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# Smallholder farmers practices of crops livestock integration in the district of Aguié (Niger): Characterization of farms

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## Abstract

Crop production and livestock are main economic activities of most of populations in Maradi region. A study was carried out in order to characterize farms in terms of farming practices of crops livestock integration in 4 villages of Aguié. The results of surveys randomly conducted on a sample of 78 farmers showed that farmers were categorized into two groups, which are farmers (67%) and agro-pastoralists (33%). However, the multivariate analysis of data highlighted existence of three categories of agro-pastoralist farmers, distinct in terms of their means of existence and levels of integration. The category were big farms (BF)(41%), medium farms (MF) (33%) and small farms (SF) (26%). Regarding average annual incomes, BF have 375,653 FCFA, MF 172,235 FCFA and SF have only 73,167 FCFA. The average land capital held by BF is 8 hectares, MF own 3 ha and SF have 1.8 Ha. For integration parameters, organic manure (OM) fertilization ratio is 4.4 cattle cart per hectare in BF, while MF put 5 per hectare against 9 in SF. For mineral Fertilizer, BF used 40 kg/Ha, against 25 kg/ha for MF and 15 Kg/ha for SF. The yield, for cereal crops, is higher in SF with 464.6 kg/Ha, 336 kg/ha for EM and 306 kg/ha for BF.

**Keywords:** Integration; Agriculture; livestock; Climate change; Aguié; Niger

## 1. Introduction

Located in the heart of Sahel, Niger is a continental country with an area of 1,267,000 km2, with nearly two-thirds (2/3) occupied by desert. The Nigerien Sahel appears as a transition zone between the Sahara and Sudan [1]. It also presents itself as a zone of convergence and contact, between the pastoral world and agricultural world, in search of new and free land for pasture and clearing. Niger's economy is essentially based on agriculture and livestock. These sub-sectors occupy more than 80% of the population and contribute nearly 33% to added value of rural sector and 12% to national GDP [2]. Demographically, Niger ranked 18th among the most populous countries in Africa with 19.7 million inhabitants in 2016, and will rank 11th with 68.9 million in 2050 when we take into account its synthetic fertility rate which is 7.6. The problem of land use characterizes relationships of complementarity and/or competition depending on whether one is a farmer, agro-pastoralist or stockbreeder. Thus, we are even witnessing conflicts related to the use of resources and leading to brutal or progressive restrictions of pastoral space. This leads to increasing difficulties in the movement of groups of animals around the country [3]. It is in this way that the relations of economic complementarity must first be grasped at level of the basic family units, considering that agriculture and livestock breeding contribute together to ensure the reproduction of social, economic and cultural systems whose agricultural production is only one dimension. The herd accompanied group in peregrinations, and is used as a means of transporting loads [4].

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Faced with these main constraints of variability and climate change with effects that are increasingly felt [5] on various sectors of socio-economic activity in Sahelian countries, it follows from consequences of irregular rainfall in time and space, recurrent droughts, decline in soil and livestock productivity in addition to constant reduction of cultivable areas and floods [6]. Studies have shown the advantages of mixed crop-livestock systems in terms of economic and climatic sustainability [7] and their central role in sustainable performance [8]. It is important to characterize current practices of agriculture and livestock integration in order to encourage the optimization of an integrated farming model.

The overall objective of this study is to identify practices and techniques of agriculture-livestock integration in this context of climate change in department of Aguié. Specifically, this study to analyze and characterize the farm practice of integration of agriculture and livestock in the study area. Material and methods

### 1.1. Study zone

The department of Aguié has an area of 2800 km2. It is one of eight departments of Maradi region and has two municipalities, including municipality of Aguié. It is bounded to the east by department of Gazaoua, to west by those of Guidan Roumdji and Madarounfa, to the north by that of Mayahi and to the south by Federal Republic of Nigeria over a length of about 50 km. This study was conducted at level of four intervention villages of Research Development project for Food Security and Climate Change (RED/SACC) in municipality of Aguié. The choice of sites in this rural commune as study area was motivated by fact of being one of intervention communes of RED/SACC Project, on one hand, and its relative ease of access compared to limit of means available on other hand. Thus, four villages (Dan Saga, Debi, Maigaoudi and Guidan Dawaye) out of five interventions of development research project for food security and climate change (RED/SACC) were selected for this study, fifth ( city of Aguié) having been dismissed, given certain difficulties linked to its urban character, but also jointly capital of department and municipality of same name, which is not very favorable to this investigation.

