



JOURNAL OF OASIS AGRICULTURE AND SUSTAINABLE DEVELOPMENT

www.joasdjournal.org



p-ISSN: 2724 – 699X
e-ISSN: 2724-7007

Typological analysis of farming systems diversity and performance: A case study of Southern Tunisia

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Article info

Article history:
Received 10/02/2022
Accepted 25/04/2022

Keywords: diversity, farming systems, performances, Tunisian arid regions, typology.



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Conflict of Interest : The authors declare no conflict of interest.

Abstract

In Tunisian arid regions, farming systems are increasingly exposed to quick environmental and socio-economic changes, which may reduce their performance and resilience. This paper seeks to assess the performance of farming systems in the district of Sidi Makhoulf (Southeast of Tunisia) considering their diversity. Thus, a typology of farms based on data from the 2004-2005 structure surveys was developed using multidimensional analyzes and the expert method. Multidimensional analyzes have identified three groups of farms: "Rain-fed olive farms", "Irrigated farms", and "Livestock farms". Representative farms were chosen by local agricultural experts to conduct an in-depth analysis of the identified groups. Then, two field surveys were performed with the chosen farmers. Characterization and analysis of homogeneous "reference farm groups" confirm their socioeconomic and technical performance diversity, according to the capital endowment and the strategies implemented by farmers. These results suggest that agricultural policies and interventions should be targeted to strengthen performances and to respond to the specific contexts of each farms' group.

1. INTRODUCTION

The context of the agricultural sector in the Middle East and North Africa (MENA) region is increasingly uncertain and risky due to many factors such as arid climate, frequent droughts, and scarcity of natural resources (Sowers et al., 2011). The effects of these contextual changes on farms' functioning and performances generally differ according to the initial endowments of farmers, their projects, the management methods of production systems, and the investment possibilities (Alary et al., 2002). Farmers are therefore likely to react differently to risks. Consequently, differences in drivers and farm characteristics will lead to diversity between and within farming systems (Righi et al., 2011; Mądry et al., 2016).

Several studies have reported that effective political interventions must consider the diversity of farms (López et al., 2008). Further, it has been suggested that the typology helps to

understand the diversity of agricultural situations and to develop adequate development policies (Andersen et al., 2007). In the same context, Deffontaines (1985) claims "The aim of the typology is to simplify, by reducing the multiplicity of individual cases into a smaller number of types, in order to allow further analysis and to facilitate the organization of actions". In other words, the typology of farms aims to distinguish, within a population of farms, a limited number of significantly different types. Likewise, in Tunisian arid regions, the territory dynamics manifested by climate vulnerability and rapid socio-economic transformations have contributed to the emergence of diversified farming systems. Therefore, the analysis and monitoring of farm diversity need to be constantly updated. However, a lack of information on these transformations and their impact on farm performance was noted. To fill this gap, an observatory of agricultural farms in Tunisia has been implemented within the

framework of technical cooperation between the Food Organization of the United Nations (FAO) and the General Direction of Studies and Agricultural Development (DGEDA) at the Ministry of Agriculture, Hydraulic Resources and Fisheries (MARHP). It benefited globally from the support of the regional initiative "World Agriculture Watch" (WAW) supported by FAO (Béliers et al., 2017).

The WAW intentions are to improve the understanding and use of agricultural diversity, as well as its performance and level of resilience to inform and facilitate political dialogue (Penot et al., 2014). In Tunisia, the WAW project (Sghaier, 2017) has considered the district of Sidi-Makhlouf - Medenine province, located in southeast Tunisia, as its pilot site.

The focus of this paper is to establish a typology of Sidi Makhlouf farms in order to analyze and understand their functioning and performance. This analysis helps to explain their different functioning modes and to understand why farmers of the same region are organizing heterogeneous farming systems (Cochet and Devienne, 2006) and are adapting differently to the same risks. This study set out to test the hypothesis that farming systems are very diverse, and that each system tries to adapt according to the available opportunities, which are based on the valuation of its resources.

