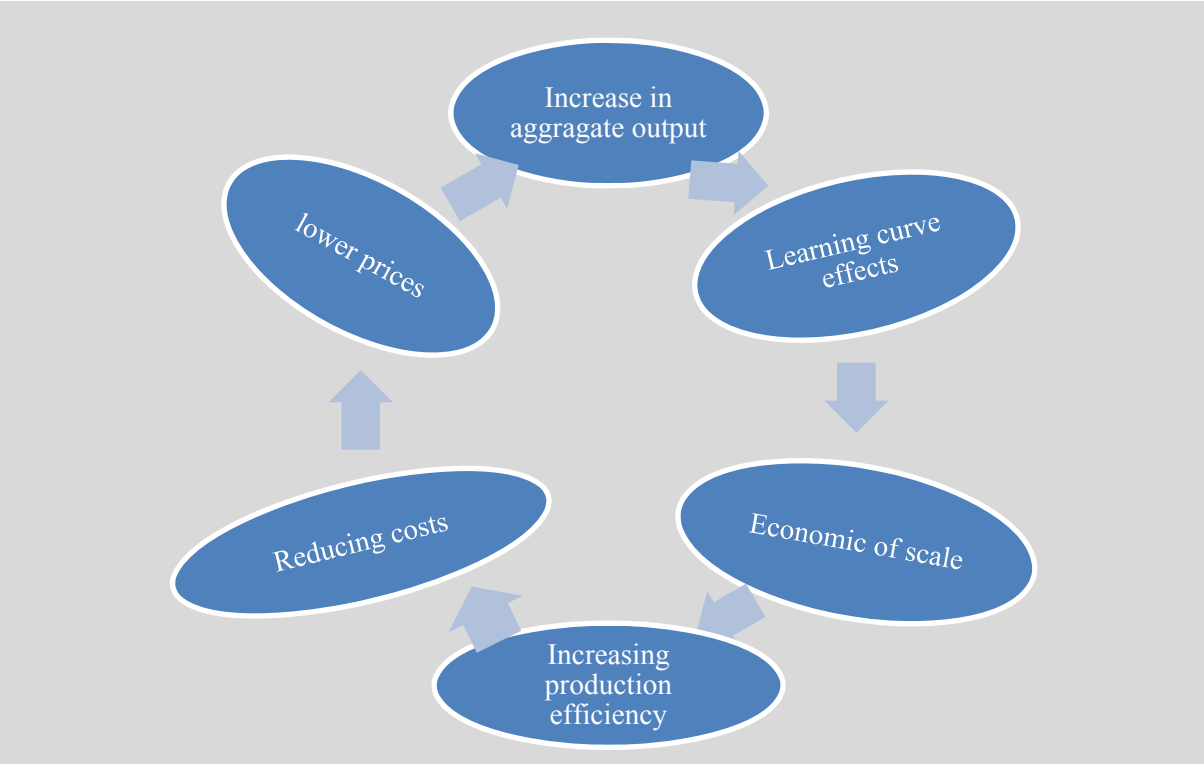
In the market, as producers don't have necessary storage and means of transport, the government should suggest incentive price to farmers to motivate them in cereal production, mainly in rice and maize production. This policy of producer price must be accompanied by sophisticated transport infrastructure building to open up lock land in rural areas and link cities to ensure the fluidity of agricultural products. Indeed transport infrastructure building will ease the accessibility of traders to areas of production and will create more opportunities to producers in terms of price choice. If areas of production are easily accessible, the coexistence of market price and producer price may improve farmers' revenues. And, if rural market price is not enough incentive to producers to commercialize their production in rural markets, rare of capable farmers can drive their output to urban area markets and gain more. Moreover, there must be appropriate storage to avoid producers to dump their crop during the

harvesting time. If farmers have possibilities to postpone their agricultural products trading, they will be able to get better price later and farmers will be able to self-fund their future agricultural activities.

For the processing, maize and rice operators should adapt semi-final products and final products to consumers' requirements. Distributed cereal must be well calibrated and homogeneous as well as diversified to meet the increasing demand of urban areas and be in pace with the increasing urbanization rate of Senegal.



VICIOUS CIRCLE



VIRTUOUS CIRCLE

And even though agricultural policy reforms stressed reliance on market signals to guide the allocation of resources by the government subsidy system, their revision is a crutial step for the improvement of domestic production. While emphasizing potential welfare gains from higher trade barriers in agricultural products, except in rice and other main staples, policy makers underscored that domestic reforms were successful keys to face challenges to enhance agriculture sector. Then restriction in trade should include all agricultural products as rice, maize and wheat to stand, boost the domestic production. Indeed, trade policies are only derived policies, necessary to implement domestic policies and to achieve domestic objectives, though their international repercussions need also to be taken into account. Moreover, it is not all objectives that must be necessarily met by traditional agricultural policies. For instance in order to meet income objectives, agricultural policy impacts have to

meet social and welfare policies already in place in each agro-ecologic zone.

The Granger-causality test between Saint-Louis market and Mpal market show that price causality direction is unique (one-way causation) in rice and maize marketing. Then, as in Senegal River Valley for rice, Mpal market prices are highly influenced by Saint-Louis market ones, efforts concentrated in rice import and imported rice subsidy must be oriented towards rice production boosting. If there was not subsidy policy, imported rice price would be higher than applied prices under the combined international effects of increasing price of rice as well as the one of the black gold (barrel price). It is therefore necessary to include all import costs in prices to incentive local production. However, this system presupposes that, main factors of pre-production, production and post production infrastructures and equipments are already available. Then instead of trying to decrease imported rice price, priorities should be focused on production boosting. And produced rice varieties must also meet consumers' requirements and desires, above all the quality, quantity and calibration.

In maize sector, the Granger-causality sense is from rural area (Mpal) to urban area (Saint-Louis). Then contrarily to the rice sector, the rural market prices drive entirely the one of Saint-Louis market at one percent level of significance. This is due to the fact that local maize is preferred than the imported one. Furthermore most of imported maize is mainly for agri-industries and livestock. Therefore the necessary efforts to improve maize production seem to be lower than the rice one as its demand is already important as well as its price level. For this reasons, public and private investors have to seize this market opportunity to satisfy all maize demand. The improvement of maize processing should be added to priorities to ease rice substitution by maize. Indeed, with a high urbanization rate (46.8%) as well as an increasing number of active women, cooking time should be adjusted to women activities.

Then for the improvement of rice and maize sectors, these two sectors must have standard storage, calibration and packaging to attract an ever increasing number of regular customers.

