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Employment

Agroecology's contribution to job creation in sub-Saharan Africa: Does more work mean more job? Data from Senegal

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Abstract: *In the context of Sub-Saharan Africa's demographic boom, the issue of youth employment has become a major concern. Many debates are ongoing regarding the role that agriculture could play in the structural transformation process and in providing jobs. We explore the opportunity of an agroecological intensification of family farming in this regard. We analyze data from agricultural households in the Niayes area of Senegal collected in 2019 and use a clustering method to rank farming systems in terms of agroecological practices. Taking into account labor allocation complexity within family farms, we compare employment indicators between farming systems to look for agroecology effect on agricultural work. We observe a diversity in intensity of labor requirement across the different systems that is mainly explained by other characteristics than agroecology. Thus, our results do not indicate a job creation potential with the adoption of agroecology in our study zone of the Niayes.*

Keywords*: agroecology, employment, sub-Saharan Africa, labor*

Introduction

The ongoing demographic boom in sub-Saharan Africa (SSA) raises the question of youth employment, as by 2050, 800 million new workers will be looking for a gainful activity (Losch, 2016). A lack of job opportunities to meet the needs of these young generations could have dramatic consequences and lead to economic stagnation, disillusionment and social unrest (Yeboah and Jayne, 2018). According to the most favorable projections, within the next decade, only a quarter of the youth will be able to find a salaried work.

Nowadays, most sub-Saharan African countries still have economies whose agricultural sectors account for a large share of their GDP (in comparison with other countries) and a very weak industrial sectors, informal employment being widespread. Thus, the agricultural sector currently employs 60 to 75% of the population in rural areas across the different countries of SSA (African Development Bank, 2019), and the prospects for a rapid industrialization which would quickly create jobs are slim.

In this context, rural areas will be specifically exposed to the demographic boom. 60% of the population live there, and an increase of 59% of the rural workforce is anticipated (Losch, 2016). In addition, it is believed that the young population might not follow a pattern of rural exodus as the economic opportunities in urban areas are declining. Jayne *et al.*(2017) highlight the need to take into account the rural-to-rural migrations to estimate the future rural population, as internal migrations have evolved in the last decades (Mercandalli, 2015). Hence rural population growth should maintain over time and the political responses will have to keep a focus on rural areas, and especially on the agricultural sector.

Debates on the structural transformation trajectories of SSA's countries often oppose the tenants of a quick industrialization and the advocates of a broad agricultural-based development. Within them, confronting views exist on how the agricultural sector could contribute to economic development and thus its place within the job creation process (Diao *et al.,* 2010). Several debates are taking place regarding the compared advantages of family farming and agro-business or the opportunity to promote more sustainable agricultural practices through agroecology.

Hence, many questions arise. One of them is the **intensification** issue of agriculture and its modalities. The acute pressure on land has already made this resource more valuable and triggered the development of land markets (Jayne *et al.,* 2017). The principle of an agricultural intensification, aiming at meeting the growing food demand and absorbing labor, would correspond to a labor intensification of agriculture, ie using more labor for a given area in order to produce more.

Land degradation, sustainable development and adaptation to climate change have driven researchers and NGOs to advocate for an agroecological intensification (Altieri, 2009; De Schutter, 2011; Tittonell and Giller, 2013; IPES-FOOD, 2018). Several local initiatives promoting agroecology have emerged within SSA's countries. The FAO started seminars on agroecology since 2014 and launched the Second International Symposium on Agroecology in April 2018; the latest High Level Panel of Experts on Food Security and Nutrition report released in July 2019 is about agroecology and sustainable agricultures. Researches are also conducted on the subject by IPES-Food expert panel, the Alliance for Food Sovereignty in Africa, and the ProIntensAfrica and LeapAgri European Programmes (Sourisseau *et al.* 2019).

Our hypothesis is that the development of agroecology in family farms could contribute to absorb labor in the context of the demographic boom and low employment of SSA. Indeed, the current knowledge regarding agroecology reports an increase of the workload due to change in agricultural practices requiring more precise and targeted interventions (Temple *et al.,* 2008, Côte *et al.,* 2019). Many existing analyses deal more specifically with conservation agriculture rather than agroecology (Nana *et al.,* 2014). Regarding this latter, increase in labor is often pointed as an obstacle to the practices adoption but is rarely precisely measured within the agronomic evaluation of the practices (Dugué *et al,.* 2012; Levard and Mathieu, 2018).

This additional work might lead to an increase in the need for agricultural workers and job creation. However, the job creation process is not an internal process relying on technical choices but is inherently dependent on the local institutions of labor mobilization, including the labor market, within which the agricultural workers evolve (Michel and Oudin, 2003; Darpeix *et al.,* 2014). In this regard, job creation in agriculture is highly context-dependent.

From an employment perspective, there are barely any studies regarding agroecology and its impact on hiring. Indeed, work content and employment are two different things and the increase in workload which is witnessed might not reflect in an increase in farm employment. Quantitative analyzes have been conducted regarding the effect of organic farming on employment in western countries (Midler *et al.,* 2019). A few studies focused on labor requirements of other types of sustainable agricultural practices in sub-Saharan countries and found a significant increase of work related to adoption (Montt and Luu, 2020; Fontes, 2020).

This paper aims at filling the knowledge gap regarding the opportunity of job creation within the development of agroecology more specifically in rural SSA based on agricultural households data from Senegal collected in 2019. Quantitative analyses are conducted on a sample of 165 households, firstly to classify them from an agroecological perspective and secondly, to evaluate variations of employment and labor requirement between agroecological levels. The results obtained do not indicate a positive effect of agroecology on job creation.

The first section explains the issues of the structural transformation of SSA's countries and the role of the agricultural sector within this process, as well as the potential for an agroecological intensification. The second section describes the context of Senegal regarding agroecology and the methodological issue of measuring job creation in agriculture; the third section describes the data and the methodology of data analysis used; the last section presents our results.

Structural transformation of Sub-Saharan Africa's countries and agroecology

Discussing the role of agriculture regarding employment and economic development in SSA leads to examine the structural transformation trajectories of its countries. The structural transformation process as first described by Lewis (1954) involved the transformation of the economies through the change in inter-sectoral labor distribution. From an agriculture-based economy, the productivity gains in this sector trigger an inter-sectoral labor transition towards more productive sectors, such as industry, allowing the increase of the overall productivity of the economy. Hence, from a structuralist point of view, the labor productivity of the economic sectors and the allocation of labor between them have a direct impact on job creation and economic development.