2. MATERIAL AND METHODS

2.1. Study area

The study area is the district of Sidi Makhlouf, which belongs to the province of Medenine, southeast Tunisia (Fig. 1). The district covers an area of 686 Km². From the south, Sidi Makhlouf is bounded by the districts of Medenine South and Medenine North, from the east by Boughrara plain, from the north by the Mediterranean Sea, and from the west by Oued Ezze. The climate of the study area is arid. Over the past 30 years, the average temperature recorded has been 21.7 °C and the average precipitation has been 215 mm. The useful agricultural area of Sidi Makhlouf is 64887 ha (ONAGRI, 2016). It is characterized by an important and diversified productive potential. The main productive choices are oriented towards the olive, fig, almond, cereal, legume, and vegetable crops. In addition, the livestock sector is an important component of the farms. Sheep farming is the most important followed by goats, camels, and cattle. Regarding employed labor force, in Sidi Makhlouf there are 5925 employees: 45 % in the service sector, 29.3

% in public works, 15.8 % in agriculture and fishing sector, 8.7 % manufacturing industries, and 1 % in mining and energy.

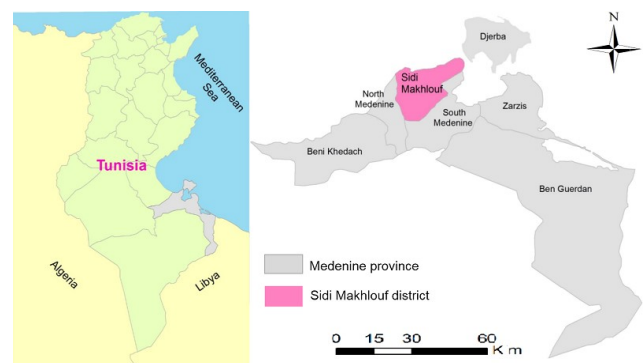


Fig. 1. Location of the district of Sidi Makhlouf.

2.2. Methodological approach

Analysis of farm diversity in Sidi Makhlouf was carried out using four steps following a progressive approach:

- In a first step: a statistic typology was carried out using the last survey database of farm structures carried out in 2004-2005 (Jaouad and Gaillard, 2017). The database contains 131 observations and 70 variables. The variables are relevant to several themes: socioeconomic characteristics of the household, institutional aspect, labor, land tenure, livestock, and agricultural equipment. Statistical analyses were performed using Excel and TANAGRA software. TANAGRA is an open-source software available on the web. It implements a series of data mining methods from the field of exploratory statistics, data analysis, machine learning, and databases (Rakotomalala, 2005, Wahabeh et al., 2011).
- In a second step: a focus group discussion with 18 local agricultural experts (7 researchers, 5 technicians, and 6 engineers from the Ministry of Agriculture of Tunisia) was organized to present and discuss the results of the statistical typology. After several sessions, the agriculture experts and researchers have validated the results of the typology and identified homogeneous groups of farms. To conduct further analysis of the existing farms' groups, the authors invited the experts to identify reference farms that represent the diversity in Sidi Makhlouf. The experts have chosen 15 reference farms based on the validated typological groups and the acceptability of farmers.
- In a third step: to deepen the analysis of the reference farm groups' diversity, two field

surveys had been performed with the chosen farmers. The first survey was carried out in April 2017; it focused on the socio-demographic characteristics of farmers and general aspects of their farms (general information on structure, functioning, and performance). The second survey was carried out in May 2017 to consolidate the first survey's data and to collect detailed technical and economic data on crop and animal speculations. Moreover, this second survey was designed to understand the different strategies developed by farmers to deal with the various constraints of their context.

- In a last step: we have characterized each surveyed group of reference farms through a set of indicators. We have designed an EXCEL structured platform for data entry of the collected information. The platform came up with the option to calculate farm indicators (structure, functioning, and performance indicators). Furthermore, to investigate the impact of the various strategies on the economic situation of farmers we have calculated:

- The overall gross margins (GM) (gross product minus variable costs) (Hubscher, 1981), the crop gross margin (CGM) and the livestock gross margin (LGM) to compare speculations (crop, livestock),
- The agricultural income (GM minus structural or fixed costs) (Razafimahatratra et al., 2017) to assess the overall profitability of farms.

The work had been estimated in Man Work Unit (MWU), with 1 MWU = 300 working days for an adult person (Hubscher, 1981).

