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Foreword

Benmehaia's paper analyzes the relationship between farm size and farm performance in Algeria. Two farming sectors are considered, namely: date palm sector and greenhouse vegetables sector. The study employs two farm performance measures, farmland productivity and land use intensity. The main findings show that the inverse relationship holds for a traditional agriculture and does not in a modernizing one. The consideration of the nature of the used technology in the underlying sector (i.e., its stage of development) is of crucial importance as a contingency factor in analyzing the inverse relationship for any farming system ignored in most studies.

Bulut and Aslan try to understand the impact of increase in livestock support policies in Turkey. The results of the analysis revealed that support to livestock does not affect the number of livestock in the short term, but has a positive effect in the long run. Furthermore, both in the short and long term, the increase in prices in the livestock sector increases the livestock fund. Even though increases in feed prices harm livestock presence in short run as expected, this negative effect disappears in the long run.

Role and organization of Fisheries Local Action Groups (FLAGs) analyzed by *Ceccacci*, *Mulazzani and Malorgio* according to the six dimensions of the Porter's Diamond Model in the context of the cluster analysis on coastal communities' competitiveness. Focusing on Italy, Spain and France, it emerges that while the literature has mostly emphasized their territorial functions, FLAGs- especially those in areas with relatively higher incidence of employment in fisheries-related sectors- have prioritized projects of sectorial scope.

The paper focuses on dairy cattle farming systems and the sources of innovation for breeders in Algeria. The origin of innovation relating to breeding practices comes mainly from local socio-technical networks, whereas formal extension by public services is ineffective. The authors *Himeur*, *Ikhlef and Madani* highlight that faced with the uncertainties of the climate, public policies and markets, the autonomy fodder is the only alternative for the economic viability and sustainability of agricultural exploitations.

AlFraj analyses rain-fed farmers' risk attitudes and farmers' perceptions of risk in Syria. The results demonstrate that precipitation shortage was the most important risk source that threaten farmers in both zones. Moreover, risks of diseases and pests and natural disasters were highly perceived by farmers so fire damages and lack of government support. The financial strategy related to the producing at lowest possible cost is perceived as an impor-

tant strategy to manage risk by farmers. The results also show that some farm and farmers' characteristics (e.g. age, experience, education, household size, farm size, family labour, extension contact, off-farm work and Co-op Member) significantly impact the risk attitudes of the farmers in both zones.

Table olive farming has an important tradition and production potential in western Turkey, and thus it is critical to assess the risk sources and risk management strategies that farmers perceive. The author *Tok* shows that financial and marketing risk sources are most prominent among farmers, and human-induced and production technology issues represent the most important risk management strategies. In table olive production, it will be beneficial to develop strategies such as increasing the number of trees, improving agricultural activities, increasing the awareness level of farmers on issues such as climate change and the use of new technologies.

Pérez Mesa analyses new approaches that strengthen the modal shift, rather than focusing simply on the reduction of externalities. A possible option is to redefine ports, conceptualizing them as redistribution and coordination centers and not only as areas of cargo exchange. The paper analyses this problem by attempting to promote intermodality (truck and short sea shipping) for the transport of highly perishable products (vegetables) exported from Southeast Spain, which is the leading supplier to Europe.

Boumali, *Mamine*, *Cheriet*, *Montaigne and Arbouche* analyse several possibilities to valorize prickly pear farming in Algeria, a context dominated by semi-arid ecosystems. The paper shows that the production and processing of prickly pear by-products present a high potential, but remains largely under-exploited. Production is mostly artisanal, collection uses traditional practices and marketing is dominated by unstructured and informal channels. An important constraint is foreign market entry. Due to the partial failure of producer's commercial export strategies', local outlets remain dominant.

