

Full Length Research Paper

Global analysis of millet-based household farms: Characterization of the Senegalese production system of Niayes and Groundnut basin areas

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Niayes and Groundnut basin areas are among the largest strongholds of rainfed agriculture in Senegal. In the agricultural holdings of both agro-ecological areas, main speculations are far from optimizing their agronomic production potential. In order to analyze the organizational capacity and decision-making processes of producers, a global agronomic diagnostic work was undertaken out on the scale of 180 agricultural holdings through socio-economic and technical descriptions, while taking into account endogenous and exogenous factors of the agrarian environment. The results revealed technical and biophysical failures of the resources in their availability and/or use, but also a plethora of constraints which hinder the increase of agricultural activity and the dynamical transition of the unit. These constraints are justified by a precarious technical framework (-15%), a modest size of the agricultural unit (7.45 ha) and a small to medium crop rotation of which 42% of UAA for the first speculation, pearl millet. For the dry cereal, 19% N.P.K phosphate fertilizers use is rated with 26.05 kg ha⁻¹, and 0.46 t ha⁻¹ of background manure for an average yield of 0.59 t ha⁻¹. These conjunctures point to a system of peasant production with low market capital, limited to the satisfaction of family needs.

Key words: Family farms, farming practices, pearl millet, Niayes, groundnut basin, Senegal.

INTRODUCTION

Senegalese agricultural sub-sector contributes 7.2% to Global Domestic Product formation (ANSD, 2015). However, it remains a serious pillar of the economy and indirectly employs 51% of the working age people labour force. Through its multiple interactions, it generates currencies for other sectors and sub-sectors (e.g. trade, transport and agro-industry, etc.). The agricultural

sub-sector relies on several industrial or export and food-producing speculations, managed according to certain eco-potentialities. The latter largely influence the agricultural vocation of the natural regions through the types of speculations and sectors of activity and lead to the identification of six ecological entities including the Niayes and the Groundnut basin areas – covering 58% of

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the country's arable land and eight administrative regions.

The Niayes area and the Groundnut areas respectively provide 80% of horticultural production and two-thirds of local groundnut and pearl millet harvests, respectively. Located Situated between the 300 and 500 mm isohyets and in a rather heterogeneous pedological context, the Niayes are characterized stand out to 70% by slightly leached tropical ferruginous soils or "dior". In adjacency, the northern Groundnut basin is also covered by "dior" soils and by brown calciform soils or "deck". Also, in the southern Groundnut basin is covered by tropical ferruginous leached soils ("baqala"), and where annual rainfall can reach 800 mm. In these areas as in the rest of the country, *Pennisetum glaucum* L., a dry cereal, is a strategic crop for rural and urban households with a high protein content (Amadou et al., 2002). It is the second most common consumption after fairly imported rice (*Oryza sativa* L.) and covers part of the nutritional intake of the population. In 2013, pearl millet seedlings were valued at 52.5% of harvested agricultural lands.

Despite economic as well as food importance, the dry cereal is subject to coercion in traditional agro-systems. In recent years, episodes saw-tooth production has been observed. The ANSD (2016) estimates the decline in pearl millet production in 2013 at 22.2%. These production rebates may be due to agro-climatic, agronomic and socioeconomic crises. Indeed, the local agricultural context is marked by the reduction of set-aside time – and thus the over-exploitation of land – and the virtual absence of fertilization. From an agronomic point of view, the solution of the problems of pearl millet cultivation in the Niayes and the Groundnut basin areas must be done first and foremost by an inclusive and critical analysis of the real conditions of production.

The logic, the decisions-making methods, the production objectives and the adaptations of farmers to the social and environmental problems lead to reconsider as cultivated ecosystems and the holding unit, as a whole, a complex system. Thus the purpose of this study is therefore to analyze the production system of the Niayes and Groundnut basin areas holding unit through its social system, its operating system, its input flows and its cultivation processes, and in particular pearl millet. This research in this context is able to determine the constraints around agricultural activity and to uncover deficiencies in the technical route of pearl millet.