It is through the increase of labor productivity in agriculture that many see the opportunity for sub-Saharan African countries to follow trajectories similar to the western countries and it is also because of agroecology supposedly low labor productivity that it is disregarded as a viable economical alternative path to development. For these reasons, we examine the ongoing state and discussions on structural transformation in SSA and the potential implication of agroecology labor productivity on this process.

Structural transformation trajectories and the opportunity for an agroecological intensification

Taking stock of the structural transformation process in SSA

Jayne *et al.* (2018) take stock of the progress of Africa's structural transformation and note that there is no overall development of the manufacturing sector despite large differences across countries. Shift in labor distribution seems to be occurring from agriculture to informal goods and service sectors, with no productivity gains (Diao, McMillan and Rodrik, 2019). Furthermore, Jayne *et al.* (2018) find the 'urbanization without industrialization' scenario which is taking place in certain countries to be the most alarming as it is not based on any economic dynamic of sectoral development. Hence, the growth observed over the last decade on the continent actually displays an overall low employment content (Gueye and Mbaye, 2018).

The role of agriculture in structural transformation process

Given the predominance of the employment in the agricultural sector, many among the development community advocate today for an agriculture based growth, seen as more inclusive and with better multiplier effects (Mellor, 2018). They support productivity gains in agriculture in order to set in motion the structural transformation process (Jayne *et al.,* 2017), through the adoption of similar technical packages as the one promoted for the Green Revolution. For instance, the Alliance for a Green Revolution in Africa (AGRA) was launched by the Rockfeller Foundation and the Bill & Melinda Gates Foundation in 2006.

Furthermore, the development of the agricultural sector would lead to the growth of upstream and downstream sectors which could contribute to major economic transformation in the region (Yeboah and Jayne, 2018).

However, certain economists have started to question the possibility of a structural transformation of SSA economies following the Lewis path, and instead suggested that other trajectories could be considered (Dorin *et al.,* 2013; Dercon and Gollin, 2014). Today's globalization has deeply modified the balance of power and SSA economies are faced with an increased international competition, a challenged state position due to liberalization ideology, and the limits of a growth model consumer of resource (Losch, 2014), all of which argue against a potential replication of the Lewis path for SSA.

Agroecological intensification trajectory

On the other hand, the necessity to intensify the agricultural production without harming the environment gave birth to the concept of sustainable intensification (Mockshell and Kamanda, 2018). From this admittedly blurred notion (Wezel *et al.,* 2015), Mockshell et Kamanda (2018) distinguish the proponents of a "continuation of technological advancements and intensive production systems with optimal input use through sustainable agricultural intensification (SAI) practices" and the advocates of a "paradigm shift to eco-agriculture, agroecology".

The integration of environmental constraints into the thinking on the future of agriculture thus adds another dimension to the debate on structural transformation paths for SSA. Dorin *et al.* (2013), when examining structural transformations around the world, propose as a scenario for SSA an alternative "Farmer developing path" relying on a labor intensification of agriculture, ie an increase of the production per surface through land productivity improvement, that would absorb more labor. This scenario of structural transformation corresponds to an agroecological intensification.

Hence, the role of an agroecological intensification could be two-fold: first, intensifying agricultural production while preserving the environment; second, contribute to an alternative structural transformation trajectory for SSA by providing employment for the youth coming from the demographic boom.

As mentioned above, the allocation of labor towards the most productive sectors of the economy is critical for development in the structuralist theory. Therefore, we examine labor productivity of agroecology in the next section, as it has direct implications regarding economic development and employment.

Agroecology and labor productivity

Definition of agroecology

Alternative forms of agriculture appeared in reaction to the environmental externalities caused by conventional farming. Agroecology is one of them and since its creation has had multiple meanings. Wezel *et al.* (2009) distinguish three of them: a science, a movement and a practice, illustrating a diversity of definitions and scales. Indeed, for many, agroecology also conveys a political vision of society involving social dimension at the food system scale (Francis *et al.,* 2003). From the agroecological farming practices scale, defined by Griffon (2017) as "using intensively and in priority the ecological and biological processes" in farming practices, other concepts have been born such as agroecological transition, ecologically intensive agriculture, double green revolution, green agriculture, etc.

Different concepts coexist regarding the description of agroecology, notably about ecosystem services that can be understood in different ways. Hence, Balmford *et al.* (2008) highlight the need to differentiate between : the ecosystem functionalities or processes, ongoing in nature; the ecosystem beneficial processes, from which human beings derive ecosystem benefits using labor and investments. Karsenty (2019) makes an even clearer distinction between the ecosystem services provided by nature and the environmental services provided by men when they maintain or enhance an ecosystem services (such as water quality), this latter being an economic service.

Potential impact of agroecology on labor productivity

The characteristics of agroecology imply certain changes in tasks performed in farming, such as more observation of the agroecosystem, localized interventions and adaptation to the local environment, but also in the organization of the work (Delecourt, 2018). This diversity of task then requires more skills to be able to perform them which means an increase in human capital but also an increase in time worked (Temple *et al.,* 2008; Jean, 2011).

Montt et Luu (2020) study the labor requirements related to the adoption of conservation agriculture in five African countries Ethiopia, Kenya, Malawi, Mozambique and Tanzania. They find an increased labor demand in household having adopted conservation agriculture: this demand is mostly met by family labor and more specifically female labor. Pereira Fontes (2020) focuses on the effect of Soil and Water Conservation practices adoption on labor allocation in Ethiopia and finds a 31,4% increase in workings days for adults and a 29% increase for children up to 78% for households with only 3 adults. These findings are consistent with an analysis by Bottazzi *et al.* (2020) concluding that agroecological practices adoption in Senegal lead to new labour control channels and paternalism ; the additional work is often supported by the weakest groups, such as women and children.

In other reports, mostly in the North, the extra work is handled by the operator of the farm, sometimes to the expense of his well-being as what Galt (2013) describes as "self-exploitation". Dumont (2019) also observes critical working conditions for Belgian farmers in agroecology who struggle to make a living from their farm. The ideological commitment related to agroecology's adoption explains why they appear ready to accept a non-decent form of employment.