Farm size and productivity in Algerian agriculture: A contingent relationship

Mohamed Amine Benmehaia*

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Abstract

The purpose of this paper is to analyze the relationship between farm size and farm performance in Algeria. Unlike most previous studies, this preliminary study uses a large dataset comprising 26 735 farmers in Biskra region. Two farming sectors are considered, namely: date palm sector (typically a traditional farming sector) and greenhouse vegetables sector (relatively a modernizing sector) as dominant activities, to the extent that they represent both 74% of the irrigated farmland in Biskra. The study employs two farm performance measures, farmland productivity (farm output per hectare) and land use intensity. A bivariate non-parametric regression (Nadaraya-Watson approach) and multivariate quantile regression are used to assess the IR in two farming sectors. The main findings show that the IR holds for a traditional agriculture and does not in a modernizing one. Then, when it holds, it follows a systematically monotonic smooth pattern, whereas in a highly input-intense modern sector, the relationship becomes, in the best cases, blurry. The consideration of the nature of the used technology in the underlying sector (i.e., its stage of development) is of crucial importance as a contingency factor in analyzing the IR for any farming system ignored in most studies.

Keywords: *Inverse relationship, Farm size, Land productivity, Farm performance, Farming system, Algeria.*

1. Introduction

The inverse relationship (IR) between farm size and productivity has long been of an increasing interest and a controversial issue among development and agricultural economists. Particularly in developing countries, the extent to which small farms use resources efficiently is particularly relevant for African countries that seek to modernize their agricultural sector and make the transition from a subsistence-based to a market-driven rural economy (Ali & Deininger, 2015). However, the relationship between farm size and agricultural performance is not clear-cut in developing economies (Verma & Bromley, 1987; Garzón Delvaux *et al.*, 2020a). Boussard (2014) nicely formulated this inference by stating that a large dimension of a farm is not the guarantee of high productivity. Due to its complexity, it seems that the empirical literature has failed to reach a consensus (Fan & Chan-Kang, 2005; Gollin, 2019).

The relationship between farm size and farm performance has been the subject of many empirical tests in large range of countries around the world. In Algeria, Africa's most large country with an agricultural vocation *par excellence*, fragmented farmland plots and small-farm sizes are typical farming units, and should be considered as a key issue by public policy-makers.

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Small-scale farming is considered as one of key leverage for Algeria's public policy to enhance and promote sustainability and higher performance of the agricultural sector since two decades. Diagnosing scale economies and size effects on the performance in Algeria is an urgent requirement for any meaningful policy analysis. Practically, it seems that no study has addressed this issue for Algerian context.

However, an understanding the IR may be important for guiding decision-making among policymakers and investment decisions within the private sector (Omotilewa *et al.*, 2020). Accordingly, as a preliminary analysis for Algerian agriculture, this paper has the advantage of accounting a very large range of farms (26 735 farmers) in one of the agricultural centers in the country, namely Biskra region. This may produce more robust and decisive results different from prior studies that have typically used to employ relatively different sampling methods and household survey data. Hence, one aspect is highlighted to explain the shape of the IR in the region, namely: the stage of development of the studied farm sector.

The date palm sector (typically a traditional farming sector) and the greenhouse vegetables sector (relatively a modernizing sector) are both considered in this study. The date palm farming is considered as a dominant activity in Biskra region, not only for now, but also as ancient economic activity for local farmers. Nowadays, the date palm activity represents 71.6% of the total irrigated farmland in Biskra region (according to statistics of MADR, 2020). It is a typical traditional farming activity, and have a considerable contribution to the national economy and an increasing trend for date exports due to high standards of dates quality (Cheriet & Benziouche, 2012; Benmehaia, 2019).

On the other hand, greenhouse vegetables farming is relatively a new activity, which has been launched and successfully expanded since 2000. As the study of Daoudi & Lejars (2016) asserts, Biskra is one of those regions where Saharan neo-agriculture (as opposed to traditional oasis agriculture) has experienced remarkable development of greenhouse vegetable crops, which have developed in this region by bringing new breath to Saharan agriculture. However, this greenhouse production sector includes today 48 254 greenhouses in Biskra (according to MADR, 2020). The greenhouse farming largely is known for its intensive use of different inputs (fertilizers, pesticides, irrigation technologies, seeds, etc.). This farming activity is considered as a modernizing sector in Biskra region, to the extent that it is in its earliest stages of development within changing nature of greenhouse production technologies.