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ACRONYMS AND ABBREVIATIONS

AATF: Africa Agricultural Technology Foundation

ACP-EU: Africa-Caribbean-Pacific-European Union

AGS (SGA): Accelerated Growth Strategy (Strategy de Croissance Accelerée)

ANCAR: National Agency of rural executive Managers (Agence National des Cadres Ruraux)

ANSD: National Agency of Statistics and Demography (Agence Nationale de la Statistique et de la Demographie)

LOASP: Agro-Pasto-Forestry Orientation Act (Loi d'Orientation Agro-Sylvo-Pastoral)

APIX: Agency of Investment Promotion and Major Projects (Agence de Promotion des Investissements et Grands Travaux)

CFAA: Country Financial Accountability Assessment

CFAA-CPAR: Country Financial Accountability Assessment- Country Program Assessment Review.

CILSS: Committee of Draught Control in the Sahel

CNCR: National Framework for Dialogue and Rural Cooperation (Conseil National de Concertation des Cadres ruraux)

CNRA: National Council of audiovisual regulation (Agence Nationale de Regulation de l'Audiovisuel)

CPAR: Country Program Assessment Review

DA: Agriculture Office (Direction de l'Agriculture)

DRDR: Regional Office (Direction) of Rural Development (Direction Regionale du Developpement Rurale)

SDRR: Senegalese Agricultural Research Institute/ Regional Societies for Rural Development.

ECOWAS: Economic Community of West African States

FAO: food and agriculture organization

FCFA: Africa Financial Community Franc (West Africa currency)

GOANA: Great Agricultural Offensive for Food and Abundance (Grande Offensive Agricole pour la Nourriture et l'Abondance)

HIPC: Heavily Indebted Poor Countries

ICT: Information and Communication Technologies

IITA: International Institute for Tropical Agriculture

ILRI: International Livestock Research Institute

IPTRID: International Program for Technology Research in Irrigation and Drainage

IRRI: International Rice Research Institute

ISRA: Senegalese agricultural research institute (Institut Senegalais de Recherches Agricoles)

ITA: Institute of Food Technology (Institut de Technologie Alimrntaire)

MA: Ministry of Agriculture (Ministere de l'Agriculture)

MCA: Millennium Challenge Account

MDG: Millennium Development Goal

MT: Ministry of Trade (Ministere du Commerce)

NAP (NPA): New Agricultural Policy (La Nouvelle politique Agricole)

NEPAD: New Partnership for Africa Development

NERICA: New Rice for Africa

NGO: Organization Non Governmental

SNFAR: Strategie Nationale de Formation Agricole et Rurale (National Strategy for Agricultural and Rural Training)

OFS (CSA): Office of food security (Commissariat de la Securite Alimentaire)

OMVS: Organization for the Development of Senegal River Valley

ONCAD: Office of National Assistance for Cooperation and Development (Office Nationale de Cooperation et d'Assistance pour le Developpement)

PADERBA: Anambé Basin Rural Development Support Project (Le Projet d'Appui pour le Developpement Rural du Bassin de l'Anambé)

PNAR: Programme National d'Autosuffisance en Riz (Rice Self-sufficiency National Program)

PRESOA: Programme de Renforcement et de Recherche sur la Sécurité Alimentaire en Afrique de l'Ouest (West Africa Food Security Capacity Strengthening and Research Program)

PROMER: Promotion of Small Rural Entreprises (Promotion des Micro-Entreprises Rurales)

REVA : Retour vers l'Agriculture (Reversion to Agricultural)

SAED: Senegal River Valley National Development Agency

SAP (PAS): Structural Adjustment Policies

SCPRS: Société de commercialisation et de Promotion du Riz Sénégalais (Senegalese Rice Promoting Marketing Society)

PRSP (DSRP): Strategic Poverty Reduction Strategic Paper

SODAGRI: Agricultural and Industrial Development Company

SODEFITEX: Textile Fiber Development Company

SRV: Senegal River Valley

TEC: Common External Tax

UAP: ECOWAS Union Agricultural Policy

WAAPP: West Africa Agricultural Productivity Program

WAEMU: West African Economic and Monetary Union

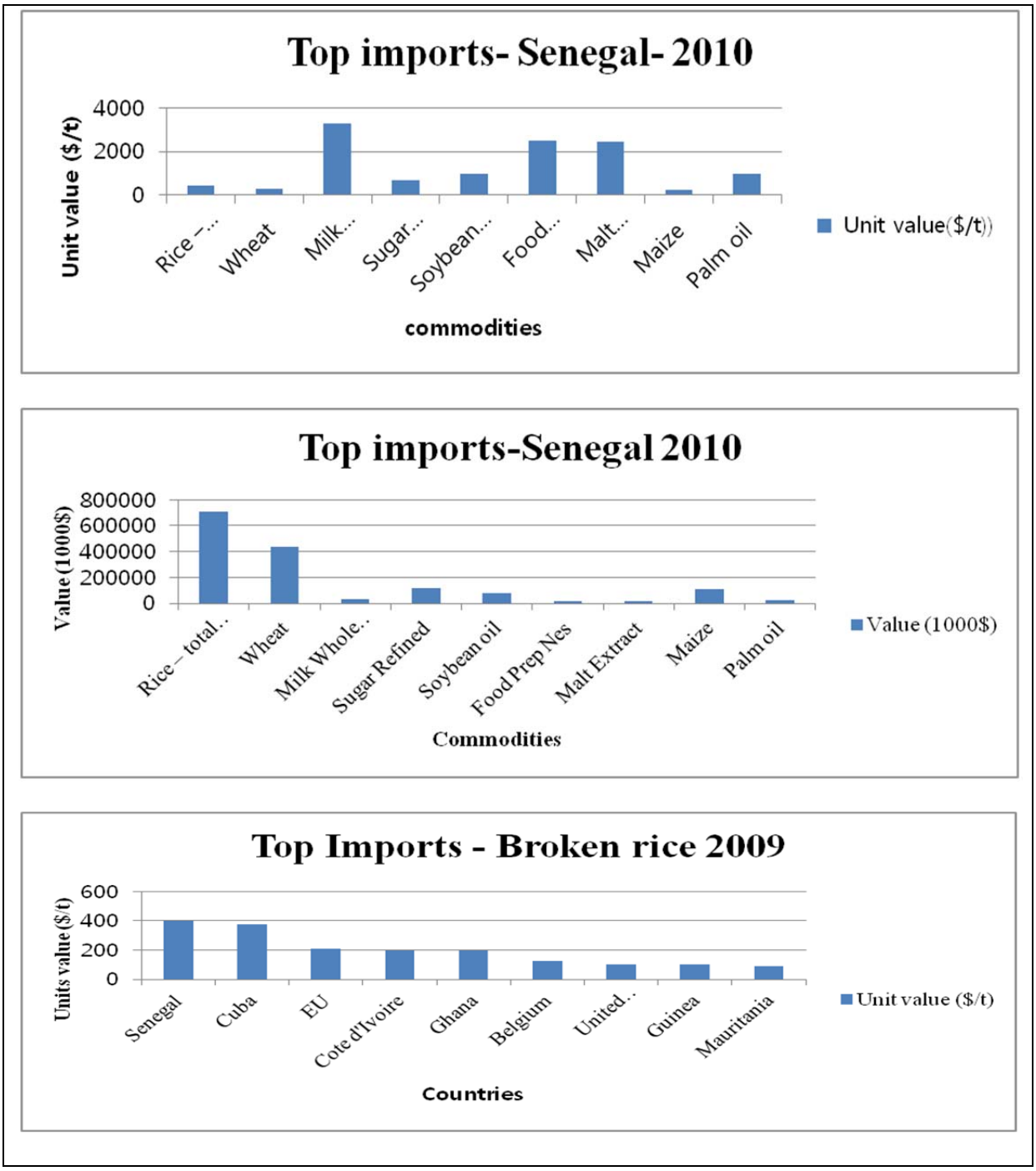
WARDA: West Africa Rice Development Association