MATERIALS AND METHODS

The prospecting route was established on the basis of the distribution of pearl millet production and the availability of farm managers. Following a concerted effort by the members of the research team, six municipalities were selected for prospecting. For the smooth running and to facilitate the practical arrangements of the survey with farmers, contacts were made with the agricultural

and rural advisers of these municipalities. With their diligence, a simple random sampling made it possible to obtain a good representation. As a result, 180 producers participated in the assessment and 30 per municipality. The meshing was therefore carried out between December 2013 and January 2016 and in the municipalities of Kab Gaye and Ngueune Sarr (Louga region), Meouane and Sessene (Thiès region), Keur Saloum Diane (Fatick region) and Paoskoto (Kaolack region) (Figure 1). To this end, no requirements were required needed for the participation of farmers in the study. He could or could not be a member of a peasant organization. The only determining factor was that he was active in pearl millet cultivation.

Once the contact was made and the unit was identified, an interview with the farmer was made. Inclusive, semi-structured interview maintenance was carried around the set of socio-ecosystem factors related to agricultural activity. The data collected over three growing seasons covered the chief holder, the labour force, the structure of the agricultural land and its tenure, crop rotation and practices, and the rate of production. The information thus collected was captured, translated into quantitative and qualitative data.

RESULTS AND DISCUSSION

The human capital of the agricultural holding

The chief farmer of the Niayes and Groundnut basin is 52 (9.79) years old. The 55-60 age group is dominant with 17% of the workforce, those aged 30 and under do at most 2% and those aged 70 and over was 4%. In 3% of cases, it is a 46-year-old woman. Less than one farmer in two is a member of a farmers' organization, with annual membership ranging varying from 1,000 to 7,500 CFA francs per year. Less than one in six producers benefit from technical guidance from rural advisors or sometimes from relay staff persons. To assist him in the field tasks, the support of other assets is required. In the Niayes and the Groundnut basin areas, the bulk of the agricultural tasks are generally carried out in general by the working family. 6.18 Human Work Unit (HWU) who evoke both a social unit of production and consumption. The evolution continuation of work by gender has moved to a level where both male and female workers from the family group are present. Thus 30.5% of agricultural workers are women. In case of overload of the works and if the financial resources means allow in 7.0% of cases, the producer rents the services of seasonals called "surga" or "nawetane". Thus, he can simply supervise and organize the work within his property. On average, this external labour force is 1.5 seasonal for a fee of 100,000 to 150,000 CFA francs per growing season. In rare cases, the farmer producer can use day labourers who are paid on the job.