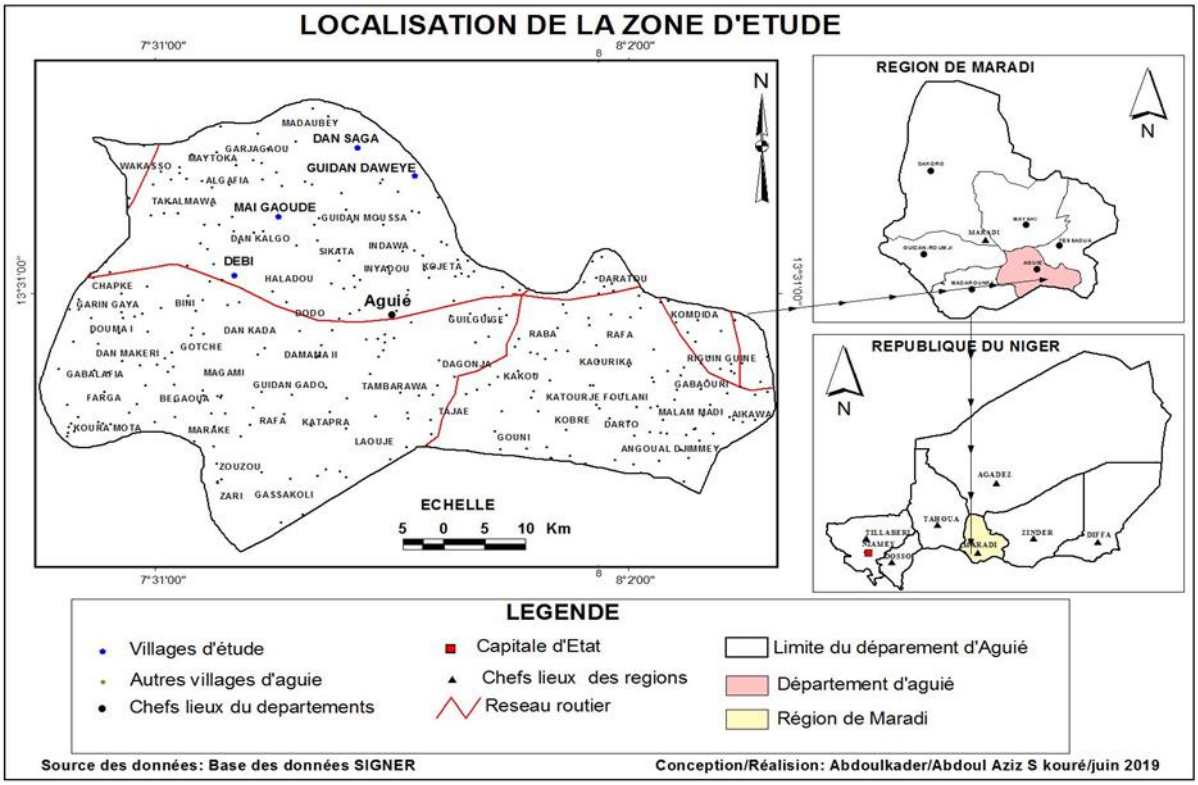



**Figure 1** The stady area

**Table 1** Geographical coordinates of villages surveyed

| Villages | Longitude | Latitude |
|---|---|---|
| Débi | 7.6 | 13.54 |
| G.Dawaye | 7.88 | 13.66 |
| Dan Saga | 7.73 | 13.7 |
| Maigaoudé | 7.65 | 13.62 |

### 1.2. Collection of data

The purpose of holding a general assembly at each site was to present and explain the purpose of the survey and conditions for its execution; it also explained the choice of sampling method and its relevance, and the framework that served for administration and information of village questionnaire.

Data collection was carried out in two stages. The first stage for information and sensitization at the level of each site on the objective of the study, the choice of respondents and scheduling appointments for data collection. The second stage consisted of actual collection of data. Two types of survey questionnaires previously developed, tested and amended were administered in field (i.e., a village questionnaire administered in village assembly and a farm questionnaire administered individually to heads of farms).