Overall, the work increase effect of agroecology is pretty consistent. However, the effect on work productivity depends on the yields of these practices. The findings regarding yields in agroecology are not straightforward. As pointed out by Sanderson Bellamy and Ioris (2017), there is no clear evidence regarding the yield gap between conventional and agroecological production systems. Most of the existing research focuses on the study of organic production system as they are easier to identify and the yield gap observed between organic and conventional farming using meta-analytic approaches ranges from 9% to 25% (Wilbois and Schmidt, 2019).

Environmental services of agroecology

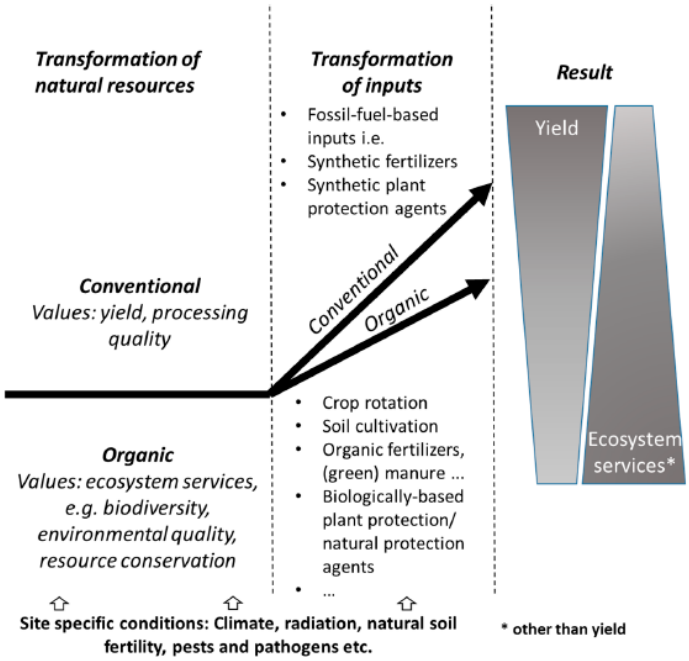

Figure 1. Simplified model to describe a cropping system as a transformation process*. Source: Wilbois and Schmidt, 2019.*

Even though, evidences tend to indicate an overall potential decrease in yield in agroecological farming, the environmental services provided have to be taken into account to evaluate its labor productivity. Hence, Wilbois and Schmidt (2019) represented a conceptual model (see below) to explain the magnitude of the gap between organic and conventional systems by integrating the output in term of ecosystem services. Thus, it appears clearly that ecosystem services constitute a fundamental part of organic systems results, as well as agroecological systems results.
To conclude, ecosystem services or environmental services being a critical output of agroecological farming it is necessary to evaluate their value to assess its labor productivity. Ecosystem services valuation is a more and more integrated solution to preserve the environment and a great variety of methodologies exists (Schröter *et al.,* 2014).

Valuation of environmental service and job creation

For agroecology to lead to job creation, the valuation of the environmental service's additional work is critical. Otherwise, farmers will either not be willing to engage in agroecology with an increased workload without economic retribution or they will, due to personal conviction, but they would have to manage the extra work with family labor and overtime hours.
Thus, if governments would consider an agroecological transition as a mean to absorb labor, markets improvements through the creation of labels (such as organic farming) or direct subsidies, such as payment for eco-system services, would be necessary to achieve this goal. For instance, the existence of a certified label and a functioning market allow for organic production to be more remunerated than conventional farming. In this regard, the literature review conducted by Midler *et al.* (2019) on job creation related to organic farming in Western countries, where organic labels are well defined, shows an overall significant positive impact of organic farming on employment. As organic farming follows a similar trend away from conventional farming as agroecology, those findings corroborate a potential job creation linked to agroecological practices under the right conditions.
Our objective is thus to inform the opportunity for job creation of agroecology under appropriate public policies based on our results on its labor requirements in the Niayes area of Senegal. These potential employment opportunities could open up new prospects regarding structural transformation trajectories for SSA.

Data collection and analysis

Context of agroecology in Senegal

In Senegal, as in many SSA countries, the issue of the employment of the youth has become a critical concern. The agricultural sector still represents 15% of GDP and 70 to 60% of the employment and for now, the exit of labor out of agriculture has been towards low productivity informal sector (Diao *et al.,* 2019). Thus, the role of agriculture in the economic development and job creation in the country is admittedly crucial. Several policies programs to support job creation in agriculture have been launched within the last few years (FAO, 2020).
Regarding agroecology, a national initiative was born in Senegal with the "Dynamique pour une Transition Agroécologique au Sénégal" (DyTAES) in 2019, after the announcement by the Senegalese President to make of the agroecological transition a national priority (DyTAES, 2020). This working group composed of organizations and platforms engaged in agroecological transition in Senegal released a report in January 2020 for the international event of "Les Journées de l'Agroécologie" held

in Dakar. They introduced a number of recommendations to scale up the local agroecological projects led by community organizations, peasant organization and NGOs.
As elsewhere in the world, the term agroecology in Senegal covers various types of farming with various levels of agroecological intensification. Thus, the distinction between so-called “alternatives” to conventional farming is not clear. Agroecology is most often referred to as organic farming, or sometimes as “Agriculture Saine et Durable”, a label created by the local NGO ENDA Pronat.
A national federation called the FENAB manages the development of “agriculture bio” (organic farming) in Senegal. The figures regarding the number of farmers committed to organic farming are most likely outdated, as local federation seldom communicates their number of adherents, but they indicate the involvement of about 300 farmers in organic farming within ten organizations across the country. The FAO knowledge platform on family farming indicates a total of about 750 000 family farms in Senegal from a national survey of 2014. Even though that figure might have changed since then, it puts in perspective the scale of the conversion to organic farming in the country.
Enda Pronat, the Senegalese NGO previously mentioned, has been promoting agroecology for decades. They accompany local federations in four areas of Senegal to help farmers transition to agroecological practices. It is within two of these local federations that our data was collected.

Data description

The study zone is the Niayes area, located near Dakar in Senegal. Its agricultural sector is very dynamic and has specialized in fruits and vegetables production, mainly for Dakar market.