The difference between the two sectors is flagrant for any observer in terms of the state of arts and the managerial skills. This is why this aspect is essential in the explanation of any structural feature of the agricultural sector of any region.

The study employs two farm performance measures, namely: farmland productivity (physical output yields) and land use intensity. A bivariate Nadaraya-Watson non-parametric regression and multivariate quantile regression models are used to assess the IR in two farming sectors. To the extent that the IR may not be considered universal for any crop or at any time (Garzón Delvaux *et al.*, 2020b), this study hypothesizes and confirms that the IR holds for a traditional agriculture and does not in a modernizing one. When it holds, it follows a systematically monotonic smooth pattern, whereas in a highly input-intense modern sector, the relationship is, in the best cases, blurry.

The rest of the paper is organized as follows. Section 2 presents a brief literature review on the IR, while the research methodology (data and the estimation strategy) is presented in section 3. The study findings are outlined and discussed in section 4 and the paper concludes with section 5 drawing out some policy implications.

2. The inverse relationship: A brief story of "*the small and the beautiful*"

It is not the aim here to review all studies on the IR, even partially, to the extent that it is a difficult task due to the abundant literature. As the section's title suggests, a brief sketch is done in order to give the pig picture of the IR, and stressing some current issues.

"Small is beautiful" is an expression that ag-

ricultural economists use to refer to a regularity often observed empirically in the context of agriculture (and elsewhere in certain economic activities). It can be summed up as follows: a small farm is generally more productive (or efficient). It was more often attributed high levels of performance (whatever measured). This debate began with the observation of Chayanov (1925, 1927) in the context of Soviet agriculture. Then, the observation becomes a well-established stylized fact through studies such as those of Sen (1962, 1966), Schultz (1964), Srinivasan (1972) and Bardhan (1973) in the context of Indian agriculture. Since then, the literature has become abundant on this subject in an attempt to examine this aspect deeply, whether on a theoretical or empirical level. The literature has advanced some hypotheses in order to explain this fascinating phenomenon, of which the monumental study of Berry & Cline (1979) testifies to the extent of this size-productivity relationship.

The hypothesis that persists until these days, systematically showing its relevance *par excellence*, is the hypothesis of labor market imperfection, or labor-based explanation: the cost of labor to family-based farms is lower than the cost of labor to wage-based farms (Sen, 1964). Along with this explanation, many others have been highlighted such as: soil fertility (Kimhi, 2006; Chen *et al.*, 2011; Barrett *et al.*, 2010), management ability (Assunção & Ghatak, 2003), technique (Gautam & Ahmed, 2019), risks, etc. However, the relationship was assumed to be linear, modeled by a simple linear regression model. Nonetheless, more recent studies have shown that the relationship may exhibit nonlinearities, or it is not even monotonous in some cases.

Presently, the real challenge for agricultural economists is the issue of the statistical estimation of the size-productivity relationship, while the explanation is exhausted by a large array of hypotheses that are appropriately and constantly tested. The shape and pace of this relationship become the cornerstone of this problem. Moreover, some went beyond that and started to question the very existence of this relationship, and contemplate the fact that it is just an artifact. As stated by Carletto *et al.* (2013), a substantial part of the debate, particularly in recent years, has focused on whether the IR may be a statistical artifact, stemming from problems with the available data. One of the current issues on the IR matter seems to be re-questioning the error measurements and accuracy in variables.

Unfortunately, the story, of the relationship between farm size and productivity, has not come to a happy ending, i.e. definitive empirically well-established confirmation. According to recent relatively comprehensive reviews of the literature on the IR, the show goes on and the image becomes ever hazier. In technical words, from a briefing on recent reviews (Garzón Delvaux *et al.*, 2020a; Garzón Delvaux *et al.*, 2020b; Gollin, 2019; Scandizzo & Savastano, 2017), the relationship could be judged as contingent. The major factor of contingency, still neglected and to be highlighted here, is the nature of the used technology at farm- or local-level (which reflects the stage of development of the studied farm sector).