WFP: world food program

WHO: World Health Organization

APPENDICES

Annex 1. SENEGAL RICE DEPENDENCY STRUCTURE



Source: FAO

Annex 2. AGRICULTURE SHARE IN SENEGALESE GDP

Years	1970	1971	1972	1973	1974	1975
DGP	241.5	248.5	275.2	279.7	340.4	408.5
Agr Share	35.6	25.7	38.7	29.0	39.5	76.3
%	14.7	10.3	14.0	10.3	11.6	18.6

Years	1976	1977	1978	1979	1980	1981
GDP	461.8	486.2	498.4	585.7	631.2	673.8
Agri share	87.0	77.8	47.6	87.3	62.4	56.8
%	18.0	16.0	9.5	14.9	9.8	8.4

Years	1982	1983	1984	1985	1986	1987
GDP	348.8	994.7	1021.2	1158.1	1303.5	1382.3
Agri share	117.6	125.1	78.6	104.3	165.8	163.6
%	24.2	13.2	7.6	9.0	12.7	11.8

Years	1988	1989	1990	1991	1992	1993
GDP	1483.3	1475.9	1551.5	1551.5	1595.4	1537.8
Agri share	188.3	136.4	164.2	148.5	152.7	144.7
%	12.7	9.2	10.6	9.6	9.6	9.4

Years	1994	1995	1996	1997	1998	1999
GDP	2022.3	2234.0	2379.3	2555.9	2752.9	2956.0
Agri share	189.5	229.3	261.1	262.4	244.8	280.3
%	9.4	10.3	11.0	10.3	8.9	9.5

Years	2000	2001	2002	2003	2004	2005
GDP	3114.0	3373.9	3551.8	3440.2	3874.0	4109.1
Agri share	335.9	360.8	241.5	282.0	278.9	336.9
%	10.7	10.6	6.8	8.2	7.2	8.2

Years	2006	2007	2008	2009	2010	2011
GDP	4894	5408	5994	6029	6367	6767
Agri share	323	281.2	461.5	482.3	534.8	399.3
%	6.6	5.2	7.7	8	8.4	5.9

GDP (FCFA billon)

Agriculture share FCFA billon

Source: MEF/ANSD

Annex 3. MATRIX OF POLICIES ANALYSIS PER ZONE OF PRODUCTION

FCFA/Kg	REVENUE	VARIABLE CHARGES	FIX CHARGES	PROFIT
PRIVATES	**A**	**B**	**C**	**D**
ANAMBE	385	171	139	75
DELTA RIVER	392	164	100	128
MIDDLE VALLEY	397	169	122	106
UPPER VALLEY	398	231	284	-117
DOMESTIC	**391**	**168**	**120**	**75**
SOCIAL	**E**	**F**	**G**	**H**
ANAMBÉ	321	152	140	29
DELTA VALLEY	382	192	104	86
MIDDLE VALLEY	388	199	94	95
UPPER VALLEY	354	222	174	-42
DOMESTIC	**361**	**191**	**128**	**42**
GAP	**I**	**J**	**K**	**L**
ANAMBÉ	64	19	-1	46
DELTA RIVER	10	-28	-4	42
MIDDLE VALLEY	9	-30	28	-11
UPPER VALLEY	44	9	110	-75

DOMESTIC	**32**	**-23**	**-8**	**33**

Source: AfricaRice, DAPS/ISRA, 2009

Annex 4. LOCAL RICE PRODUCTION COMPETITIVENESS

RATIOS	DOMESTIC	ANAMBÉ	DELTA VALLEY	MIDDLE VALLEY	UPPER VALLEY
Financial profitability	75	75	128	106	-117
Subsidy rate: L / E	0.10	0.14	0.11	0.03	-0.21
Subsidy equivalent: L / A	0.09	0.12	0.11	0.03	-0.19
Nominal protection: A / E	1.08	1.20	1.03	1.02	1.12
Effective protection: (A-B) / (E-F)	1.31	1.27	1.20	1.21	1.26
Factors cost: C / (A-B)	0.54	0.65	0.44	0.54	1.04
Economic Benefit-Cost	0.88	0.91	0.77	0.76	1.12
Competitiveness	0.75	0.83	0.55	0.50	1.32

Source: AfricaRice, DAPS/ISRA, 2009

Annex 5. REVENUE, COST &BENEFIT STRUCTURE PER ZONES

	STRUCTURE (F CFA/Kg)			PROPORTION (%)		
	REVENUE	COST	PROFIT	REVENUE	COST	PROFIT
ANAMBÉ	385	310	75	24	22	39
DELTA RIVER	392	264	128	25	19	67
MIDDLE VALLEY	397	291	160	25	21	55
UPPER VALLEY	398	515	-117	26	38	-61
TOTAL	1572	1380	192	100	100	100

Source: AfricaRice, DAPS/ISRA, 2009

Annex 6. TECHNICAL SHEET OF RICE FARMING IN SRV

Farming season and seeding date	-Two main cropping seasons: rainy and non rainy (irrigation) seasons -Rainy season seeding date: between July 1st and August 15th -Irrigated system: between February 15th and march 15th
Varieties	-Short cycle: Sahel 108 (wet season, 105-110 days; dry season : 125 days) -Medium cycle: Jaya, Sahel 201, Sahel 202, IR 1529 (wet season, 120 to 150 days
Type of soil	-High fertility soil with good capacity retention of water -"Hollaldé" soil in preference or "fondé" having at least 30% of clay content
Perimeters preparation	-clearing and dikes and canals repairing -Deep tillage every three years -Offset: pre-irrigation and offset after soaking (in absence of tillage, two cross offset must be done) -Leveling
Quality and quantity of seeds	-Selected and certified seeds -Level: R1 or R2 -Measure: direct seeding; 120Kg/Ha and transplanting, 40Kg/Ha
Seeds preparation	-Soak seeds during 24 hours and incubated them 24 hours again -Sow on wet mud or low water slide immediately after first signs of pre-germination of seeds.
Irrigation and	Irrigation at different stage of rice plant development by strip water with variables levels (5