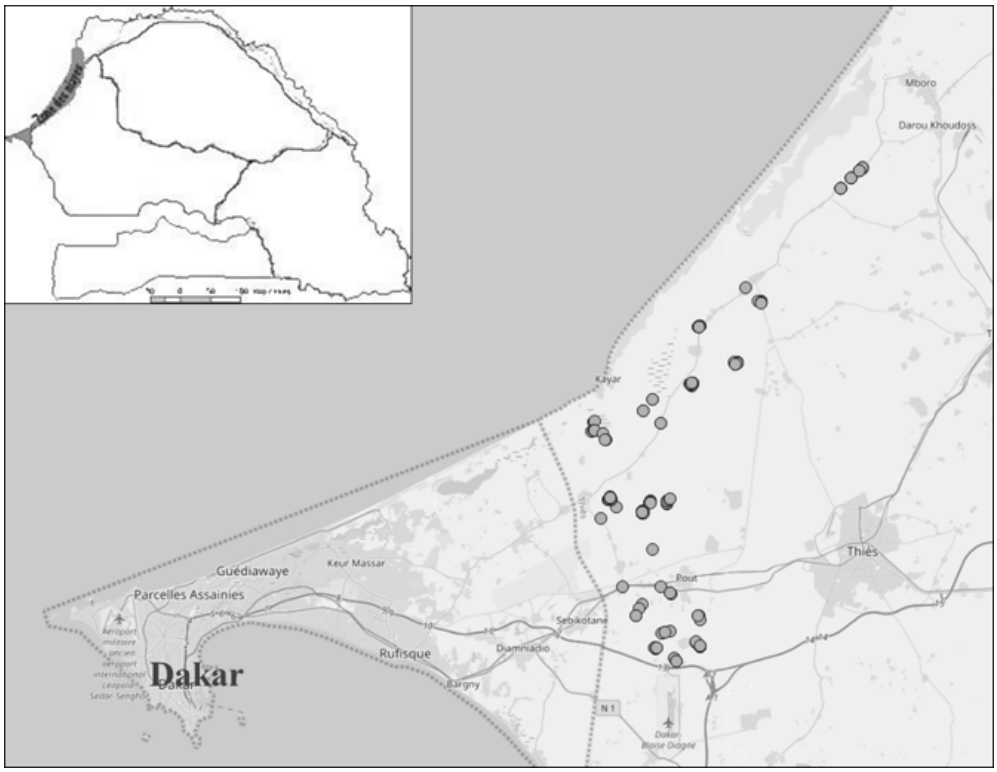

Figure 2. Location of the study zone in Senegal

About 30 qualitative interviews were conducted in the study zone of the Niayes prior to the quantitative data collection. They allowed to characterize the processes of labor allocation within the activity system, especially on farm, and compare technical itineraries between organic and non-organic farmers.
Quantitative data was collected from 165 households practicing gardening across the Niayes area in Senegal in November 2019. Two federations promoting agroecology were identified, the Federation des Agro-Pasteurs de Diender (FAPD) and the Federation Woobin. 54 farmers classified as organic farmers from these federations were included in the survey to serve as proxy for most agroecological farms. The sample also included farms recruiting wage workers, either for daily tasks or for a yearly contract.

	Total	***Organic farmers***	***Non-organic farmers***
Size of households	12.54	12.69	12.48
Number family worker on farm	4.26	3.94	4.41
Number of activites off farm	2.16	2.11	2.19
Off farm revenue (FCFA)	934 447	824 706	987 835
Surface owned (ha)	3.08	2.47	3.38
Cultivated area (%)	73.70	76.38	72.4
Number of animals	7.26	8.09	6.86
Farm revenue (FCFA)	2 486 898	1 337 434	3 046 097

Table 1. Sample description

The sample construction aimed at gathering households with diverse farming systems to allow for their comparison between agroecological levels regarding labor. Thus, the chosen households are representative of the diversity of the zone but overall not of the actual repartition of the Niayes, as organic farmers are over-represented on purpose in relation to conventional farmers.
Within the interviewed households, the activities on and off farm of all family members over the last 12 months were recorded. The time spent in off farm activities or migration was entered for each month of the year as well as the type of participation to the family farm. For this latter, members of the households were either considered full time workers, weekly or punctual workers, and for each type a weekly or monthly workload was defined.
External contribution to peak farm work was also taken into account. For different tasks, such as weeding or harvest, households use labor exchange or daily wage workers. Thus, the amount of labor mobilized this way was estimated by number of workers and number of hours. A specific set of questions regarding the agroecological practices of the farms were asked as well as regarding their economic results.

Analysis conducted

Description of the HCPC process on agricultural practices data

The first step of the analysis was to identify different levels of agroecology within the farms interviewed. This process is complex as agroecology is a multi-dimensional concept and is defined on principles rather than precise delimitations. Hence, research is still discussing the elaboration of a methodology to specify on the field what is agroecology and what is not. Recent contributions have proposed different methodologies to identify and evaluate agroecological systems (FAO, 2019; Levard *et al.,* 2019).
In our study, 53 variables were collected regarding the agricultural practices of the farms and their linkages within the food system (self-sufficiency, production destination, etc). The objective was to identify sets of practices implemented in certain farms that would allow to distinguishes groups of farms

with specific levels of agroecology. We conducted multiple correspondence analysis (MCA) on this set of data regarding farming practices exclusively, excluding the rest of the data on the households.
After several tests, 22 of the variables were selected as discriminating enough and conveying the necessary information. They are all categorical variables on: the use of chemical inputs, organic matter management, fallow, ploughing practices, diversity in vegetal and animal production, crop rotation, integration with livestock and food autonomy (see the annex for the exhaustive list).
The implementation of a hierarchical clustering on principal components allowed to identify 5 clear clusters describing farming systems (FS) with specific practices that will be presented in the results.

Statistical tests on employment indicators to compare farming systems

After having distinguished 5 groups regarding agroecology, two types of tests were performed using R to determine statistically significant differences regarding employment and work indicators between these groups. ANOVA tests to compare the means of the different groups and Kolmogorov-Smirnov test to compare their dispersion.
Before running the ANOVA test, we controlled for the assumption of homoscedasticity by performing Levene tests. The households are unevenly distributed across clusters which is dealt with by R when calculating the sums of square for the ANOVA test.
15 variables regarding the work on the farm, family and wage, in number of hours per hectare per year, as well as the remuneration of this work calculated from the farm revenue and the off-farm activities and migration of the household members are compared.