3. RESULTS

3.1. Results of multidimensional analyses

The first multidimensional analysis (PCA) was carried out on the 34 variables of our database. Variables that did not contribute, or which have a weak contribution to the explanation of dispersion were gradually eliminated. Finally, the analysis was carried out with 17 variables (Table 1). The PCA allowed a graphic differentiation of correlations between the identified variables (Fig. 2). The 17 retained variables are related to five themes:

- Variables related to land capital: Total land area (TT_Area), Agricultural area (Ag_Area), Plowing Area (Plow_Area), Rangeland area (Rg_Area), Number of plots (Nb_Plot) ;
- Variables related to productive choices: Number of cereal plots (Plot_Cr), Number of legume plots (Plot_Lg), Number of forage crop plots (Plot_Frg), Number of vegetable plots (Plot_Vg), Number of arboriculture plots (Plot_Arb) ;
- Variables related to technology: Irrigated area (Irr_Area) ;
- Variables related to livestock size (in Livestock Unit (LU)): Total livestock size (Size_Lvstck), Cattle size (Size_Ctl), Size of sheep flock (Size_Sheep), Size of goat livestock (Size_GT) ;
- Variable related to labor: Number of employees engaged in the farm (Hir_Lb).

Table 1. Comparison of the selected farm groups through the retained variables.

Structure variables	Group 1 (n= 12)	Group 2 (n= 93)	Group 3 (n= 26)
Total land area (ha)	138	4.5	18
Agricultural area (ha)	135	4.4	17.65
Plowing area (ha)	118	4.35	16.5
Rangeland area (ha)	17,4	0.05	1.15
Number of plots	10.4	3.4	6.3
Number of cereal plots	4.4	0.7	0.8
Number of legume plots	0.4	0.12	0.15
Number of forage crop plots	0.9	0.3	0.23
Number of vegetable plots	0	0.39	0.7
Number of arboriculture plots	1.5	0.8	2.3
Irrigated area (ha)	1	0.65	6.19
Total livestock size (LU)	15.1	3.52	39
Cattle size (LU)	2.3	1.4	2.4
Size of sheep flock (LU)	11.9	1.2	7.5
Size of goat livestock (LU)	0.5	0.07	0.84
Hired labor (MWU)	0.6	0.03	0.73

ha: hectares, LU : Livestock Unit, MWU: Man Work Unit

PCA inertia of the first five factorial axes represents 71.92 % of the total inertia with strong representativeness of the first two axes. Thus, the factorial plan (F1, F2) is essential in the results interpretation and group's definition since it represents 45.62 % of the total inertia (Fig.2).

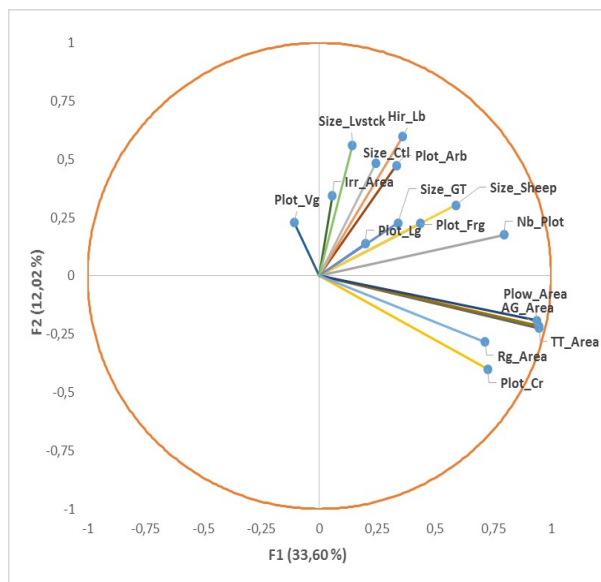


Fig. 2. Projection of PCA variables in the factorial plan F1-F2.

TT_Area: Total land area; *Ag_Area*: Agricultural area; *Plow_Area*: Plowing Area, *Rg_Area*: Rangeland area, *Nb_Plot*: Number of plots; *Plot_Cr*: Number of cereal plots; *Plot_Lg*: Number of legume plots; *Plot_Frg*: Number of forage crop plots; *Plot_Vg*: Number of vegetable plots; *Plot_Arb*: Number of arboriculture plots; *Irr_Area*: Irrigated area, *Size_Lvstck*: Total livestock size, *Size_Ctl*: Cattle size; *Size_Sheep*: Size of sheep flock; *Size_GT*: Size of goat livestock, *Hir_Lb*: Hired labor

Axes' significance is expressed through the contribution analysis of the retained variables to the total inertia (Table 2). The interpretation is focused on the first two factorial axes given their high representativeness:

- The first axis represents 33.6% of the variance and reflects an association between size and specialization of farms.
- The second axis explains 12% of the variance and shows an association between farming activity and the number of employees engaged on the farm.
- The third axis expresses 10.1% of the variability and shows the importance of irrigated crops (vegetable crops and legumes).
- The fourth axis justifies 8.8% of the variability and confirms the importance of irrigated crops, especially fodder crops associated with cattle farming.