drainage	to 10cm of height) - After seeding standing water by irrigation must attain and be sustained at 5cm height till panicle initiation - From panicle initiation to dough stage, water level must be around 10cm height -drain 24 hours before application of chemical herbicides (according on variety) and irrigate again after 48 hours. -Decrease strip at it strict minimum level possible to apply fertilizers and irrigate again after 72 hours - Drain completely perimeter 15 days after flowering (dough stage).
Chemical fertilization	-Basic manure: 100 Kg/Ha of 18-46-0 (DAP) buried during tillage and no later than the first application of Urea -Manure of cover: three times application with a total quantity of 250 to 300 Kg/Ha Urea 40%: tillering start, 23 days after sowing Urea 40%: panicle initiation, 45 to 60 days after sowing Urea 20%: elongation, 10 days before flowering
Plants protection	Two main chemicals products - Propanyl: 8 L/Ha, post emergence stage of weeds (2-3 leaves) stage, grainy, broadleaf weeds and young sedges. - Weedone: (2,4-D): 1L/Ha effective on sedges. - Complete with manual weeding. Against insects and thrips treat with Furadan; 2Kg /Ha at germination, tillering and to heading stages
Harvest	-Rice is harvested when grain moisture is between 20 and 25% -Yield: 5.7 to 6 t/Ha, with peaks of 9 t/Ha

Source: SAED, April 2009

Annex 7. STANDARD BUDGET OF RICE FARMING/ INTENSIVE AND SEMI-MECHANICAL FARMING IN A LARGE PERIMETER

Charges	Qty	UP	FCFA/ha
1. Land preparation			
1.1Tillage	0.33	40 000	13 200
1.2 Offset	1	25 000	25 000
1.3Manual maintain			3 200
Sub total			**41 400**
2.Seeds			
2.1 Certified seeds	120	250	30 000
Sub-total seeds			**30 000**
3. Inputs			
3.1 Fertilizers			
DAP (18-46-00)	100	398	39 800
Urea (46-00-00)	300	280	84 000
3.2 phyto products			
Propanyl	8	3 800	30 400
2 -2D (Weedone)	1	3 100	3 100
Sub-total inputs			**157 300**
4. Irrigation (charges			
paid to Union)			
4.1 Fuels & lubricants	1	16 190	16 190
4.2 maintenance & SP	1	3 110	3 110
4.3Pump & guard charge	1	2 000	2 000
4.4 Union operation	1	1 270	1 270

Results	Qty	UP	FCFA/KG
Paddy (Kg/Ha)	6 000	130	780 000
Total products			**780 000**

SOME INDICATORS OF PERFORMANCE	
Production value (FCAF/Ha)	780 000
Added value	486 300
EBITDA (FCFA/ Ha)	366 000
Operating profit (FCFA/Ha)	366 000
Profit (FCFA/Ha)	349 659
Net profit/hectare (FCFA/ Ha)	349 659
Cash flow capacity (FCFA/ Ha)	351 059

4.5 Pump renew	1	12 430	12 430
4.6Network maintenance	1	30 000	30 000
Sub-total irrigation			**65 000**
5.Labor			
5.1 Family labor			
(harvest out),70 pers.day	70		
5.2 Seasonal labor			
(harvest),20pers/day	1	25 000	25 000
Sub-total labor			**25 000**
6.Mechanical threshing			
6.1 Threshing			
10% of output	600	130	78 000
Sub-total threshing			**78 000**
7.Others charges			
7.1 Inputs transport	0.40	3 500	1 400
7.2 Bags	14	450	6 300
7.3 Crop transport	64	100	6 400
7.4 OMVS fees	1	1 800	1 800
7.5 Sprayer depreciation			1 400
Sub-total other charge			**17 300**
8.Financial charges			
8.1 7.5%/year for 9 MM	5.6%	290500	16341
Sub-total FF			**16 341**
Total charges			**430 341**

Paddy production cost (FCFA/ Kg)	75
Husking cost (FCFA/ Kg)	15
Transformation rate	66 %
Milling cost (FCFA/ Kg)	23
Bran (FCFA/ Kg)	35
Straw	Almost free
White rice cost (FCFA/Kg)	185
Husked rice cost (FCFA/Kg)	170
Margin of profit (FCFA/ Kg)	-15
Security margin (Kg/ Ha)	3 044
Variable charges (FCFA/ Ha)	90 700
Fix charges (FCFA/ Ha)	339 641
Productivity (Kg/ Ha)	2 956

Profitability index.	0.51
Operating leverage	1.88

Source: SAED, April 2009

Annex 8. TECHNICAL SHEET OF MAIZE FARMING IN SRV

Farming season	Two main seasons -Rain fed: from June-July to September-October -Irrigated system: from October-November to February-March Irrigated system provides higher yield
Seeds	-Hybrids: to renew year. More interesting yields -Composites: (JDB, Early Thai), more utilized varieties
Land preparation	-Light soils ("Fondé, Faux Holaldé") are more suitable. - Deep tillage: at least once every three years - Offset: about 15-20 cm of deep - Farming must be done is on straight and parallel ridges
Seeding	- Rain fed: seeding must be done between June 15th and July 15th - Irrigated system: seeding must be done between October 15th and November 15th - Plant density: + 62 500 plants / Ha (mechanized ridging) + 66 600 plants / Ha (manual ridging) - Spacing: + 80 cm x 20 cm (mechanized ridging) + 60 cm x 25 cm (manual ridging) - Seeding depth = 3-5 cm. - Dose of seed / Ha = 15 to 20 Kg / Ha (2 seeds per hole) - Pre-irrigation before seeding (among other things it allows to track water filtration height and thus sow at a level which will allow a best lifting change - Seeding must be generally on the upper 2/3 of the ridge

Maintenance	- Thinning if required during 4-5 leaf stage or 15-20 days after plant emergence - Avoid excess of water: draining conditions must be met - Chronology of farming operations strict follow up: Weeding, Urea, ridging, Irrigation, plants Treatments
Protection	Treat with: + Carbofuran (10 Kg / Ha) + "Lasso"GD or Atrazine (herbicides): 4-5 Liters / Ha + Bazoline 10 (insecticide)
Fertilization	- Basic manure: 200 Kg / Ha of 9-23-30 to apply o bands and buried during ridging activity - Manure of coverage: 150 Kg / Ha of urea divided into: +100 Kg / Ha at vegetative stage beginning (5-leaves stage, or 15-20 days after seedling) + 50 Kg / Ha during vegetative phase (9-10 leaves stage, or 25-40 days after first Urea application). These two fertilizers applications are done at plant feet
Irrigation (without any rain)	6 000 to 7 000 m^3 of water under three different frequencies: - Semis elongation (45 days): 10 to 15 days intervals depending on the type of soil - Elongation-early maturing: 7 days - Early maturing-harvest: 10-15 days Irrigation must be done at 10 to 12 times during maize vegetative cycle.
Harvest	Harvest: - When plants become yellow and when grain black point is visible -When grain moisture rate is between 9 and 15% for storage conditions