Results

Tasks comparison between organic and non-organic farms

Based on our qualitative interviews, we find a low diversity of agroecological practices within the farms, which is confirmed by the literature on organic farming in the Niayes area (Kettela, 2016; de Bon *et al.,* 2019); even though the interviewed farmers were recommended by the federations which would make them "good performers". Thus, according to Hill et MacRae (1996) conceptual framework, the organic farmers of the area seems to be in the "substitution" phase, with mainly substitution of the chemical fertilizer by manure and of the pesticides by organic preparations (mostly made from plants with repellent powers). No reconception of agricultural systems was observed. Similar observations are made by Dugué *et al.* (2017) on the same federations in the Niayes.
We compare tasks between organic and non-organic farmers by performing chi-squared tests on categorical variables about practices (0 this task is not performed/ 1 this task is performed) using our quantitative data. Only 8 of them showed significance, the results are shown in the graphs below.
Figure 3 shows that organic farmers mostly do not use chemical inputs, either fertilizer or pesticides, which confirms their organic status. Figure 4 displays their practices regarding compost. It shows that even though more organic farmers use compost than non-organic farmers, this use remains pretty limited with only about 35% of the organic farmers declaring using compost and about the same proportion (certainly the same individuals) declaring preparing their compost. Compost preparation is a time consuming process that constitute a net increase in work. Figure 5 displays the proportions of farmers using and preparing organic pesticides. More than 60% or organic farmers use these products and about 35% prepare them themselves. In figure 6, we see that crop combination is also more practiced by organic farmers than non-organic farmers. However, it is less likely to have an impact on

work. Breeding is done in high proportions by both organic and non-organic farmers. However, chi-squared tests showed us that breeding practice is significantly higher within the organic farmers.

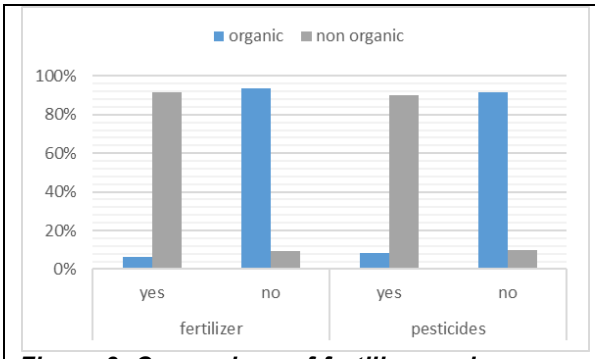

Figure 3. Comparison of fertilizer and pesticides use.

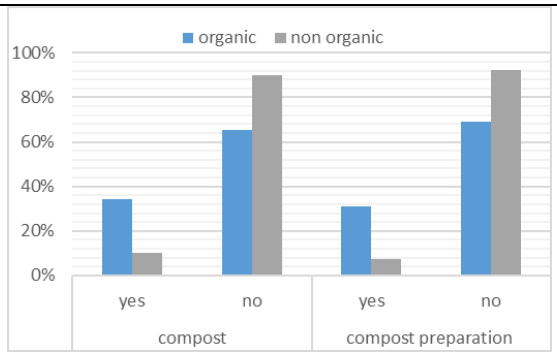

Figure 4. Comparison of compost preparation and use.

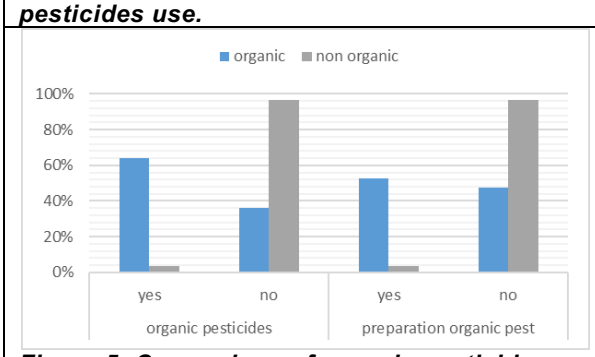

Figure 5. Comparison of organic pesticides preparation and use.

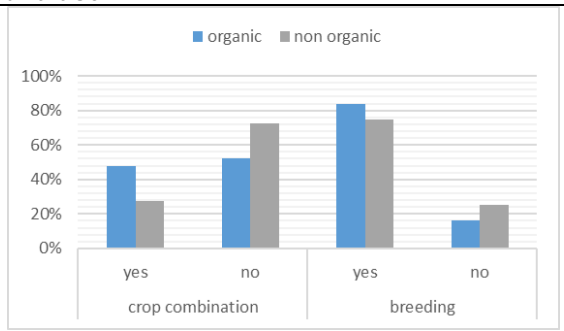

Figure 6. Comparison of crop combination and breeding.

In terms of labor requirements, those results highlight two differences between organic and non-organic farmers that might lead to additional work for organic farmers: the preparation of the substitute to chemical inputs and breeding. Furthermore, when comparing breeding between organic and non-organic farmers, we find that organic breeding is significantly more diverse with a higher average number of species and that organic farmer tend to use more their manure for crop cultivation. Both characteristics implies more labor.

We find evidence that additional tasks performed in organic farming involve more work. We want to evaluate the effects of these extra tasks on the farms working hours and number of workers. To go beyond the organic/non-organic distinction, we first define levels of agroecology in our sample.

Definition of the farming systems

The clustering analysis conducted on the data regarding agricultural practices classified the farms into 5 groups differentiated on their practices only, presented in figure 7. This 5 clusters correspond to farming systems that can be described by the categories the most statistically significant within them.

To identify levels of agroecology among farming systems, for each of them, we highlight in red the categories corresponding to conventional practices and in green the categories corresponding to agroecological practices for each farming systems in table 2.