- The last axis represents 7.2% of the variability; it highlights the importance of olive growing associated with goat farming.

Table 2. Contribution of eigenvalues to the inertia of the selected factor axes.

Factorial axes	1	2	3	4	5
Eigenvalues	5.37	1.92	1.63	1.4	1.16
% Inertia	33.6	12.02	10.19	8.8	7.29
% Cumulated	33	45.6	55.8	64	71.9

3.2. Identification of farm groups and choice of reference farms

The identification of farm groups is based on the hierarchical tree (dendrogram) issued from HAC and the distribution of variables in the factorial plans of PCA. After several iterations of PCA and HAC, three main groups were identified. The incision in the HAC dendrogram (Fig. 3) and the distribution of explanatory variables on the factorial plan (F1, F2) illustrate this typology with three homogeneous farm groups:

- Group 1 : « Rain-fed olive farms » (n= 12 farms) ;
- Group 2 : « Irrigated farms » (n= 93 farms) ;
- Group 3 : « Livestock farms » (n= 26 farms).

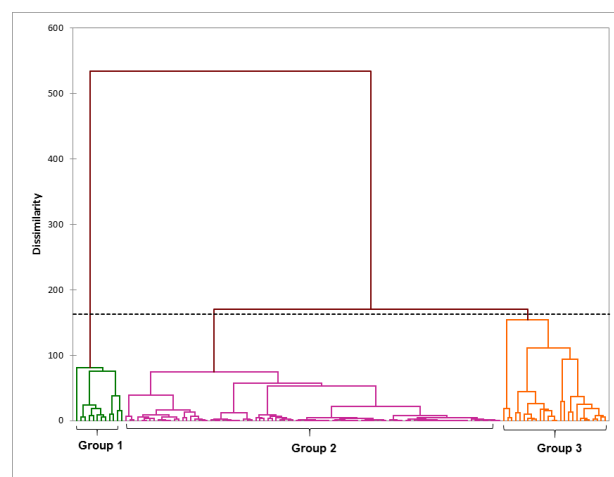


Fig. 3. Dendrogram of the Hierarchical Ascending Classification.

Typology results have been validated by local experts from the Tunisian Ministry of Agriculture. Fifteen reference farms representing the three validated groups were

chosen to conduct in-depth analyzes of farming systems diversity in Sidi Makhoul:

- Group 1: « Rain-fed olive farms » (n= 3 reference farms);
- Group 2: « Irrigated farms » (n= 8 reference farms);
- Group 3: « Livestock farms » (n= 4 reference farms).

3.3. Socioeconomic analyzes and characterization of the homogeneous groups of reference farms

Through the field surveys carried out with farmers of the 15 reference farms, a deeper analysis of functioning and performances was carried out on each group of farming systems.

Group 1: Rain-fed olive farms with low economic performance

Represented by three farms of reference, this group is specialized in rain-fed olive associated with small ruminant farming. The socio-demographic characteristics of this group reveal that farms' heads are the oldest with an average age of 54 years (the average age of all farmers is 50 years) and that households are significantly large (8.3 members on average).

The farming system is characterized by the most significant land capital of 76.3 ha (the average area of all farms is 40.2 ha), dispersed over 5.3 plots on average. Farms are poorly equipped with agricultural material; only one farmer of three has a tractor. Further, the capital of the farm is distinguished by the highest number of olive trees (an average of 698 olive trees by farm) compared to the average of all farms (569 olive trees), and by an average livestock based on small ruminants (10 LU by farm). Concerning commercial orientation, only 26% of the products are sold on the market. The family consumption is important, particularly in terms of crop production (olive oil). Traditional techniques choices and low resource endowment of this group provide some explanation as to why economic performances are weak compared to other groups. Indeed, the CGM (Crop Gross Margin) and the LGM (livestock gross margin) are low, 9527 TND and 5215 TND respectively (the average CRG and LGM of all farms are 23017 TND and 11290 TND respectively). Despite the significant herd size, the low level of LGM raises questions about the efficiency of livestock husbandry, which did not allow the empowerment of these farms. Likewise, the average agricultural income /

MWU is only 375 TND/ month, which is lower than the SMAG (465 TND/month). Further, two out of three farms have an agricultural income lower than the SMAG (Fig. 4). Low agricultural incomes could explain the diversification of income sources by the farms' heads of this group. In fact, two out of three practice off-farm activities (trade) to meet the needs of their households and to sustain agricultural activities.