Source: SAED, April 2009

Annex 9. STANDARD BUDGET OF MAIZE FARMING/ INTENSIVE AND SEMI-MECHANICAL FARMING IN A LARGE PERIMETER

Charges	Qty	UP	FCFA/ha
1.Land preparation			
1.1 Tillage	1	40 000	40 000
1.2 Offset	1	18 000	18 000
1.3 Ridging	1	30 000	30 000
Sub-total			**88 000**
2. Seeds			
2.1 Seeds	20	250	5 000
Sub-total			**5 000**
3. Input			
3.1 Fertilizer			
9-23-30	200	200	40 000
Urea	120	170	20 400
3.2 Phyto products			
Carbofuran	10	1 500	15 000
Sub-total			**75 400**
4.Irrigation (paid to Union)			
4.1Fuels and lubricants	1	16 190	16 190
4.2 maintenance & Spare P	1	3 110	3 110
4.3Pump & guard charges	1	2 000	2 000
4.4 Union operation	1	1 270	1 270
4.5 Pump renew	1	12 430	12 430
4.6Network maintenance	1	30 000	30 000

Results	Qty	UP	FCFA/Kg
Maize (Kg/Ha)	400	125	500 000
Total benefit			**500 000**
Some indicators of performance			
Production value (FCAF/Ha)			500 000
Added value			266 600
EBITDA (FCFA/ Ha)			167 530
Operating profit (FCFA/Ha)			167 530
Profit (FCFA/ Ha)			154 401
Net profit/hectare (FCFA/ Ha)			154 401
Cash flow capacity (FCFA/ Ha)			154 401

Sub-total			**65 000**
5. Labor			
5.1Family labor			
86 pers/day	86		
5.2 Seasonal labor			
20 pers/day	20	1 000	20 000
Sub-total			**20 000**
6. Shelling			
6.1 Shelling: 5% of output	5%	500000	25 000
7. Others charges			
7.1Inputs transport	0.32	3 500	1 120
7.2 bags	9	450	4 050
7.3Output transport	47	1 000	47 000
7.4OMVS fees	1	500	500
7.5 Sprayers depreciation			1 400
Sub-total			**54 070**
8.Financial charges			
8.1 FF: 7.5%/year for 9MM	5.6%	233400	13 129
Sub-total			**13 129**
Total charges			**345 599**

Production cost (FCFA/ Kg)	86
Margin of profit (FCFA/ Kg)	39
Security margin (Kg/ Ha)	1 457
Variable charges (FCFA/ Ha)	76 050
Fix charges (FCFA/ Ha)	269 549
Productivity (Kg/ Ha)	2 543
Profitability index.	0.36
Operating leverage	2.53

Source: SAED, April 2009

Annex10. THE PROVISIONAL 2010/2011 CEREAL BALANCE SHEET (1000 tons)

Section	Rice	Wheat	Other	Total
1. Availability	**434.8**	**27.0**	**1015.3**	**1477.1**
Gross production	604.0	0.0	1163.8	1767.8
Available production	359.4	0.0	989.2	1348.6
Initial stocks	75.4	27.0	26.0	128.5
Farmers' stocks	0.0	0.0	0.0	0.0
Other stocks	75.4	27.0	26.0	128.5
2. Needs	**1012.2**	**383.2**	**1117.4**	**2512.8**
Human consumption	932.1	350.2	1051.6	2333.9
Final stocks	80.1	33.0	65.8	178.9
Farmers' stocks	0.0	0.0	60.0	60.0
Other stocks	80.1	33.0	5.8	118.9
3. Surplus (+) Deficit (-)	**-577.3**	**-356.2**	**-102.1**	**-1035.7**
4. Balance Import/Export	**716.2**	**350.0**	**113.5**	**1179.7**
Commercial imports	700.0	350.0	108.5	1158.5
Food aids	16.2	0.0	5.0	21.2
Export				
5. Net surplus (+) deficit (-)	**138.9**	**-6.2**	**11.4**	**144.0**
6. Cereal availability (kg)	**85**	**27**	**84**	**196**
7. Official norm (consumption/Pers (kg))			**185**	