Factors and means of agricultural production

The family farms of the both two areas are small units

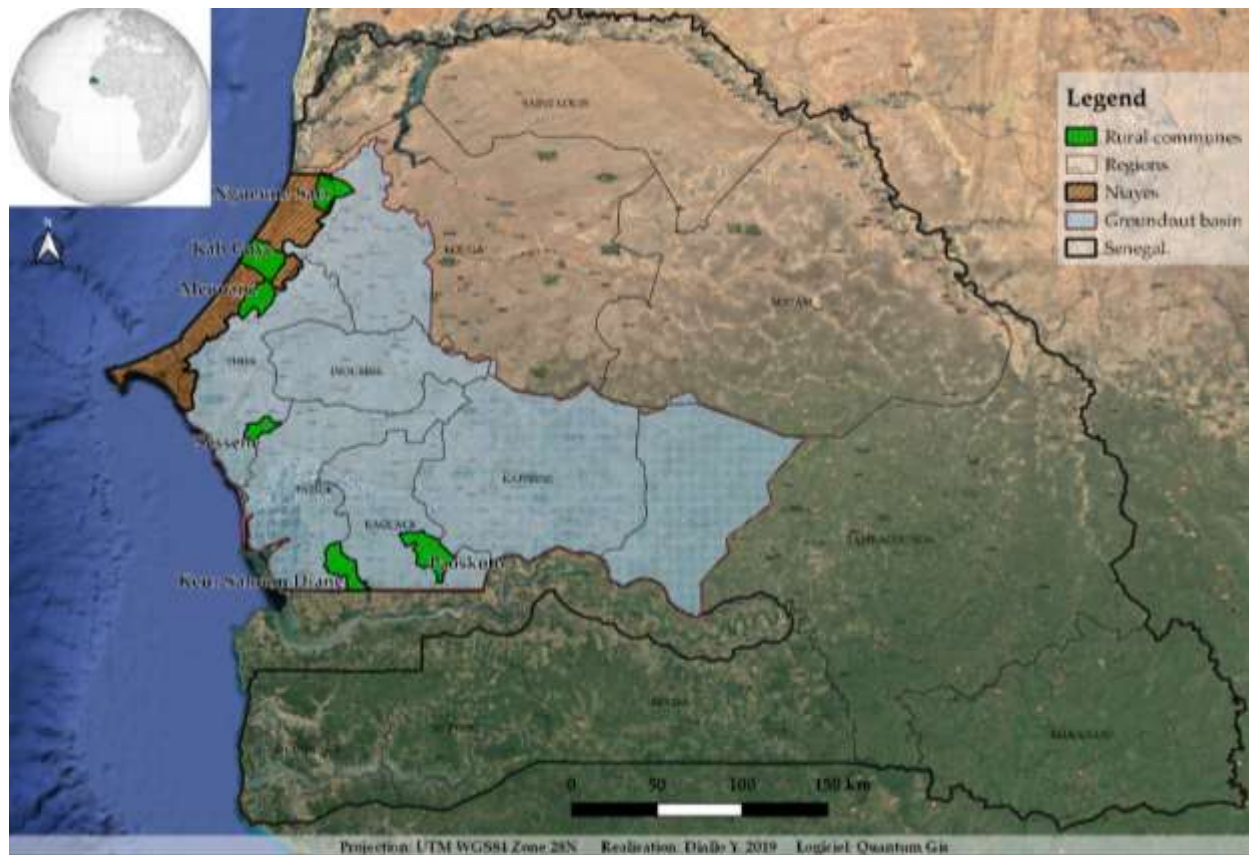


Figure 1. Study area: Municipalities surveyed in the Senegalese Niayes and Groundnut basin.

farms, often fragmented into three parcels of land. On average, the useful Utilized Agricultural Area (UAA) is 7.45 ha but can range from 2 to 21 ha. Small units of 2 to 7 ha represent 69 % of farms and large units of 14 to 21 ha make up 9%. The farms are the result of the dismantling of larger family estates domains used in owner-occupation. The difficult access to larger estates areas, and the overload of co-operators lead some producers (15.6%) to acquire land. This acquisition by lending, renting or sharecropping (“bey seedo”) represents approximately 24.2% of the total Utilized Agricultural Area (UAA).

On these farms, a cell livestock (e.g. cattle, sheep, goats, equines and asins) is formed and for a density index of ruminants about 0.31 livestock Unit per hectare (LU ha⁻¹). Sheep make up 35% of ruminants, cattle 33%, and goats 32%. The farmer has more than 1.76 traction-coupling animals, 64% of which are equines. Cattle count for are a very small part of draught animals. In terms of availability compared to the diverse working tools of work, the results show near autonomy in the realization of the cultural, pre- and post-cultural operations. Agricultural equipment is often made up of a carts used for

locomotion and the transport of heavy loads to the field, disc drills, tracted tool (e.g. “sine” or western hoe), and handle-type tool (e.g. “iler”, “daba”). The thresher is the least available equipment and is often privately owned.

Agricultural production

Land the use of agricultural land shows a standardization of uniform the agrarian landscape. Pearl millet and groundnut [*Arachis hypogea* L.] are the two main crops, accounting for less than 80% of the seeded area planted. Secondary crops are subject to some sectorization, probably because a function of soil predisposition (Table 1). Millet is used with varieties: *Souna*, *Thialack*, *Souna 3*, *Sosat C88*, *Thialack 2*, *IBMV 8402*, *Gawane* and *ICTP 8203* at very low-use. Groundnuts are found in the forms *28-206*, *55-437*, *73-33*, *PC 79-79*, *GH 119-20* and *Fleur 11*. *Early Thai*, *Pan 12*, *Camara 1* and *Synth C* are the crop types of corn grown. The various varieties of cowpea (*Vigna unguiculata* (L.)) sown are *66-35*, *Yacine*, *Melakh* and *Mougne*. Cassava (*Manihot esculentum* (L.)) is present there with *Soya*, *Kombo 1* and *2* and sorghum

Table 1. Rotation and main crops grown in the Niayes and the Groundnut basin.