The other tools used for data collection are knight chart and kraft papers for participatory diagnostic and analysis work (VEN diagram, resource maps; analysis of constraints for different areas, a camera for taking view and a GPS for georeferencing. The logistics having made it possible to accomplish this work, which for the most part took place in the field (collection of primary data). A "Hilux 4X4" vehicle was mobilized to facilitate movement of investigators who are part livestock technical service agents with a certain knowledge of area coupled with their experience in collecting socio-economic data from the rural world. It was systematic and at intervals at level of each village. The objective was initially to survey one hundred (100) farms in total, with twenty (20) per village. However, village of Aguié having been finally ruled out, 80 farms were targeted and 78 were finally affected by this survey. Thus, we have a representative sample of 9.1% of households in four villages (i.e. 78 out of 857 households).

The choice of sample was random and consisted from a practical point of view of:

- numbering, from 1 to N, of all units included in sampling frame (where N is size of total population in each village);
- determination of the sampling interval (k) by dividing number of units included in population by size of desired sample (here 20 per village);
- randomly drawing of a number between 1 and k by an assistant at a village assembly. This number was chosen randomly and is considered the first included number in the sample;
- the selection of each (kth) unit in a regular and progressive way after the first number on the nominative list available from village that represents our sampling base.
-

### 1.3. Statistical analyzes

The data collected was previously entered, organized and checked in an Excel spreadsheet for statistical processing. Pivot tables and charts were produced for a first assessment. A second analysis by generalized mixed model in GenStat 9th edition was carried out.

Categories were included as fixed effects and producers were considered as a random effect. The Student Newman-Keuls test was used to compare means with significant differences. The third analysis (multivariate) was performed using Minitab-14 software. The latter made it possible to carry out the principal component analysis (PCA), followed by an ascending hierarchical classification (AHC) to highlight similarity between operators and correlations between variables.

## 2. Results

### 2.1. Characterization of farms

*2.1.1. According to the perception of producers*

The typology made on basis of declaration of heads of farms highlight two types of farms, one made up of farmers and other of agro-pastoralists. Thus, starting from analysis of eight (8) variables (Table 2) on characteristics of livelihoods, averages are compared between two types of farms. Statistically significant differences were observed in terms of land capital (P<0.032), amount of mineral manure used (P<0.027) and the number of small ruminants, especially sheep (P<0.026). Thus, average land held by agro-pastoralists is worth twice that of proclaimed farmers, but with great internal heterogeneity in two categories. The mineral fertilizer used by agro-pastoralists is worth three times that used by farmers and for small ruminants, especially sheep, agro-pastoralists have a little less than three times what farmers have.

**Table 2** Comparison of the averages of variables by main activity

| Variables | Farmers (52) | Agro-pastoralists (26) | Probabilities (5%) |
|---|---|---|---|
| Total area (ha) | 3.7 ± 2.7 | 6.1 ±6.7 | <0.032 |
| Agricultural assets | 3.846 ± 4 | 3.4 ± 2.1 | 0.583 |
| Production of organic manure | 17.5 ± 14.3 | 22.2 ± 15.5 | 0.191 |
| FM quantity (50kg bags) | 2.4 ± 5 | 6.6 ± 11.5 | <0.027 |
| Draft cattle | 0.5 ± 0.5 | 0.8 ± 1 | 0.109 |
| Sheep | 1.6 ± 2.9 | 3.8 ± 5.5 | <0.026 |
| Goats | 4.2 ± 3 | 6.1 ± 7.4 | 0.12 |
| Poultry | 6.7 ± 11.8 | 5.9 ± 7.3 | 0.768 |

Note: ± Standard error; Means with same letter on the same row are not significantly different.

*2.1.2. Characterization according to a multivariate analysis*

The ascending hierarchical classification (AHC) made it possible to group producers into three (3) categories of farms. Big farms represent 38% of producers surveyed, while medium and small farms have each 31% of farms in study area. Thus, variables having been grouped by more or less homogeneous parameters, we distinguished structural parameters, integration parameters and production parameters. ascending hierarchical classification (AHC) made it possible to group producers into three (3) categories of farms.