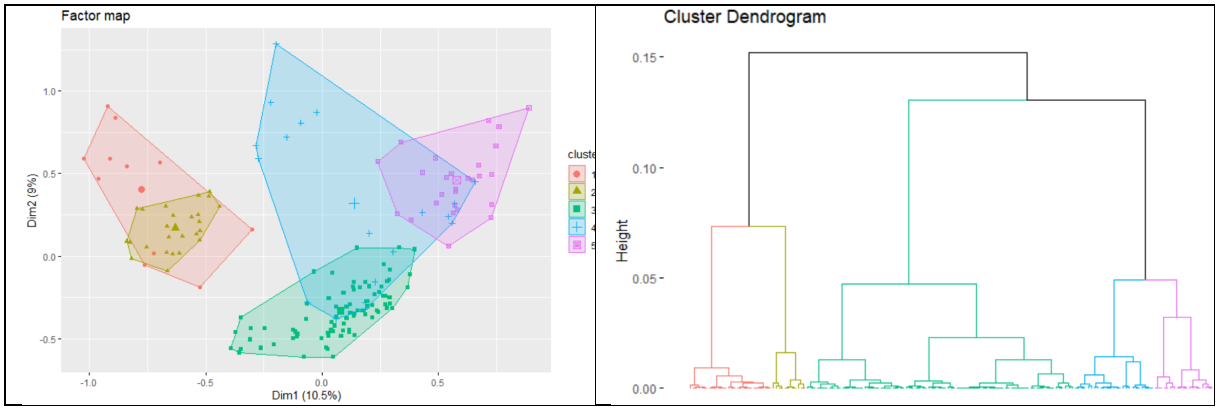

Figure 7. Results of the HCPC.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Number	11	26	82	19	27
Overrepresented categories within clusters	rotation_cult_0 semences_0 labour_0 fertil_elevage_0 conso_alim_0 (aucune autonomie) mode_alim_0 type_alimentation_0 nb_especes_anim_0 asso_cultures_0 fumier_0 nb_cultures_1 nb_prod_1	mode_alim_0 type_alimentation_0 nb_especes_anim_0 fertil_elevage_0 pesticides_1 pesticides_bio_0 engrais_1 prepa_pest_bio_0 conso_alim_3 (<50% autonomie)	pesticides_bio_0 prepa_pest_bio_0 engrais_1 pesticides_1 compost_0 nb_especes_anim_2 mode_alim_1 (zone parcage) type_alimentation_2 (fourrage+grain) fertil_elevage_1 rotation_cult_1 conso_alim_2 (50% autonomie) nb_especes_anim_1 semences_1 labour_1	engrais_0 pesticides_0 pesticides_bio_1 prepa_pest_bio_1 regul_ecol_0 evol_arbres_3 jachere_1 nb_cultures_3 compost_1 type_alimentation_1 (fourrage only) asso_cultures_1 conso_alim_2 (50% autonomie)	pesticides_bio_1 prepa_pest_bio_1 pesticides_0 engrais_0 fertil_elevage_1 type_alimentation_2 (fourrage+grain) nb_especes_anim_4 compost_1 regul_ecol_1 jachere_0 conso_alim_3 (<50% autonomie) nb_cultures_8 nb_especes_anim_5 mode_alim_3 (parcage+pature) nb_prod_3 fumier_1 nb_especes_anim_3
Interpretation	No breeding and monoculture. Extensive arboriculture	Gardening, no breeding and use of chemical inputs	Intensive gardening associated with breeding	Organic farming, gardening	Organic farming with greater diversity (plant and animal)
Number of AE modalities	2	0	3	10	13
Agroecological Ranking (1 best/ 5 worst)	4	5	3	2	1

Table 2. Description of the farming systems

Certain variables are more difficult to classify within a binary notation, agroecological or not. Hence, indicators regarding the feeding of the animals or the degree of food autonomy of the households display several levels. The opposite extreme levels are easy to classify as “detrimental to the environment” or not, the intermediary ones are left not classified for now.

From the classification of each modality between agroecological or not, we create a count of the agroecological modalities per cluster which in turn allows to rank the farming systems from an agroecological point of view. We then name the farming systems (FS) from 1 to 5 according to their agroecological ranking. The combination of practices highlighted by the clustering and the qualitative

interviews conducted on the field also allow to interpret the farming systems in terms of productive orientation (see in Table 2), which sets apart the FS 4 that does not display gardening characteristics.

Comparison of the employment indicators between FS with ANOVA and Kolmogorov-Smirnov test

We first compare the farming systems using ANOVA test on employment and work variables. From the 18 variables tested, 3 of them do not verify the assumption of homoscedasticity and thus cannot undergo the ANOVA test. The other variables passed the Levene test but only one gave significant results showing statistically different means between farming systems. The variables for which no statistically significant difference in means were found when performing ANOVA tests are presented in the annexes. Overall, this absence of results indicates that there are similar levels of work and revenues across farming systems.

A significant difference between farming system is found on the **number of daily family worker per hectare**. We look at the dispersion of the variable across farming systems to identify a relation with the agroecological levels defined previously.

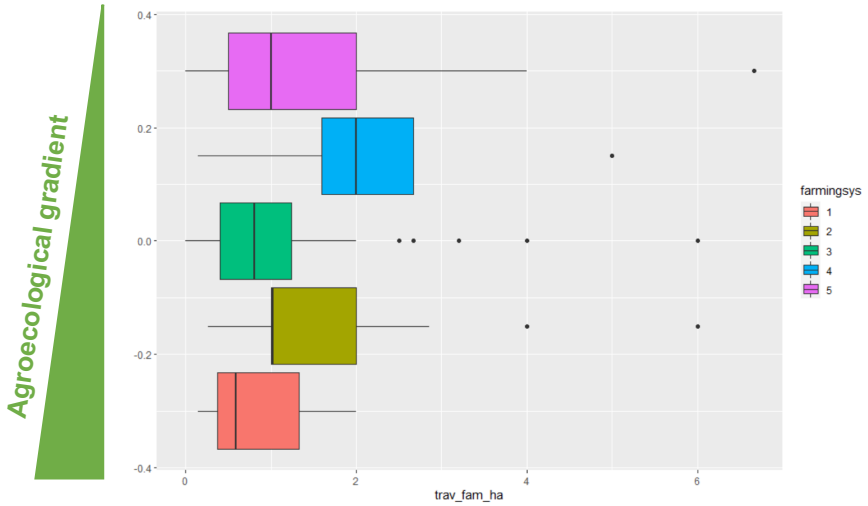

Figure 8. Distribution of the variable number of daily family workers per hectare across farming systems.

No clear trend appears regarding the effect of agroecology on the number of daily family workers per hectare (Figure 8). A slightly larger dispersion along the gradient from more agroecological to less might be glimpsed but it is very subtle. If it is confirmed, it would imply more work in less agroecological systems in our study zone.

We then compare the dispersion of the employment variables across farming systems by performing Kolmogorov-Smirnov tests. 9 variables show significant differences in dispersion between certain farming systems. We investigate the differences found for the different types of labor used on the farms by presenting the dispersion of 4 of these 9 variables.