Municipalities	UAA (ha)	Millet UAA (ha)	Groundnut UAA (ha)	Secondary crops UAA (ha)
Kab Gaye	8.50 ± 4.78 ^{ab}	3.20 ± 2.21 ^a	3.08 ± 1.36 ^a	Cassava (2.22 ± 1.98) ^{ab}
Ngueune Sarr	6.50 ± 3.81 ^b	3.20 ± 2.51 ^a	2.80 ± 1.66 ^{ab}	Cowpea (0.50 ± 0.51) ^c
Meouane	9.35 ± 4.04 ^a	2.87 ± 1.12 ^a	2.80 ± 2.06 ^{ab}	Cassava (2.73 ± 2.75) ^a ; Cowpea (0.95 ± 1.09) ^b
Sessene	6.35 ± 3.58 ^b	3.65 ± 2.68 ^a	1.96 ± 1.72 ^b	Sorghum (0.74 ± 0.77) ^c
Keur Saloum Diane	7.00 ± 3.59 ^{ab}	2.70 ± 1.58 ^a	3.00 ± 2.05 ^{ab}	Maize (1.30 ± 0.82) ^{abc}
Paoskoto	7.00 ± 3.82 ^{ab}	2.96 ± 1.41 ^a	2.88 ± 2.01 ^{ab}	Maize (1.16 ± 1.18) ^{abc}
Mean ± SD	7.45 ± 1.20 ^{ab}	3.10 ± 0.33 ^a	2.75 ± 0.40 ^{ab}	1.60 ± 1.18 ^{abc}

Averages with the same alphabetic letters (a, b and c) are not significantly different ($P > 0.05$) according to the Kruskal-Wallis test.

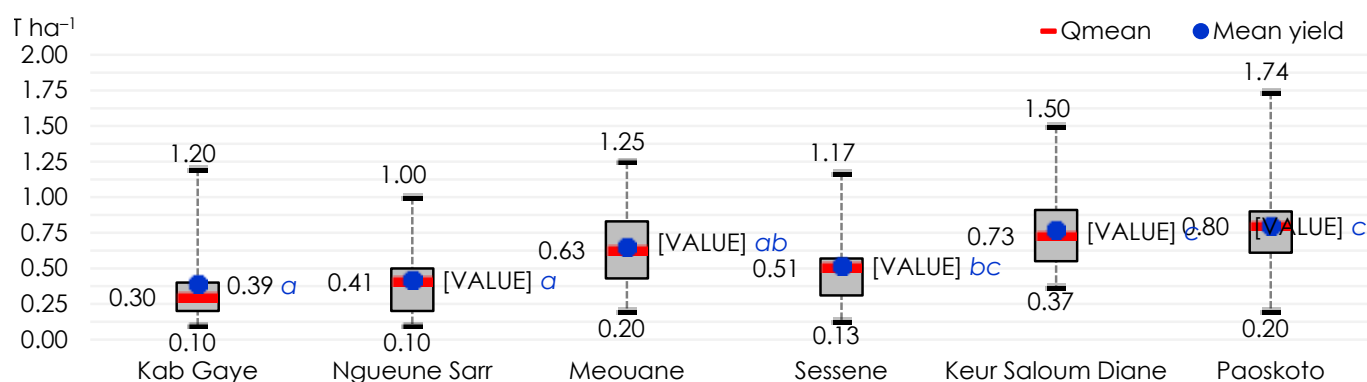


Figure 2. Yields of millet observed ($t\ ha^{-1}$) in the Niayes and the groundnut basin averages with the same alphabetic letters (a, b and c) are not significantly different ($P > 0.05$) according to the Kruskal-Wallis test.

([*Sorghum bicolor* (L.)] with *Nguinth* and *Darou*).

Pearl millet is grown on plots located around a 2 km radius of the concessions and covering 42% of the UAA. 60% of the crop is planted on sandy soils, while the bottom soils are present on 7% of the millet plots. The annual balance sheet in the two zones shows generally fairly low and highly very variable yields of millet grain (from 0.10 to 1.74 $t\ ha^{-1}$). The average yield recorded is 0.59 $t\ ha^{-1}$ (Figure 2).