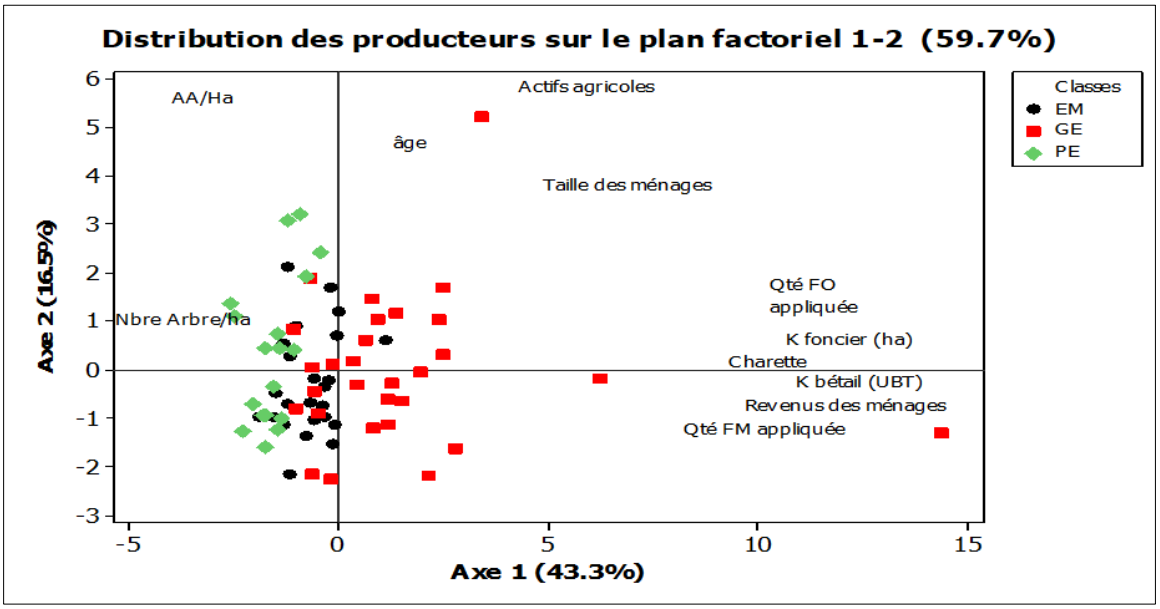
*2.1.2.1. Principal component analysis (PCA)*

Principal component analysis (PCA) made it possible to discriminate farms according to distribution of structural variables and other means of production on agricultural and livestock practices. The contribution of 12 PCA factorial axes (Table 3) ranged from 0.6 to 43.3%. Factorial axes 1 and 2 (Table 3) explained 60% of total variability. Thus, the first axis (43.3%) discriminated farms according to land capital, producer income, quantities of organic and mineral manure invested, livestock capital and carts. As for second axis (16.5%), it is explained by age of producers, agricultural assets, ratio of agricultural assets per hectare and the people in charge (size of households). The factorial plane (figure 2) gives a distribution of producers, with dig farms (in red) being more to the right, Medium Farms (in black) more or less in the middle and Small Farms (in green) to the left

Table 3 Variation of eigenvalue on 12 PCA axes carried out on characteristic variables of agropastoral farms in the municipality of Aguié in Maradi region in Niger.

**Table 3** Variation of eigenvalue on 12 PCA axes carried out on characteristic variables of agropastoral farms in municipality of Aguié in Maradi region in Niger

| Axis | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Own values | 5.19 | 1.97 | 1.28 | 0.93 | 0.71 | 0.57 | 0.45 | 0.30 | 0.25 | 0.17 | 0.09 | 0.08 |
| % variability | 43.3% | 16.5% | 10.7% | 7.8% | 5.9% | 4.8% | 3.7% | 2.5% | 2.1% | 1.4% | 0.8% | 0.6% |
| Cumulative % | 0.43 | 0.60 | 0.70 | 0.78 | 0.84 | 0.89 | 0.93 | 0.95 | 0.97 | 0.99 | 0.99 | 1.00 |