Some scholars maintain that the IR subsists only in traditional agriculture, as a characteristic attribute. Deolalikar (1981) affirmed that the inverse relationship is true only of a traditional agriculture, and that it breaks down with technical progress. While Flinn & Buttel (1980) highlighted the idea that the social consequences of increased scale and mechanization in agricultural production are, of course, exceedingly complex, (a) changes in the socioeconomic characteristics of farm personnel, and (b) changes in the characteristics, especially population size and employment levels, of rural communities. Meanwhile, it seems that researchers on this matter do not consider (or accentuate) this aspect in their conceptual frameworks. Ignoring this contingency factor may lead to a serious prejudice in the conclusions on the shape of the IR whatever the context.

What is certain is that there is no single economically optimal agrarian structure; rather, it appears to evolve with the stage of economic development (Rada & Fuglie, 2019). As the study of Garzón Delvaux *et al.* (2020a) confirms, the IR cannot be taken for granted because of empirical complexities in accurately assessing it and evidence that such a relationship depends on the performance indicator analyzed and may not necessarily be systematic, continuous, stable through time, irreversible or universal.

3. Research methodology

Data sources

The source of data in this study is the "Comprehensive Regional Survey" of Biskra region relating to the year 2018-19, collected on the behalf of the Algerian Ministry of Agriculture and Rural Development (MADR, 2020), by the Division of Agricultural Services and the collaboration of the Regional Chamber of Agriculture in Biskra (Algeria). The dataset comprises 26 735 farmers. The data includes two main farming systems of the region, namely: date palm sector (with 21 502 producers) and greenhouse vegetables sector (with 5 233 producers). The cross-sectional data used covers all the 33 communes (districts) of the region. It is noteworthy to stress that Biskra region have a significant contribution in terms of agricultural production at national level for some crop and livestock products. Moreover, it is a semi-arid pastoral zone with a vocation in agriculture. It is considered as an agricultural pole at the national level, about a third of domestic production in 2018. However, at some extent, the dataset could be representative at national level, while incontestably, it is broadly representative for the two farming systems in the country.

Dependent and explanatory variables

This study utilizes two independent variables, namely: Yield (*Y*) and Land Use Intensity (*LUI*). This choice is highly constrained by the available measures in the used dataset. Nevertheless, many other proposed variables would be more relevant for this matter, such as the net output per acre, total factor productivity, technical efficiency, as recommended by Muyanga & Jayne (2019), Rada & Fuglie (2019), Ferreira & Féres (2020) and Helfand & Taylor (2021). Nevertheless, each measure may have its own advantages and inconveniences. The yield measure, computed as the gross value of output per hectare, is a good proxy for the land productivity and is considered as the standard measure in the *IR* study (Muyanga & Jayne, 2019). While the land use intensity, measured as the ratio of cropped land on the total farmland holding, is a well-established proxy for the intensity of land use, meanwhile, it should be noticed that an ideal definition of land use intensity would go beyond the special aspect to include cultivation practices, use of fertilizers, etc. (Sampath, 1992).

In the data subset concerning the dates production sector, this study uses as explanatory variables the available information about structural and socioeconomic characteristics of farms, namely: farm size (operational cropped land in hectares), irrigated land (effectively irrigated plots in hectares), a multinomial variable for different irrigation systems used for each farm, a dummy variable for farmer specialization in dates production, and a locational dummy for the 33 communes. The socioeconomic aspect is reflected by farmers' age and his farming experience (both in years), which are considered as good proxies for farmers' human capital (Bojnec & Fertő, 2021). For the data subset on greenhouse vegetables production sector, due to the available information in the database, the study uses only 4 explanatory variables previously mentioned, namely: farm size, as a mandatory variable for the IR study, in addition of the irrigation system dummy, farmers' age and the locational dummy.