Group 2: Irrigated farms with high economic performance

This group is represented by eight reference farms, which are distinguished by the importance of irrigated crops associated with the herding of small ruminants. The socio-demographic characteristics of this group differ from the first since farms' heads are the youngest (an average of 43 years) and households are relatively numerous (average household size = 10.45 members).

The farming system is characterized by a land capital of 30 ha (dispersed over 3.6 plots) including an important irrigated area of 5.5 ha. Farms of this group are supremely equipped: 6 out of 8 farms have tractors and irrigation equipment. The water used for irrigation is from private wells (6 farms) and public wells (2 farms). Private wells are equipped with electric or diesel motor pumps. Further, these farms have on average two buildings with an area of 500 m². The capital of the farm is highly diversified including 587 olive trees and 224 of other fruit trees (peach, vine, fig, almond...). The herd size is almost equal to that of group 1, an average of 9.5 LU of the small ruminant.

As for technology level, this group is distinguished by high input costs compared to other groups (14192 TND spent for purchase of water, fertilizer, mechanization, treatments...). Nevertheless, the cost of livestock feeding is lower than the other groups (5016 TND). This result may be explained by the diversification within the cropping system, which generates significant residues intended for feeding livestock.

Regarding market integration, farms of this group seem to have a high commercial orientation with 73% of products sold on the market, notably vegetables, olives, and fruits. The capital of the farm and innovative productive choices have led to significant economic performance. Indeed, this group is characterized by the highest level of economic performance in crop production compared to other groups with CGM of 33857 TND / year (compared to an average of 23017 TND / year).

Two farmers have given up some agricultural activity (notably vegetables) because of some constraints that have not been able to overcome, in particular water salinity, which exceeds 6 g / l, they, therefore, resort to off-farm activities to meet the needs of their households.

Group 3: Livestock farms

This group is represented by four reference farms specialized in livestock herding (small ruminant and camel herding). The socio-demographic characteristics of households reveal that the farms' heads are 50 years old and that the households' size is smaller than the other groups (6.75 members on average). The farming system is characterized by a large herd size: 23 sheep LU and 8.4 camel LU. The land capital is also significant, 35.3 ha dispersed over 3.5 plots. Furthermore, the capital of the farm includes a significant number of olive trees (437 trees). Farms of this group are well equipped: tractor (2 farms) and wells (one farm).

The economic performance of this group is characterized by the highest LGM (15908 TND) which may be explained by the significant herd size of this group. The CGM records high economic performance reaching 11453 TND. These results led to an important average income per MWU equal to 975 TND / Month. Furthermore, all livestock farms have an average income greater than the SMAG (Fig. 4).

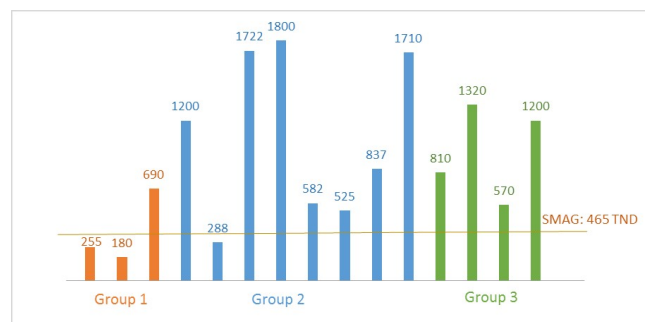


Fig. 4. Average agricultural income per MWU per Month in Tunisian Dinar per type of farm group.

4. DISCUSSION

The findings of this study confirm the hypothesis supporting the diversity of the farming systems in Sidi Makhoulf. Further, they provide an understanding of how initial capital endowments can lead to different levels of technical and economic performance. However, diversity can also be explained by the different management strategies adopted by farmers. Indeed, each group of farmers tries to adapt its

strategies according to the socioeconomic and technical potential and natural resources accessibility.