Technical itinerary for pearl millet cultivation

Taking into account the specificities of each culture crop and the dynamics of rotation place the development blossoming of subsequent speculation. The study of rotary crop rotation systems shows that in the six municipalities, a biennial sequence rotation with groundnut, a *fabaceae*, is practiced in agricultural units to the tune of 73%. Apart from groundnut, the precedents of millet are diverse. Among these previous crops, pearl millet is renewed in 11% of fields, cowpea 6%, unprocessed annual fallow 5%, maize and sorghum 2%,

and cassava 1%. These various precedents have immediate effects on millet cultivation but are contrasting, both in terms of nitrogen residues and on the plant health aspect.

Clearing or slash of the seedbed ("routhie") in this traditional environment exists in two ways: the simple or without burning and the one by burning or slash and burn. However, simple clearing was not noticed. In the pre-cultural cleaning of the millet plots, the producer of this both areas the Niayes and the Groundnut basin gathers the stumps and other residues to for burning them, in order to clear the seedbed. This practice, which poses a high risk of degradation of organic matter, helps to eliminate good part of would contribute to the removal of much of the weed seeds from the surface layers of the soil, and to the destruction destroy of a good number of subservient parasites, especially after a previous cereal.

In the agro-pastoral zones of the Niayes and the Groundnut basin, the basic manure is in the form of livestock manure and household waste. Based on the survey results, the amendment on the pearl millet plot is practiced by 92% of producers with an average of 0.46 $t\ ha^{-1}$. Local background manure with doses range varying

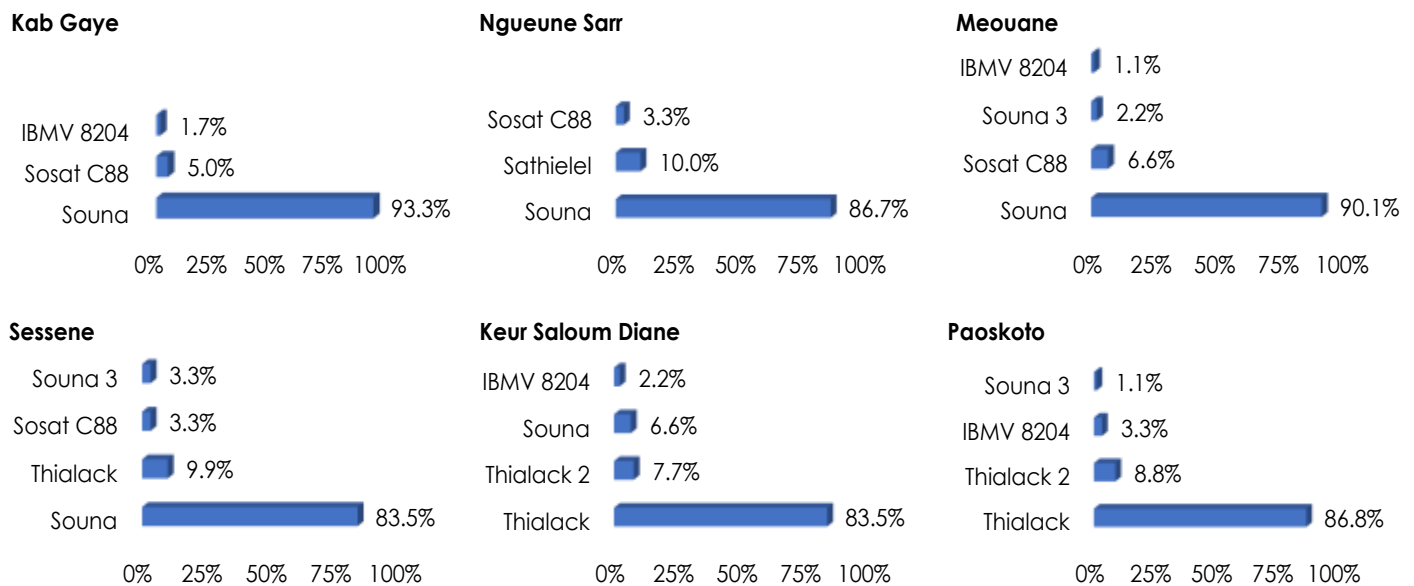


Figure 3. Distribution of the main varieties of pearl millet grown in the Niayes and the Groundnut basin.

locally from 0.14 to 0.90 t ha⁻¹. These quantities of background manure do little to meet the needs. If the practice improves the yield, it seems more advantageous to associate it with the effects of ploughing for an improved seedbed. Yet this superficial tillage or scratching is practised by only 22% of producers.