Estimation procedure

The analysis in this study is based on the neoclassical production function approach for the cross-sectional data form. The function relates the farm output to some inputs involved in the production. Its general form is:

$$Q_i = f(\mathrm{X}_{ij})$$

where Q_i stands for the output for farm i (namely: productivity, income, net value, etc.) and X_{ij} for matrix vector reflecting the used input j in farm i. For the purpose of this study, the full empirical models to be estimated are specified as:

$$Y_i = \alpha_1 + \beta_1 S_i + \gamma_1 Z_i + \varepsilon_{i1} \qquad [1]$$

$$LUI_i = \alpha_2 + \beta_2 S_i + \gamma_2 Z_i + \varepsilon_{i2} \qquad [2]$$

where Y_i and LUI_i represent the Yield and Land Use Intensity respectively, S_i is the farm size measure for each farm, Z_i is a vector of explanatory variables set. The variables are used in levels which provides the most straightforward test of the relationship between farm size and productivity (Muyanga & Jayne, 2019). The main purpose of the estimation strategy is to find out the statistical signification and the sign of β_i coefficients for both farming systems.

Before the final estimation procedure, many regressions were run to explore the relevance of the IR in this modeling approach (specifically: ordinary least squares regression, heteroskedasticity-corrected linear model, and some instrumental regression methods) on the whole dataset for each farming system. It was found that the IR holds anyway, with high statistical significance. This would be misleading for many reasons: the systematic divergence between small and large farm scale (Savastano & Scandizzo, 2017; Scandizzo & Savastano, 2017; Feder, 1985; Cornia, 1985), the distribution of conditional mean of the independent variables, normality and non-linearity aspects in regression assumptions. Some of these inconveniencies can be demonstrated by the Kernel density estimation of the two independent variables for both underlying farming systems.

Figures 1 and 2 display the Kernel density of the dependent variables for dates and greenhouse vegetables sectors respectively. Both measures exhibit some anomalies with reference to typical regression assumptions mainly the apparent bimodality and the positive skewness along the whole distribution. Besides, none of the conditional distributions appears to be Gaussian (i.e., convergence by central limit theorem). Moreo-

Figure 1 - Kernel density estimates for dates production.

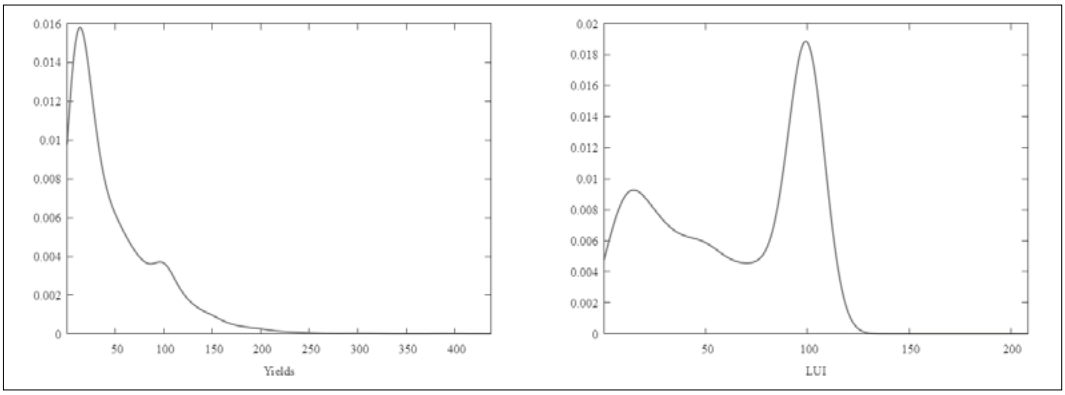
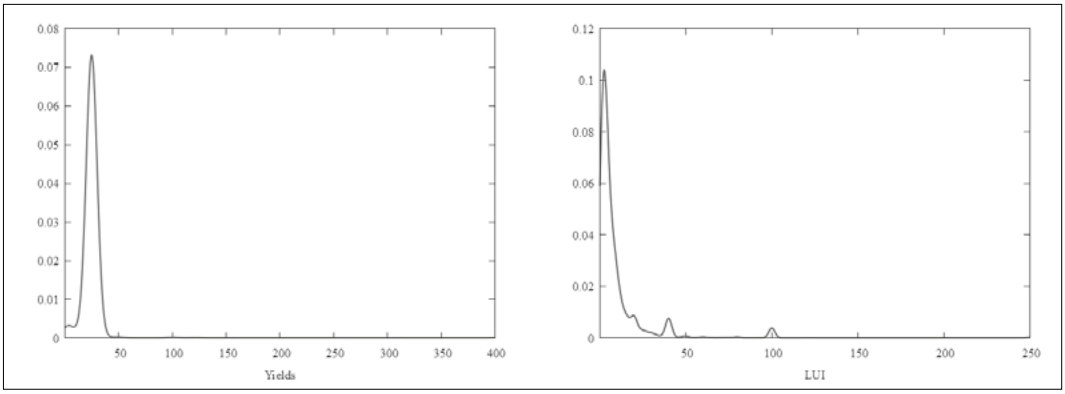