GE: Big farms (BF); EM: Medium farms (MF); PE: Small farms (SF); FO: organic manure (OM); Agricultural workers per hectare: AA/Ha; Qté: Quantity; FM: Mineral fertilizer, UBT : Tropical livestock unit

**Figure 1** Factorial plan of the distribution of categories of farms according to the livelihoods of producers

**Table 4** Contributions of different variables to construction of main axes of the factorial plan

| Variable | PC1 | PC2 |
|---|---|---|
| Ages | 0.035 | 0.414 |
| Household size | 0.245 | 0.346 |
| Agricultural assets | 0.140 | 0.589 |
| Land capital (LC) | 0.403 | 0.007 |
| Producer income | 0.384 | -0.101 |
| Quantity of organic manure (OM) applied | 0.369 | 0.013 |
| Mineral fertilizer quantity | 0.363 | -0.120 |
| Carts | 0.350 | -0.038 |
| Livestock capital (Tropical livestock unit) | 0.408 | -0.056 |
| Poultry | 0.158 | 0.022 |
| Number of trees/ha | -0.131 | 0.133 |
| AA/ha | -0.101 | 0.560 |

PC : Principal component

### 2.2. Discrimination settings

The structural parameters classify farms into three types, namely big, medium and small (Table 4). These parameters are in particular people in charge (P=0.004), land capital (P=0.001), annual farm income (P=0.001), average and annual quantity (number of carts) of organic manure produced and/ or collected (P=0.001), quantity of mineral manure annually invested per farm (P=0.001), presence of carts in a farm (P=0.001), number of draft oxen (P=0.001) and the number of small ruminants owned by a farm (P=0.001).

Other parameters, considered integration, also discriminate between these farms. These are number of agricultural workers per hectare (AA/ha, P=0.001), Quantity (number of carts) of organic manure (OM) per hectare (Quantity (OM) ha, P= 0.001) and finally the number of trees and shrubs counted per hectare (Number of trees/ha, P=0.001), highly significant statistical differences exist, but only between small farms and two other categories. For the quantity of mineral manure applied per hectare (number of 50 kg bags of urea or DAP, P=0.039), the difference is highly significant between small and big farms, while medium farms remain more or less similar to small than to big farms. The yields of cereals and legumes are not statically different from one category to another.

For the production of cereal (millet and sorghum, (P=0.002)) and legumes (cowpea and groundnut, (P=0.008)), there are very significant statistical differences between big farms and other two categories. The same observation is made on production of cowpea residues (haulms). About production of residues (stems) of sorghum (P=0.001) and bran of sorghum statistically significant differences are observed between small farms and two other categories.

Livestock capital is another characteristic that differentiates big farms from other two. This is case for draft oxen and small ruminants (P<0.001).

**Table 5** Comparison of averages for structural parameters between logging categories

| **Categories** | **SF** | **MF** | **BF** | **lsd** | **P<0.05** |
|---|---|---|---|---|---|
| Household size (People) | 10.05a ±2.92 | 9.54a ±2.85 | 14.97b ±3.20 | 3.84 | 0.004 |
| Household size (People) | 3.05 ± 0.64 | 3.04 ± 0.44 | 4.80 ± 0.84 | 2.046 | 0.109 |
| Farm Assets (People) | 1.79a ± 0.1 | 3.00a ± 00 | 8.13b ± 1.04 | 2.14 | 0.001 |
| Land capital (ha) | 45 473.68a ±8592.42 | 171 208.33b ±27666.43 | 375653.33c±77 929.99 | 168.31 | 0.001 |
| Household income (FCFA/year) | 0.16a± 0.09 | 0.42a ± 0.01 | 0.83b ± 0.14 | 0.35 | 0.001 |
| Carts (Unit) | 0.26a ± 0.17 | 1.00a ± 0.18 | 1.83b± 0.34 | 0.78 | 0.001 |
| Draft cattle (Unit) | 2.37a ± 0.46 | 5.50a± 1.07 | 11.57b± 2 | 4.52 | 0.001 |
| Number of small ruminants (Unit) | 14.37a ± 2 | 16.04a± 1.09 | 32.63b ±5.37 | 11.51 | 0.001 |
| Amount of FO collected per season (Cart trip) | 0.42a ± 0.11 | 1.58a ± 0.27 | 7.03b ± 2.06 | 4.28 | 0.002 |
| Quantity of FM purchased per season (Cart trip) | 32a ±8 | 15b ± 3 | 6 b± 1 | 13.01 | 0.001 |
| Number of trees/ha (Stands of trees/ha) | 9a ±1 | 5b ± 0.4 | 4.4b± 0.5 | 2.209 | 0.001 |
| Input FO/ha (cart trip/ha) | 0.3a ±0.1 | 0.5ab± 0.1 | 0.8b± 0.2 | 0.4117 | 0.039 |
| Input FM/Ha (Bag/ha) | 2a | 1b | 1b | 0.485 | 0.001 |
| AA/hA (Number of people/ha) | 464.6 ±102 | 336 ± 44 | 306 ±50 | 199.1 | 0.220 |
| Cereal yield (Kg/ha) | 156 ±70 | 151 ± 41.2 | 146 ± 31 | 133 | 0.991 |
| Legume yield (Kg/ha) | | | | | |