Despite the availability of improved seeds (for example Thialack 2, Sosat C88, Souna 3 and IBMV 8204), the utilization rate remains very low (Figure 3). Thus, Thialack 2 and Sosat C88 are adopted, respectively, at rates of 2.8 and 3.8%. Widely present on plots (91.73%), landraces (Souna and Thialack) are more appreciated for their adaptation to the diversity of traditional millet cropping farming systems of the Niayes and the Groundnut basin areas, despite their problems of low productivity issues. 75% of the cultivated millet varieties come from producers' personal reserves, 28% are purchased on the local market and 7% come from extension.

The recommended seeding densities for pearl millet are between 3.50 and 4.00 kg ha⁻¹, with spacing of 0.90 and 0.80 m between the lines and 0.80 m between the hills seed pockets. In practice, these densities go beyond or below these differences, depending on whether the crop(s) are pure or associated. The recorded doses are quite good, with a mean of 3.80 kg ha⁻¹, although between farmers it varies from 3.00 to 6.00 kg ha⁻¹. The date of sowing depends on the type of crop rotation (types and number of crops). 70% of producers proceed with a use dry seeding to alleviate lighten the growing calendar.

According to the results, only 29% of the producers practice a binary crop association (pearl millet and

cowpea). The choice of species and varieties to be combined, the date of sowing and densities are above all essential to avoid any competition due to allelopathic effects. In the light of the study, millet is sown first and for the technical choice of a spatial organization, cowpea pokes patches are placed alternately between the lines of the cereal to allow mutual and enhanced production of crops and facilitate weeding operations.

Hoeing operations are carried out in two phases and rarely in three. The first maintenance phase, or "baxao", is usually carried out in the first week by 47% of producers and 53% in the second week following the millet surge. During this step, the thinning demarcation or wolle is done at three millet plants per poke. The second weeding or "bayaat" coincides with the run-up phase and is done between the 15th and 20th days following the first weeding by 67% of the farmers in the agro-systems or between the 25th and 30th days by the other farmers. A third weeding or "balarci" optimizes the phytosanitary aspect and is performed by more than 30% of farmers within a fortnight of the second weeding.

In the areas studied, only 19% of farmers acquired NPK phosphate fertilizers of type N.P.K. This ratio goes from 17 (Kab Gaye and Sessene) to 43% (Paoskoto). The fertilizer dose applied to the plot is 26.05 kg ha⁻¹. From one municipality to another, the dose ranges from 15.80 (Sessene) to 38.50 kg ha⁻¹ (Paoskoto). The various formulas of N.P.K identified are 15-15-15, 15-10-10, 10-10-20 and 6-20-10. Fractionation is usually done based on the amount of fertilizer available. Thus, cover fertilization, for 35% of the plots was carried out in two phases (sowing-thinning demarcation or thinning-running-up rigging) and thus 65% in one step (sowing or thinning

singling).

Following a millet harvest of millet ears, two threshing options are possible. In the first case, the ears are piled up packed in bundles of 8 to 15 kg and kept in granaries attics. Manual threshing is done carried out as needed and in small quantities to cover the daily food ration diet. It is carried out in 14% of the units households. Less restrictive, the second option is practised by 86% of operators. The use of time threshers is one of the major constraints. The producers waiting, store their crops in the field. Once motorized threshing is completed, the grain is placed in bags and placed in a storehouse room in the dealership.