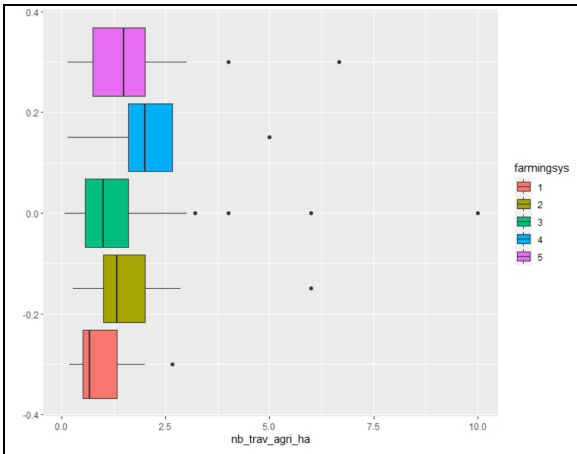

Figure 9. Dispersion of the number of total daily workers per hectare (family workers + wage workers)

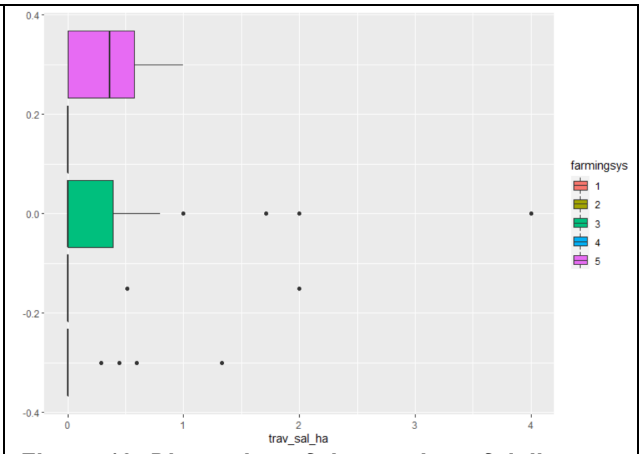

Figure 10. Dispersion of the number of daily wage workers per hectare

We first examine the dispersion of total **daily workers**, either family workers or wage workers (figure 9 and 10). Only a very slight trend of an increase in the means and dispersion of daily worker with less agroecology appear (from FS 1 to FS 5), which actually go against a potential job creation with agroecology and corroborates the trend previously observed. This potential trend would have to be studied further with econometric modelization.

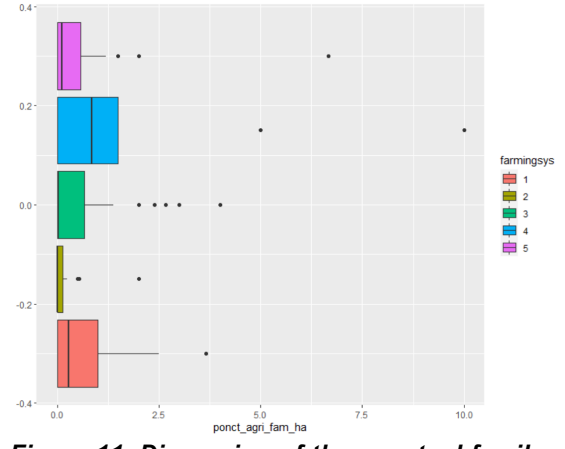

Figure 11. Dispersion of the punctual family worker participation per hectare.

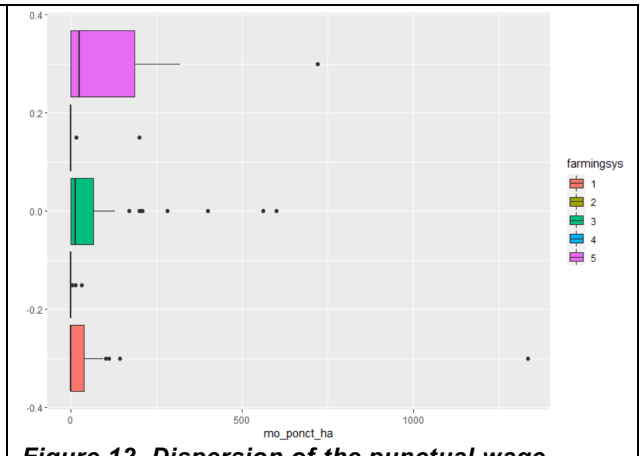

Figure 12. Dispersion of the punctual wage worker participation per hectare.

When looking specifically at daily wage worker, only two FS display relatively high levels of use of this type of labor, FS 3 and FS 5. The difference with FS 4's absence of wage workers use can be explained by its specificities as an extensive arboriculture system. Thus, if focusing on gardening, there is a clear difference between the more agroecological FS such as FS 1 and FS 2, which are organic farming and display almost no use of wage workers, with more conventional FS such as FS 3 and FS 5. Our hypothesis is that it can be explained by larger margin generated by intensive gardening which allow these FS to recruit wage workers. Binta Ba et Barbier (2015) also compare the results of organic and

conventional farming in the Niayes areas and find that conventional farming has better overall results due to higher yields and rely more on wage workers, which is consistent with this hypothesis.
Regarding punctual participation to farm work, either by punctual wage workers or family punctual work, no specific trend regarding our agroecological gradient appears. We note that there is an important difference between FS 1 and FS 2, the two most agroecological FS. FS 2 displays almost no punctual work, which could mean that the labor needs for work peaks is sufficiently low to be managed by daily workers, whereas FS 1 shows higher levels of punctual work both for wage and family labor. FS 4 displays higher levels of punctual family worker participation, which can be explained by the importance of the peak work for harvesting in arboriculture. Finally, FS 5 displays the highest level of punctual wage worker use, consistent with an intensive gardening system with many harvests during the season.

Discussion

From our results, differences in labor mobilization across farming systems do not seem to be specifically related to agroecological levels and can be explained by other characteristics of the systems.
Our qualitative interviews in the area provided elements regarding the importance of the effects of irrigation on the workload. So, we formulated the hypothesis that the differences observed in number of daily workers per hectare is mainly influenced by levels of mechanization of irrigation, thus hindering the possibility to grasp an agroecology effect. Therefore, we looked at the irrigation equipment of the farming systems by performing chi-square tests on the categorical variables for motorized pumps and irrigations devices comparing the farming systems. At first, the results were in line with our hypothesis, but when looking further into irrigation working time and working time outside irrigation, we find no significant difference. Thus, irrigation equipment cannot be the reason why we do not observe effect of agroecology on work in our data.
However, from our qualitative interviews and the tasks comparison results, we know there is additional work in more agroecological farming; the diversity of the farming systems in itself implies more management. Binta Ba and Barbier (2015) did found differences in working time between organic and non-organic when collecting data at the field scale. Hence, we conclude that it is our data collection methods that do not allow to grasp this extra work because: (1) its effect is rather small and has no impact on the number of workers; (2) the additional tasks might be managed with the activity system flexibility.
The possibility that the new tasks related to agroecology might be supported by farmers overtime or other family members such as spouse or children is suggested by the recent literature (Montt et Luu 2020, Pereira Fontes 2020). For instance, in the Niayes, breeding animals are often kept within the family house; thus, women staying at home might be the ones taking care of them and supporting the extra work related to the increase in breeding diversity. For the preparation of chemical inputs substitute it might be done in between other tasks, hence not increasing significantly the overall working time. These hypotheses need to be verified by further data collection.
We did not find significant differences in revenue between farming systems. A commercialization network has been set up by the NGO Enda Pronat in the area to provide better price for the famers in agroecology. However, it faces a number of logistical challenges and, as our data showed, these farmers do not appear to get a premium on prices compared to conventional farmers. The issue of the agroecological production valuation is critical for a decent remuneration of the extra work it generates. Higher revenue might allow farmers to have an additional person working full time on the farm, either family or wage worker, which would correspond to job creation.