This section shows and discusses the main management strategies adopted by the identified groups of farmers. Then, it explains how the comprehension of farm diversity may support public policies.

4.1. Three main management strategies

Farmers of Sidi Makhoulf are implementing three main management strategies to achieve their production goals and to ensure farms sustainability. Among these strategies, two are manifested by the investment in the production system to increase incomes. The other one is a preventive strategy that aims to limit risks linked to farming activities.

• Produce diversified crops with high value-added while developing irrigation

This strategy is adopted mostly by the « irrigators » group. These farmers aim to increase and secure their income by developing diversified value-added crops (vegetables, arboriculture) while modifying the rotation (adoption of new crops and reducing others that are less profitable) or extending the cultivated area. The extension of cultivated areas can be done by improving water access through investments (occasionally subsidized by the State) in the deepening of wells or the introduction of drip irrigation. Our findings are in line with previous researches showing that crop diversification improves the performance of farming systems (Souissi et al., 2018), enhances its resilience and offers food security to households (Darnhofer et al., 2010). The effectiveness of this strategy is conditioned by the availability of assets on farms, particularly wells, tractor, finance, and family labor. Access to these factors of production can respond to the pressures and difficulties encountered throughout the production process. Farmers with enough investment capacity favor the diversification strategy since it allows farm capital intensification and transmits an economically efficient working tool to their children.

However, these farmers are expressing difficulties in supplying crucial inputs for crop

diversification (energy, seeds, plants, phytosanitary treatments, fertilizers, irrigation equipment, labor, etc.). Thus, such strategy is hindered by the availability of factors of production, which constitute heavy costs to farmers. This makes farm incomes very sensitive to the price variability in markets. Therefore, some farmers are discouraged from investing more in vegetables, especially in the absence of state incentives. Farmers with limited and random water access reduce the vegetable area and tend to plant fruit trees since they are less water consuming and more sustainable. In addition to the water availability, crop diversification depends considerably on its quality. Indeed, the use of saltwater can lead to a decrease in productivity (Safdar et al., 2019). This observation is proven through two farmers of our study, which abandoned vegetables because of excessive water salinity. Salinity concerns most water resources in Tunisia, it exceeds the international threshold for agricultural uses (30% with a salinity greater than 4 g / L) (Mansour and Hachicha, 2014). Farmers affected by this problem choose to be limited to cereal cultivation and to expand their orchard.

• Creation of profitable and improved association between livestock husbandry to crop production

The association of livestock husbandry to crop production has been observed in most farming systems in the Southern Mediterranean as a form of response to risks and uncertainties (Souissi et al., 2018). Likewise, in southeast Tunisia, this adaptive measure can be considered as a mitigation strategy to face climatic and socio-environmental risks. Livestock plays an important role in stabilizing income and accumulating capital through reproduction. It also represents an asset, which can be sold if needful. Our investigations show that all farmers in our study case are adopting this adaptive measure. However, the livestock management methods were different between farm groups depending on farmers' orientation to crop or livestock production. Concerning "irrigators" and "herders", it is thanks to the diversification within their cropping system that important residues are generated in farms. This improves the herd's feed and reduces its costs. Moreover, livestock husbandry provides the manure needs to cropping systems, which reduces input costs. Thus, the association

between livestock and crop production has guaranteed the independence of these farms to market. These results support the idea that irrigated systems contribute to livestock husbandry viability and vice versa, especially in arid regions (Jemaa et al., 2016). Nevertheless, Nefzaoui (2004) pointed out that these interactions remain dependent on irrigation water.

However, in « rain-fed » farms, the interaction between crop and livestock production is not valued as in « irrigated » farms. Indeed, residues generated from cropping systems are negligible and are not enough to feed livestock. In addition, the contribution of pastures to feed livestock has decreased significantly due to the reduction in the rangeland area and the increase in livestock size (Nefzaoui, 2004). The livestock pressure on rangelands is therefore increasing. Besides, Tunisia has the highest density in Africa for sheep farming: 40.3 sheep / km² (Snoussi, 2003). Hence, the use of supplementary feed resources for livestock is crucial and farmers are dependent on market price variability (Elloumi et al., 2011), which increases their farming systems' vulnerability. This distress was expressed by most surveyed farmers who face difficulties linked to the high costs of herd feeding. They are often obliged to sell one or two animals to cover feed costs of the rest of the herd. Insights from these farms prove that subsidies offered by the Tunisian government to herders for some food resources are not sufficient. Thus, policies adopted for food resource development need to be reformed.