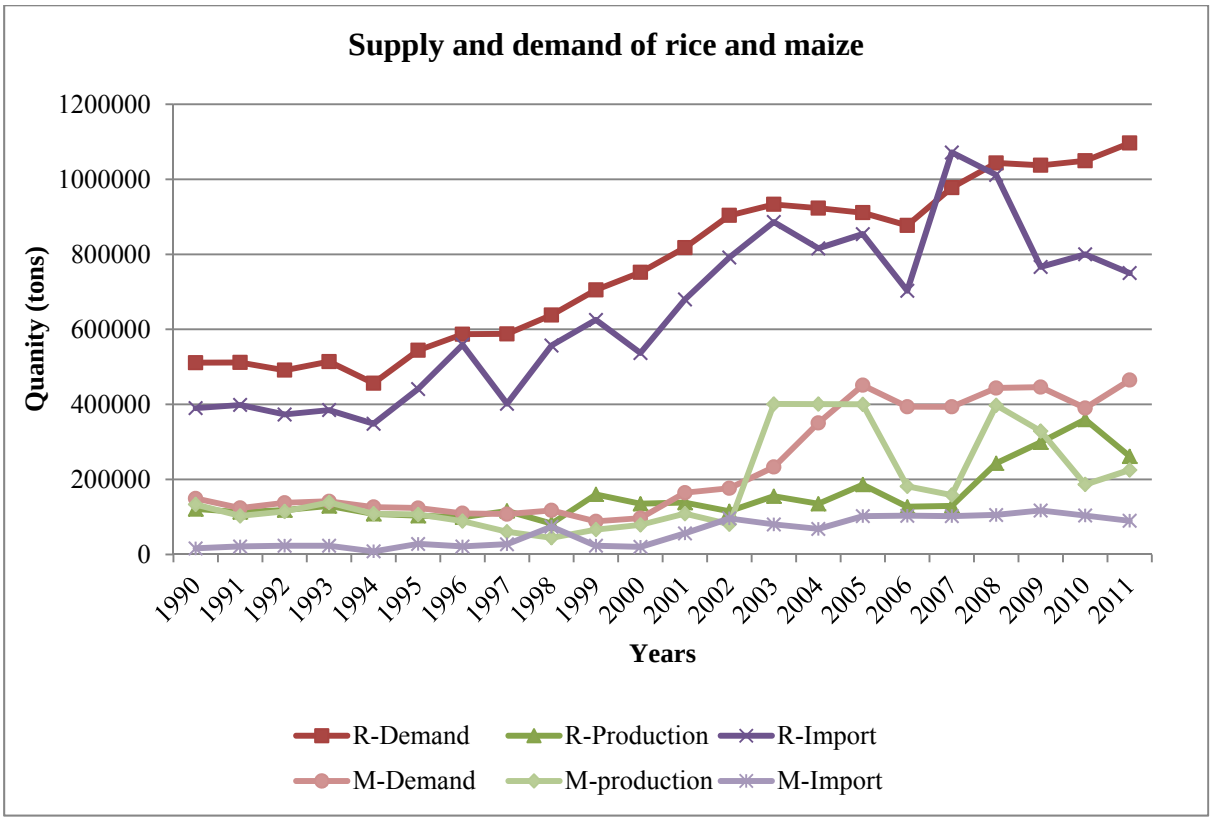
Source: ANSD, 2012

Annex 11. Senegal dependency structure

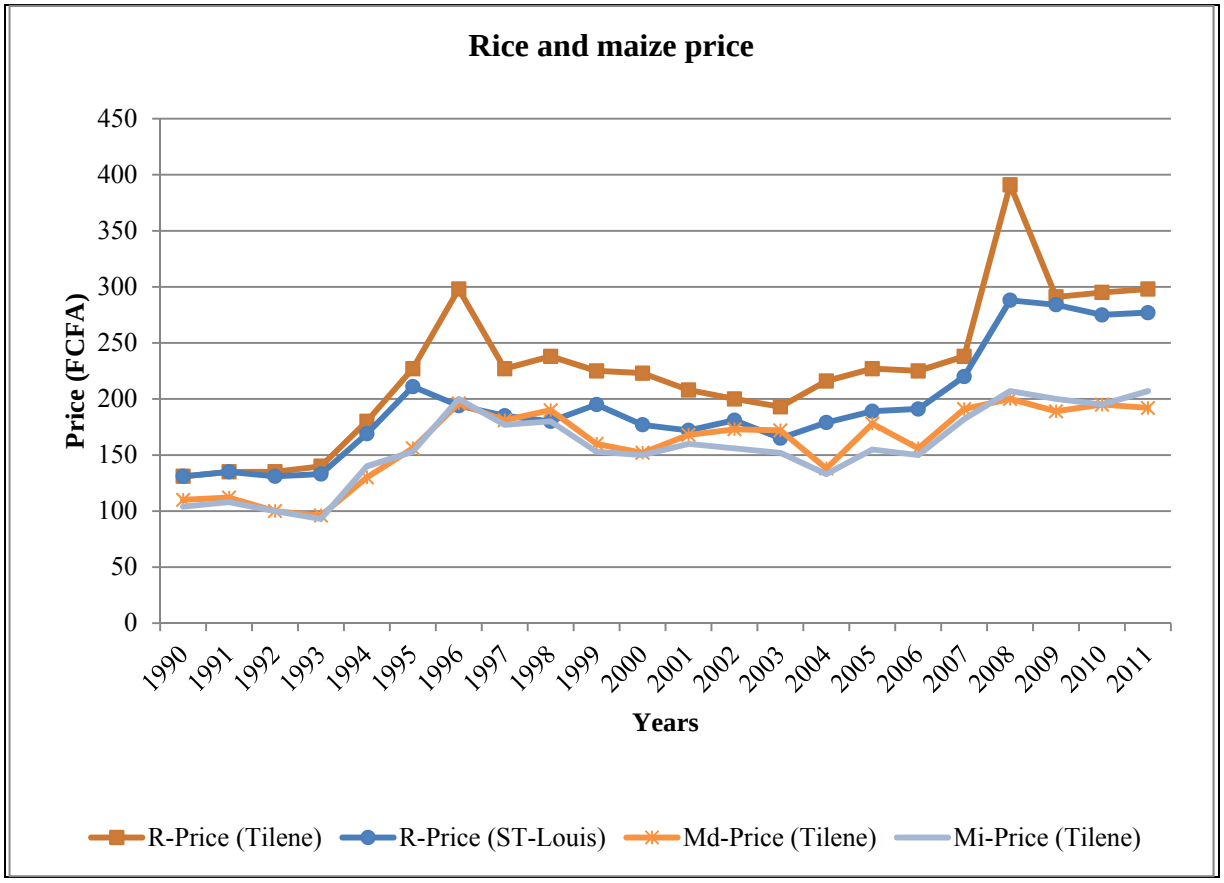
Years	Rice IDR	Maize IDR
2007	84.7	52.9
2008	83.5	49.6
2009	80	52.9
2010	79	47
2011	77.7	49.9
5 years average	80.9	50.5

Source: ANSD, 2012

Annex 12. Supply and demand of rice and maize



Annex 13. Rice and maize price trends



Source: FSO, 2012

Annex 14. Descriptive statistics of variables from January 2000 to December 2011

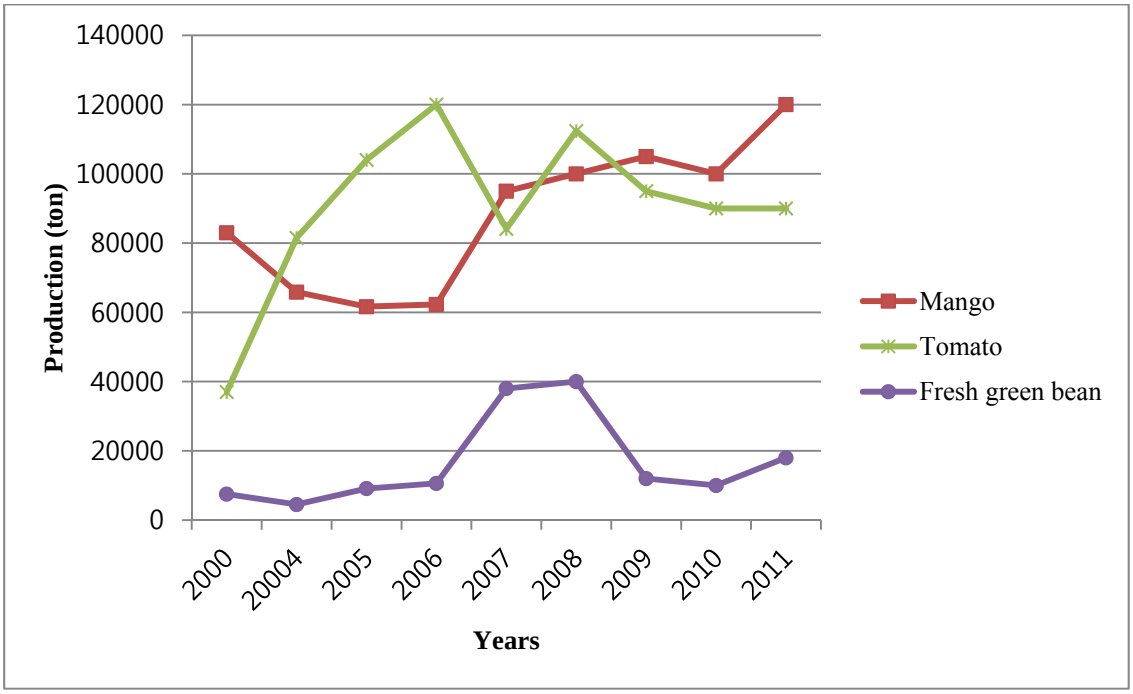
Variables	Descriptions	Obs	Mean	Std.Dev	Min	Max
SLlmp	Saint-Louis local maize price	144	181.42	28.31	125	269
SLlrp	Saint-Louis local rice price	144	218.79	47.11	149	388
Mlmp	Mpal local maize price	144	175.1	31.79	250	250
Mlrp	Mpal local rice price	144	210.19	55.33	140	367