Note: ± Standard error; Means with same letter on same row are not significantly different.
Big farms (BF); Medium farms (MF); Small farms (SF)

### 2.3. Small Farms

In this category, average number of people in charge is 10, but only 3 are active for different agricultural productions. Their land capital is estimated at 1.8 hectares and one (1) out of five (5) farms has a mono-cattle or mono-asine animal traction unit. There are 2 to 3 small ruminants and their average annual income is 45,473.68 FCFA. The average contribution per hectare and per year of organic manure is 8 cattle carts, and 0.5 bags of mineral manure (i.e., 25 kg) of urea or DAP. There are up to 59 trees per hectare.

### 2.4. Medium Farms

In this second category of farm, number of people in charge varies from 8 to 12 people in charge and 3 agricultural workers. However, average land capital (3 ha) is worth a little less than double compared to that of small farms. and less than half that of big farms. On average farms, one (1) family out of 3 owns at least one cart and one draft ox on each farm. There are six (6) small ruminants and their average income is 171,208.33 FCFA per year. The average contribution per hectare and per year of organic manure is 5 cattle carts, and 0.5 bags of mineral manure (i.e. 25 kg) of urea or DAP. There are up to 59 trees per hectare.

### 2.5. Big Farms

In the category of big farms, heads of families are oldest (52 years old, see appendix) and have biggest families with 12 to 18 people in charge, including 5 agricultural workers. Their land capital is 8 hectares on average. They use up to 7 bags of 50 kg of mineral manure (Urea and/or DAP) and bring up to 33 trips of organic manure carts per year. There are 40 trees per hectare. Their average income is 375,653 FCFA per year. In this category, almost every producer has a cart and two (2) draft oxen and 10 to 14 small ruminants.

## 3. Discussion

### 3.1. Survey and data analysis

For comparison of means, nature of data especially observations which include a lot of zeros (0) at the level of certain variables, choice of ANOVA method was ruled out, justifying the use of the generalized mixed model in order to take into account data variability.

The principal component analysis and hierarchical ascending classification made it possible to make a categorization of exploitations according to possession, level of investment and exploitation that they make of their means of subsistence.

### 3.2. Characterization of farms

The principal component analysis made it possible to remove ambiguity on local perception of peasants and to bring precisions on certain practices of integration agriculture and breeding. Thus, three categories of farms in terms of agriculture and livestock integration have been revealed with particular emphasis on levels of vulnerability. se results are similar to those obtained by an author [9] who also highlighted 3 classes of farms in commune of Djirataoua and another [10] who also distinguished two categories of agro-pastoral farms and one type operation of farmers in southern Mali. In addition, some researchers [9] [11] reported that three types of family farms along the Senegal River in Senegal have been identified.

Agricultural practices in the study area are essentially conditioned by access to and/or availability of cultivable land and mostly free labor, which is bigly made up of household members. Indeed, land capital is the most determining factor. However, it also remains a limiting factor with regard to agriculture-livestock integration practices, because the construction of livelihoods almost depends on it, and nowadays there is fierce competition with livestock due to lack of methods of exploitation or appropriate management. Fallow land has almost disappeared, pasture areas have gradually been nibbled away or encroached on for agricultural purposes and agricultural production is still threatened by grazing animals.