• Importance of non-farm activities to overcome the weak economic performance of farms

To deal with risks and uncertainties related to agriculture, some farmers choose to invest only in one or two activities and to renounce others (vegetables, arboriculture, etc). This requires high levels of technology and production factors. The abandonment of such crops is caused by the lack of water and price variability. Therefore, these farmers prefer to maintain traditional systems based on rain-fed olive trees and small ruminant livestock farming. Such situation weakens the economic performance and reflects the high level of vulnerability of these farms.

Regarding household economic strategy, farmers seek to overcome the weak economic performance of their farms by the reliance on non-farm activities. This result supports many previous researches, which proved that off-farm

activities may respond to the inability of agriculture to generate sufficient income for households (Sghaier, 2012) and present an adaptation strategy to keep productive farms (Jayne et al., 2014). Off-farm income enhances farmer flexibility and allows a rapid resolution of management problems such as the purchase of water for irrigation or food for livestock. This strategy is more illustrated in «rain-fed olive farms» that have difficult access to resources (water, capital, etc.) and finance.

However, off-farm diversification has not been significantly recorded among «irrigators» and herders since their orientation implies a permanent availability on the farm. They are always faced with the challenges of deciding which rules should be changed, when and how to make changes. Besides, the generated agricultural income must be sufficient and guarantees the farm's viability. Thus, the diversification of economic activities is the most appropriate form of adaptation for households least endowed with resources and finance.

4.2. Is farm typology a relevant tool to support public policy?

The results of our investigations highlighted a differentiation of economic performance and productive choices between the farms' groups. This disparity is dependent on the capital endowment and farmers' capacity to mobilize productive resources. Two main situations were identified: (i) farms with traditional productive choices and weak economic performance, and (ii) farms with significant capital endowments and high economic performance. Therefore, agricultural policies must, firstly, develop existing farms' potential taking into account the gap of performance between groups. Secondly, they should promote and consolidate the productive choices that demonstrate their effectiveness in some groups.

In terms of trajectories, farms with high performances may become entrepreneurial farms through capital accumulation and intensification of farming systems. This evolution may not concern all farms with high capital; some of them may not overcome some constraints and experience regressions or negative transformations. However, farms with low capital could experience a total decline in productivity because of their vulnerabilities and low adaptive capacities. Thus, specific agricultural policies must take into account these differentiated evolutions to consolidate and

promote positive transitions and reduce risks of negative transformations. Special attention should be given to the most vulnerable farms in order to increase their economic performance and promote their adaptability.

5. CONCLUSION

This paper confirmed the diversity of farming systems in the district of Sidi Makhlof. Indeed, farm diversity has resulted in differentiated levels of technical and economic performances. The presented study revealed farm groups with significant capital endowments, sufficient economic size, and high levels of performance such as the case of "irrigators" and "herders". These groups seem to be developing a capital consolidation strategy allowing them to be flexible in terms of productive and technological choices. The findings highlighted also another group with weak economic performance and reduced capital endowments, which is the "rain-fed olive farms". These farms are vulnerable due to their difficult access to resources and funding. Despite the differentiation of performance levels, most farmers have demonstrated an ability to adapt to changes in their context in different ways. This diversity should be taken into account when formulating development policies and programs. In fact, these findings provide information to develop agricultural advisory for the different groups of farms. Furthermore, this study constitutes a knowledge base for the development of a monitoring and decision-making tool within the farms observatory. It could represent a basic reference for further studies of trajectories to follow the transformations of the reference farms. Likewise, the used methodological approach could serve as a reference that can be applied at the regional or national level to formulate targeted agricultural policies.

Acknowledgements

This work was carried out within the framework of the interregional TCP / 3504D project, of technical cooperation between the FAO (WAW program) and the General Direction of Studies and Agricultural Development (DGEDA / MARHP) of Tunisia. The authors would also like to thank the local actors of the Ministry of Agriculture (the local extension cell of Sidi

Makhlouf) and the farmers for their collaborations.

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