Source: FSO, 2012

Annex 15. Annual FDI projects registered with APIX by sector in Senegal, in millions of FCFA, 2003–2009

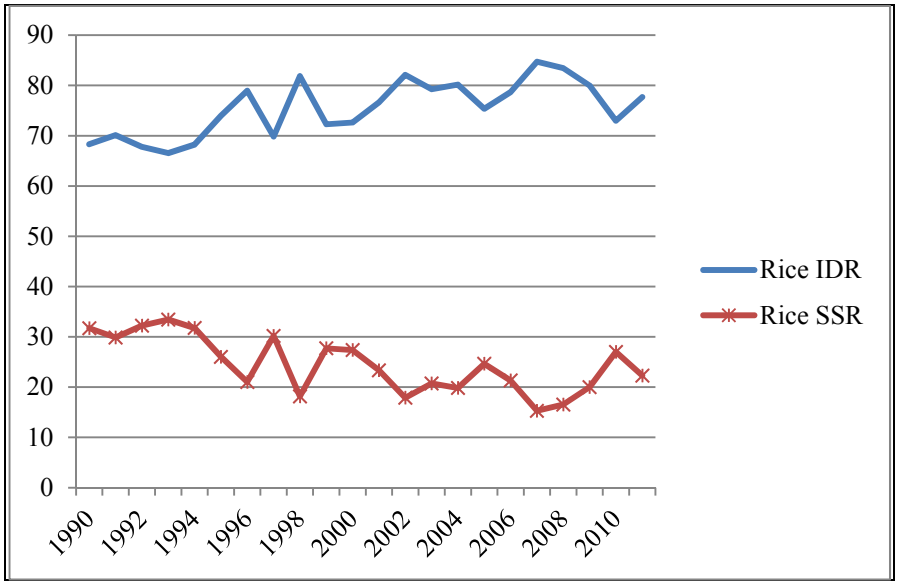
Activities	2003	2004	2005	2007	2008	2009
Agriculture	10 503	3 621	11 852.4	14 846	12 395.1	4 989
Agri-food	81.4	356.5	264.9		94.5	233.8
Agri-industry	27 264.7	2 984.8	16 072.7	15 244.7	14 190.9	3 944.7
Wood	-	-	73	200	-	174
Livestock	515	148.2		633	1 926	150
Fishery	1 868.3	5 286.2	6 689.6	4 558	3 699.2	518.2

Annex 16. Horticulture production



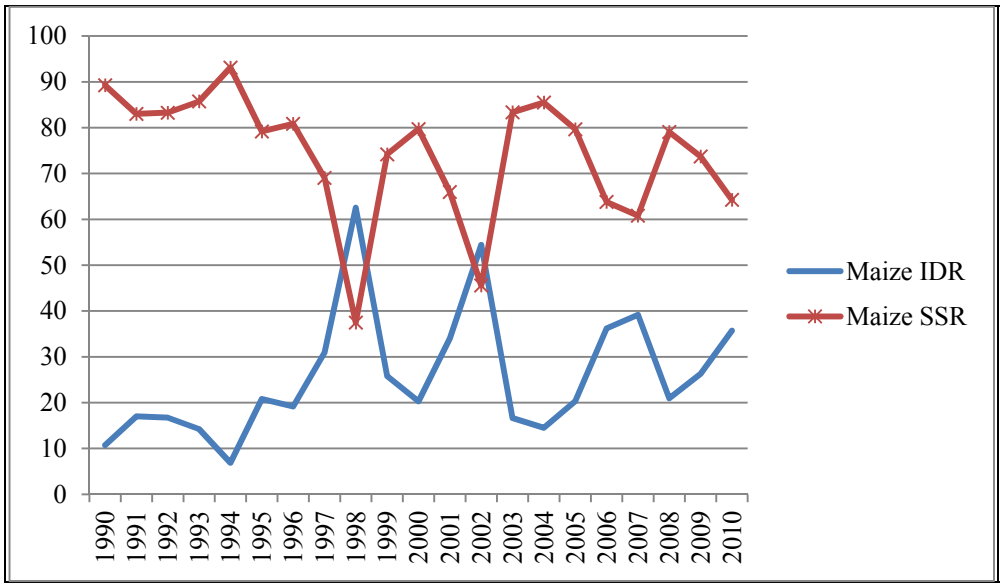
Source: Horticulture Office/ANDS 2012

Annex 17. The evolution of rice self-sufficiency ratio and import dependency ratio



Source: FAO, 2012

Annex 18. The evolution of maize self-sufficiency ratio and import dependency ratio



Source: FAO, 2012

Abstract (in Korean)

국문초록

세네갈 농업은 농지의 대부분이 천수답이고 계절성 높은 농업생산에 의존하며 낮은 농업 생산성으로 특징지워질 수 있다. 이 때문에 세네갈의 주요 곡물의 수입 의존도는 높은 수준이다. 쌀, 밀, 옥수수와 같은 주요 곡물의 수입의존도는 점차 증가하고 있는데, 이는 땅콩과 면화와 같은 환금 작물에 비해 낮은 수익성, 부적절한 농업 생산정책, 농업 생산성 정체 등의 요인으로 생산이 부족하기 때문이다. 세네갈의 경우, 곡물 생산에 있어 비료 사용량이 적고, 생산요소가 적절하게 사용되지 않기 때문에 국내 곡물 생산량이 국내 수요량 대비 약 40% 수준에 머무르고 있는 실정이다. 구체적으로, 쌀과 옥수수의 경우, 각각의 수입 의존도는 80%, 50%에 이른다.

이를 해결하기 위해 정부는 자급률 향상과 국내 생산 증대를 위한 농업 정책들을 시행해왔다. 정부의 농업 정책에 농업 연구소를 통한 규제 및 강화뿐만 아니라 농업 인프라 구축, 생산 요소(종자의 개량 및 인증, 토지 개선, 비료)의 접근성 개선, 적절한 생산자 가격 수준의 유지 등을 포함한다. 지금까지 세네갈에

는 다양한 농업정책들이 실시되어 왔다. 대부분의 농업연구소들은 대도시에 자리하고 있고 이로 인하여 농촌의 실질적인 수요와 맞지 않은 정책이 개발되었으며, 일반적으로 농정의 연속성이 담보되기에 어려울 정도로 다양한 농업정책이 일관성 없이 추진되었다. 이로 인하여 많은 정책 시도에도 불구하고 국내 농업 생산 수준은 여전히 낮고, 생산성 향상과 농촌 지역의 생산자 소득 증진이라는 정책적 목표를 달성하기에는 농업정책의 실효성이 낮으며, 따라서 GDP에서 차지하는 농업부문의 비중은 계속 감소하고 있는 실정이다.