Senegalese agricultural social system

The farmer of the Niayes and Groundnut basin areas is a senior-aged leader with more than a dozen valid arms, mostly from the domestic square. The high labour costs explain very little the contribution to the salary activity of the family unit. It is more justified by the form of reciprocity or loyalty within the Senegalese family, which makes its agriculture a family activity (Gafsi, 2014). More than one in two managers is over 51 years old. The total tenacity of the elderly at the head of the units is partly explained by the hierarchical basis of the traditional Senegalese society. The inheritance of land is hereditary and is done according to a legitimate lineage (Bosse-Platière, 2007). The son who has the right to inherit, simply supports his father within the unit, by organizing the family support caregiver. These present circumstances, combined with the by the children of farmers from the sector, are placing putting more and more women in charge of family farms. Cultural and religious burdens being unfavorable to them, especially the access to labour land; little was done to make them responsible for the productive work of the units. The number of women who have their own farm is still relatively insignificant. The general observation is that they seem to be more perceived as surplus labor (Bessière and Gollac 2014). Otherwise, his the lack of crude adherence of the producer to peasant development networks on the one hand and its precarious supervision by the advisory structures on the other hand, justify its weak cooperative work, its precarious capacity in the logic of production and marketing but also in the management of its production unit.

Senegalese agricultural operating system

If the UAA of the farm and the resources mobilized return to a small family farm, the social dimension of productive purposes makes the farmer of both Senegalese agro-systems, a subsistence farmer (Sourisseau et al., 2012).

Furthermore, inheritance of the family property to the heirs frequently leads to the nuclearization of agricultural land, and has establish in Niayes and Groundnut basin to the phenomenon of peasant landless and the land market. The understanding of the system of primary production of goods involves the regionalization of crops, linked either to the quality and availability of land, and to local activities, thus to the district economic base fabric. Beyond the natural features, the intended productive goals relate mainly to the life cycle of the agricultural holding unit, its social structure and the professional singularities of the farm manager (Madelrieux et al., 2012; Pradel and de Gervillier 2011). These production goals generally revolve around major crops such as groundnuts and pearl millet and secondary or minor speculations – occupying less than 5% of the agricultural area, often planted as infill or field borders. However, the adoption of a productive system must meet the obligation to finance the agricultural unit and the primary needs in order to ensure the social cohesion of the family. Thus the chosen medium field must have suitability for cultivation to sustain a certain production.

“Dior” soils guarantee a good root respiration, nevertheless its carbon, nitrogen, in useful water and exchangeable bases, make the crop production systems of the Niayes and the Groundnut basin are uncertain. Short-term fallow becomes an obligation to restore the productive land base of land (Boli and Roose, 2000). However, its inadequate local practice leads to reconsider a the land pressure as well as a and the changes of actors – with new production objectives – in the transmission of farming land. By socioeconomic and technical-economic parameters, the frequency of biennial rotation of the majority biennial is explained, besides an agronomic interest, by the surplus-value of the groundnuts in the 1960s. This priority development for cash crops often allows for hoarding in livestock production, diversifying activities and cash receipts. In spite of this, the lack of pasture roads in the areas and the insecurity in rural areas zones can only allow in the majority of the production units, a case small breeding.

Input flows and millet cultivation processes

The technical itinerary of pearl millet cultivation reveals peasant practices based on knowledge and perceptions related to the socio-economic environment. The producer, thus, becomes rational in his decision and is right to do what he does. The family farm unit of the Niayes and the Groundnut basin areas is confronted to the difficulty of using human and animal energy to conduct the crop (Gafsi et al., 2007). The primary tillage of the soil is insufficient and its non-performance cannot be justified by the reduction of the organic base but by the heavy work for the draught animal. The amended