Conclusion

From the analysis of our data collected in the Niayes area of Senegal, we find no evidence of higher labor requirements related to agroecological practices. Our results show statistically significant differences between the farming systems identified but they appear to be mostly due to other specificities of the farming systems. Our qualitative interviews and task comparison did highlight an additional number of tasks for farmers in agroecology. However, it does not reflect in job creation.

Yet, we believe that a better valuation of the organic production might allow the recruitment of workers on the long run, as it is observed for organic farming in western countries where there are functioning certification systems and specific markets (Midler *et al.,* 2019). Job creation might also be achieved through the implementation of a Payment for Ecosystem Services (PES) scheme in the area, by valuing the ecosystem services provided by the farmers. The Niayes is actually an appropriate zone for such scheme as the water supply for Dakar urban area is a groundwater table located there, with contamination risks from farming. Compensating farmers for a reduction of their chemical inputs use in order to protect water quality is actually the most widespread form of PES (Salzman *et al.*, 2018).

These results are context specific but nonetheless indicate that the opportunity for job creation in agroecology is not straightforward and most likely also depends on characteristics of the farming systems and on local institutions of labor mobilization. In the Niayes, farmers declare hiring workers very easily; the zone is actually known for attracting migrant workers from other regions of Senegal (Ba *et al.,* 2018). Massive youth unemployment in Senegal facilitates labor availability for agriculture in certain areas, however the question of the sector's attractiveness is still critical elsewhere (Sumberg *et al.,* 2014). Therefore, drudgery of work and decent working conditions should also be considered when discussing structural transformation paths.

As underlined earlier, our data and method face a number of limits. First, agroecology observed in our study zone is mostly at a substitution stage which does not allow to measure the full benefits of certain systemic functioning of agroecology. Also, one major difference in terms of work is usually found regarding the use of herbicide versus manual weeding, whereas in our zone, both conventional and organic farmers were doing manual weeding. The effects of agroecology on gardening, an already labor intensive production, might be smaller than on other types of productions, such as rain-fed crops. To fully grasp the difference in work between agroecological and conventional farming, a data collection at the task and field-level would allow to go into more details. Finally, in terms of data analyses, multivariate analyses are still necessary to validate our results and disentangle certain effects. As agroecology and labor market are heavily context dependent, a number of similar studies in different contexts across SSA should be necessary to validate a trend in job creation that could provide insight regarding desirable structural transformation pathways.

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Annex 1 – List of the variables used for the HCPC delimitating the farming systems

Variable name	Description
engrais	Chemical fertilizer use
fumier	Manure fertilizer use
jachere	Practice of fallow
compost	Compost fertilizer use
pesticides	Chemical pesticides use
pesticides_bio	Organic non-chemical pesticides alternative use
prepa_pest_bio	Preparation of the organic non-chemical pesticides alternative by the farmer
semences	Certified purchased seeds use
labour	Practice of plowing
paillage	Practice of mulching
asso_cultures	Combination of cultures
div_varietes	Plant varieties for a given production
rotation_cult	Practice of crop rotation
evol_arbres	Evolution of the number of trees on the farm (decrease, maintenance, increase)
regul_ecol	Presence of ecological regulation area on the farm
nb_especes_anim	Number of animal species bred
conso_alim	Share of the family alimentation provided by their farming (all/more than 50%/ less than 50%/zero)
type_alimentation	Type of feeding for the animals (fodder only/fodder and feed grains/feed grains only)
mode_alim	Mode of feeding of the animals (pasture or within the family home where they are kept)
fertil_elevage	Use of the manure of the farm's animals for fertilization
nb_prod	Number of type of production (gardening, arboriculture, breeding, or rain-fed production)
nb_cultures	Number of crops grown

Annex 2 – Variables and means showing no statistically significant difference between farming systems

Variable content	Variable name	Mean of FS1	Mean of FS2	Mean of FS3	Mean of FS4	Mean of FS5
Number of daily family workers per hectare	trav_fam_ha	2.04	1.56	1.07	2.70	0.85
Number of daily wage workers per hectare	trav_sal_ha	0.00	0.38	0.33	0.14	0.10
Number of hours worked of punctual family worker per hectare per year	trav_fam_ponct_ha	541.16	173.17	215.27	77.46	208.49
Number of hours worked of weekly family worker per hectare per year	trav_fam_hebdo_ha	509.98	594.27	456.52	329.33	382.42
Number of hours worked of punctual family worker per hectare per year	trav_fam_quoti_ha	2858.33	3866.44	2281.50	5207.46	2283.36
Total hours worked by family workers per hectare per year	tot_trav_fam_ha	3909.48	4633.89	2953.29	5614.27	2874.28
Total hours worked by external labor for peak work per year	mo_ponct_ha	24.00	114.46	58.82	2.94	77.91
Remuneration of the family work : added value of the farm divided by the number of family worker	rem_trav_fam	35 456.61	213 559.21	472 529.68	255 738.82	365 375.41
Hourly remuneration of the family work : added value of the farm divided by the number of hours worked by family worker	rem_heure_trav_fam	48.98	156.92	323.12	215.08	465.87
Added value divided by number of total workers (family+wage) divided by hectare	va_par_actif_ha	153 511.6	232 415.4	299 540.5	417 243.5	354 726.2
Total off-farm activities of the household	tot_activites_hors_agri	2.11	1.76	2.29	1.72	2.68
Total remuneration of the off-farm activities	rem_ext	1 097 780.9	617 889.1	1 016 251.0	711 666.7	1 106 560.5