This state of affairs characterizes farms by a crucial lack of arable land and a many people to take care of (4.5 ha for 12 people on average). Thus, these results are similar to those of certain researchers [9] who presented a ratio of 4.2 ha for 10 people but different in terms of hectare according to a study carried out by authors [12] where mixed crop-livestock farms are characterized by average cultivated areas around 7 hectares with a big number of tropical livestock unit and an average of 12 people in charge. However, they are lower than the national average which is 4.7 ha for 7 people. These results are confirmed by the findings of the authors who announced that all spaces likely to be occupied by agriculture had been cultivated continuously for more than 60 years in certain sectors. The integration of agriculture and livestock

is nowadays an adaptation strategy that guarantees resilience in the face of challenges posed by demography and effects of climate change. Strengthening integration between agriculture and livestock is often considered a central strategy implemented by farmers to consolidate productivity and sustainability of their production systems [13][14]. Even if producers surveyed rely on socio-economic practices of their ethnic origins to claim to be farmers, breeders or agro-breeders, we almost always find in all families simultaneous practices of these two sub-activities. Livestock management, even a few small ruminants and/or poultry with farming and/or gardening huts everywhere and by everyone, even if it is on a loaned piece of land, however vulnerable it may be -operation. However, principal component analysis and ascending hierarchical classification made it possible to group farms into three main categories. All farms are characterized by very big families, with few agricultural assets for production of wealth. This partly explains in this community, gradual reduction of arable land, disappearance of fallow land and entrenchment of poverty.

There are no big breeders, nor exclusive breeders or farmers. All producers engage in quite diverse and aggregated subsistence practices, including agricultural activities. We talk about agro-pastoralists according to level and type of agriculture and livestock integration. The interesting integration elements in study area are quantity of organic manure (number of carts per year and per hectare) for a farm, quantity of mineral manure (Kg/ha) used per year, number of trees and shrubs planted and/or maintained per hectare, number of agricultural workers employed per farm and per hectare. However, principal component analysis and ascending hierarchical classification made it possible to group farms into three main categories. All farms are characterized by very big families, with few agricultural assets for production of wealth. This can partly explain for this community, why there is a gradual reduction of arable land, disappearance of fallow land and entrenchment of poverty.

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When we observe different categories of farms under prism of vulnerability and in a Sahelian context, we notice that families with mixed herds are most resilient families in the face of effects of climate change and threat represented by demographic pressure. It emerged from other investigations that given a reduction in available land per worker, farmers are encouraged to increase their investment per hectare. In doing so, embarking on such a path in a context of rainfall, economic and land tenure uncertainty means exposing oneself to risk of not being able to make investment made profitable [15][16][17]. They must therefore reconcile a process of intensification (through labor and/or through capital + inputs) with a strategy of risk minimization. The integration of agriculture and livestock by increasing availability of agricultural energy and organic manure and allowing recycling of fodder biomass on-farm has long been proposed as an intensification model suitable for farms in West Africa [18]. Deepening allows livestock farmers and market gardeners to increase water storage capacity of ponds and lowlands in order to meet water needs of herds and crops in dry season [19][20][21].

## 4. Conclusion

The study, having dwelt on characterization of practices of integration of agriculture and livestock, highlighted three categories of agro-pastoral farms, classified according to level of acquisition of means of subsistence, integration of different variables and their production and operating capacities. Big farms (BF) are the bigst holders of livelihoods with almost twice the land than medium farms (MF) and four times that of small farms (SF). The same observation is made for small ruminants (12 small ruminants in BF 6 for MF and 2 for SF). On the other hand, for integration variables, Small farms seem to have more performance. Thus, their yields are better because they have less cultivable land to develop with many more agricultural assets and better supply of organic manure per hectare. They still have many more trees per hectare because they are still target of interventions by NGOs and Assisted Natural Regeneration Projects in Aguié area. There are no farms of exclusive farmers or breeders, but agro-breeders who are distinguished from one category to another by their integration and production capacities.

## Compliance with ethical standards

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*Disclosure of conflict of interest*

No conflict of interest has been reported.

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