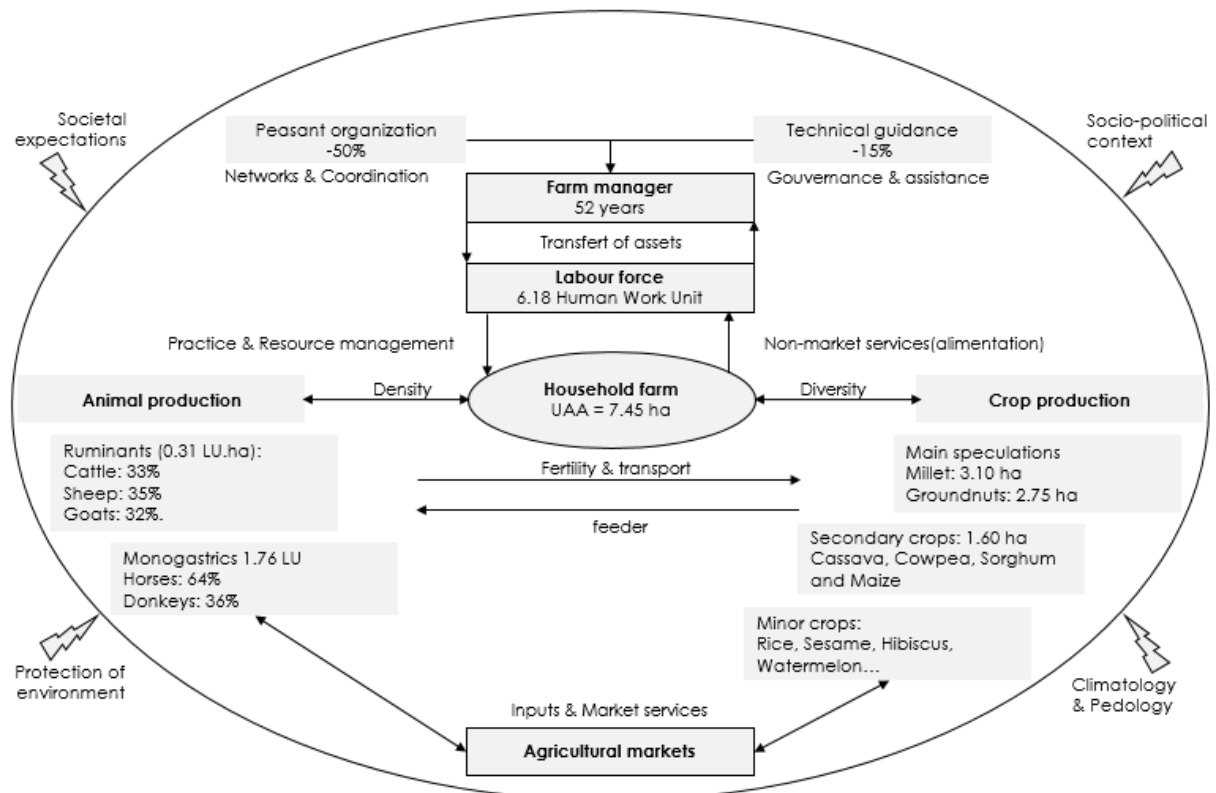


Figure 4. Systemic vision of the household farm of Senegalese Niayes and groundnut basin.

quantities do not allow a significant gain in pearl millet productivity in these agro-systems. These doses are relevant to the size of the farm. Crop systems are globally, without or with low fertilizers because of the input cost and value ratio of the millet crop, poorly commercial, and because of the lack of subsidy policies. But the low uptake of improved varieties is partly related to the delegate aspect of extension and not to a the thorny question of purchasing power, hence a regular and adaptive renewal of seed capital. In view of Compared to the rainy regime, the first rains are of crucial decisive importance for the lifting, the start-up of the grain and its competition against weeds (Fox and Rockstrom, 2003). In both agro-systems, the heaviness of manual labour and the obsolescence of agricultural equipment constitute an obstacle to good harvests of crops. However, weed pressure can be reduced by a cultural association with cowpea (Lawane et al., 2010). Although and the poor means of crop conservation remain the major problem of pearl millet culture in Senegal.

Conclusions

The agronomic analysis undertaken at the scale of the Niayes and the Groundnut basin suggests an interesting

diversity of productive logics underlying technical skills the economic and organizational aspects of the agricultural unit and its social links to the activity (Figure 4).

Clearly the methodology of the overall analysis of the agricultural holding reveals many failures and adaptive processes of the local production system in phase with the sociopolitical and climatological injunctions through its exploiting population, its farming land, its management and its relations with other actors. These failures are materialize at the level of the agricultural holding by a weak alternation crop rotation and precarious cultivation activities. These conjunctures deficiencies are exported on the millet plot by a crop route and farming practices defective. Overall, it emerges, a Senegalese family and food agriculture, with weak policy of support and financial capacity for production, extensive and low level of efficiency that is rather unstable and subject to the hazards of the climate and the vagaries of domestic markets.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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