본 연구의 목적은 식량자급을 목표로 세네갈 농업이 나아갈 방향을 설정하기 위하여 농업 생산성에 관련된 이슈를 중심으로 세네갈의 농업이 현재 어떠한 위치에 있는가, 그리고 주곡의 생산을 증대하기 위하여 어떠한 정책적 개입이 필요한가를 분석하는 것이다. 구체적으로 첫째, 현재 생산 수준과 잠재 생산 수준을 비교 분석하고, 둘째, 세네갈 강 계곡을 중심으로 쌀과 옥수수의 생산에 영향을 미치는 요인에 대한 실증 분석을 시도하고, 셋째, 농촌시장과 도시시장의 시장통합의 방향을 Granger 인과성 검정을 통하여 시도하고, 넷째, 한국과 세네갈의 국제농업협력에 대한 정책적 도구를 제시하고자 한다.

본 논문의 분석 결과는 아래와 같이 요약될 수 있다.

첫째, 국가 전체적으로 보았을 때 생산성 차이로 인한 단수 격차(yield gap)는 쌀 생산 잠재 수량의 49.75%, 옥수수 생산 잠재 수량의 79.75%를 설명할 수 있는 것으로 분석되었다. 그러나 Senegal River Valley의 단수 격차는 쌀과 옥수수의 경우 각각 37.9%와 58.75%로 국가 전체의 경우와 비교하여 약간 낮은 것으로 나타났다. 이와 같은 단수격차는 생물학적, 사회경제적, 제도적 원인과 같은 요인들에 기인하며, 이러한 제약들은 수확 및 수확 후 관리에 문제를 야기한다. 이러한 제약을 극복하기 위한 재정적 지원에는 소요자금 규모가 크고 현재 세네갈 정부의 재정 능력을 고려하면 농가와 정부의 역할 보다는 외부자금이 유입에 의존하지 않을 수 없는 실정이다. 실제로 수십년간 국내 생산성 증대를 목표로 한 다양한 농업 정책적 시도가 허사로 돌아간 이유 중 하나는 필요한 자금이 부족했기 때문이라는 것이 정설로 받아들여지고 있다..

둘째, Senegal River Valley의 실증 자료를 이용한 확률적 생산함수 추정결과는 세네갈의 쌀 및 옥수수 자급을 확보하는 데 주요한 시사점을 제공한다. 이를 실현시키기 위해 쌀과 옥수수 생산에 많은 수단이 수반되어야 하며, 이러한

수단들은 세네갈이 쌀과 옥수수 생산에 비교우위와 경쟁력을 유지하기 위한 농업 생산 효율성 추구와 지속가능한 농업생산의 가능성 등 다방면의 활동을 포함한다. 특히 농업 인프라 구축, 생산 요소(정부 보증 종자의 개발, 종자 개량, 농지 개발, 비료, 농업기계의 확충)의 확보 및 신용 시장의 확대 등이 중요하다. 나아가 정책 입안자들은 생산자 가격의 안정화를 통하여 생산자의 생산 의욕을 고취시키고, 미판매 물량의 저가 판매에 따른 위험 해소에 기여함이 필요하다. 또한 수확기에는 자녀 교육과 융자 상환으로 인한 사회, 경제적 압박감으로 생산물을 저가에 판매하는 것을 방지할 수 있는 적절한 정책적 수단을 개발하여야 한다.

셋째, 쌀에 대한 국가 보조금과 국산 옥수수 선호도는 시장 가격에 중요한 영향을 미치는 것으로 분석되었다. 이러한 점을 반영하여, 쌀의 선측인도가격(FOB) 가격과 수입 쌀 가격의 상관계수는 0.3189, 옥수수의 선측인도가격(FOB) 가격과 수입 옥수수 가격의 상관계수는 0.3189로 낮은 상관관계가 식별되었다. 세네갈 리버 벨리 지역의 곡물(쌀과 옥수수 정곡) 가격은 세이트루이스(Saint-Louis) 시장, 엠팔(Mpal) 시장과 높은 상관 관계를 가지는 것으로 분석되었다. Granger 인과성 검정 결과, 인과성 방향이 쌀의 경우 도시시장에서 농촌시장으로, 옥수수의 경우

농촌시장에서 도시시장으로향하고 있는 것으로 추정되었다. 이러한 분석결과는 쌀에 대한 수입 보조금을 국산 쌀의 품질향상 및 증산을 장려하는 보조금으로 전환시키는 것이 효과적임을 시사한다. 세네갈 내 국산 옥수수는 수입산보다 선호되고 있으므로 내수 충족을 위해 생산성 증대를 위해 노력해야 할 것이다. 또한 농산물 가공과정에 선진기술을 도입하여 도시 및 농촌의 증가하는 국내 수요를 충족시킬 수 있어야 한다.

넷째, 한국의 농업 발전에는 연구개발을 통한 기술진보, 재정 지원 등의 요인이 중요하게 작용하였다. 그러나 한국의 경우 쌀을 제외한 주곡의 수요를 국내생산으로 충족시키지 못하고 있는데, 그 이유로는 경작지 부족이 주요한 요인으로 작용한다. 이러한 점을 반영하여 한국정부는 식량안보의 달성을 위하여 한국의 투자자로 하여금 해외농업개발을 시도하고 이를 통하여 경작면적 증대를 도모하고 있다. 이러한 관점에서 한국과 세네갈 사이의 상호 협력의 효과는 상당히 클 것으로 기대된다. 한국의 협력 분야는 세네갈 농업 인프라 구축, 농업인 교육과 기술 이전 등이 될 수 있을 것이며, 이러한 협력관계의 구축은 세네갈 식량안보 문제의 해결에 도움을 줄 수 있을 것이다.

결론적으로 농업 부문 개선을 위해서는 농업의 상부/하부 구조와 연결되어 있는전반적인 요소들을 효율적으로 연계시키는 것이 필요한다. 이를 위한 농업정책은 농가의 생활수준, 소비자의 요구, 환경 보호 및 개선, 요구 충족과 지속가능성 등이 종합적으로 고려되어야 한다. 이러한 복합적인 목표가 달성 가능할 때 저임금-낮은 저축률-저위의 농업생산성이라는 세네갈의 악순환 고리를 끊고 식량자급의 달성-지속가능한 세네갈 경제성장이라는 선순환 구조로 나아갈 수 있을 것이다.

주요어: 세네갈의 농업생산정책, 식량자급, 단수격차, 확률적 생산함수, Granger 인과성 검정, 세네갈 리버 벨리 지역, 한국의 해외농업개발