Figure 2 - Kernel density estimates in greenhouse vegetables production.



ver, when a bivariate non-parametric regression is to be run (using Nadaraya-Watson approach)[1] between the used independent variables and the farm size variable, the estimation results should exhibit the systematic (or at least contingent) effects for different ranges of farm size scales.

For these reasons, it seems more appropriate to estimate equations [1] and [2] by the Quantile Regression Model.[2] This econometric approach seems to relevant and robust in the IR studies and recently used by Omotilewa *et al.* (2020), Savastano & Scandizzo (2017), Scandizzo & Savastano (2017), Ramoneda & Pene (2017), Evenson & Mwabu (2001).

4. Results and discussion

Tables 1 and 2 show the main characteristics of farms in both underlying farming systems. The first, Table 1, displays the descriptive statistics of variables used for dates production, and Table 2 for the descriptive statistics in greenhouse vegetables production.

For dates production sector, small farms are less than 2 ha, medium farms scale is between 2 and 10 ha, large scale is to be more than 10 ha. Whereas, in a highly input-intensive farming sector such as in relatively modernizing farming systems, farmland area is not the critical factor for scale. However, in this case specifically, the number of greenhouses (GH) is more relevant and informative. By doing so, the small scale is for farms having 3 or less greenhouses, medium scale is between 4 and 9 greenhouses and large farms scale is to have more than 10 greenhouses. This classification takes into consideration the common regional farming patterns specificities.

The last column for both tables represents the full dataset. Records in this column seems to be less informative and non-relevant for the IR subject due to large range of the sample. Records in the three scale categories are more instructive.

For dates production sector, small, medium and large scales represent 33.7%, 52.6% and 13.6% respectively, which imply that the medium farm size is the dominant scale in this sector, having in average 5.8 ha for the size, 3.2 ha as irrigated area, 64% of them are specialized in dates production. Small farms, by having an average size of 1.3 ha, are more likely irrigated (1 ha), and more strictly committed and specialized (85%), while large farms have in average 22 ha as farm size mean, with largely less irrigated area (about 10 ha) and they are less specialized (53%). Age and experience do not exhibit any significant differences in terms of the underlying scales. For greenhouse vegetables production sector, it seems that the three scale categories are uniformly distributed (28.8%, 34.8% and 36.3% for small, medium and large farms respectively). The farm size and farmers' age do not seem to exhibit any significant differences in terms of the underlying scales.

In terms of the used independent variables, some empirical regularities could be highlighted. For dates production sector, the IR is obviously remarkable. Small scale has higher performances in terms of yields (80 Qx/ha) and land use intensity (about 77%). Medium scale is associated with intermediate performances (32 Qx/ha for yields and 58% for the *LUI*). The large-scale farms present lower performances (17 Qx/ha for yields and 45% for the *LUI*). What makes this blatant regularity unintelligible is their respective variabilities in terms of standard deviations.

For greenhouse vegetables production sector, the picture is ambiguous from the beginning. At the first sight, it seems that the inference exhibits a reverse relationship rather than an IR, i.e., a positive relationship. More specifically, for both independent variables, small-scale farms are associated with low performances, and larger ones with higher performances. Once again, the variability of the underlying records cannot lead to any inference or interpretation ambiguous.

[1] Developed initially by Nadaraya (1964) and Watson (1964), it is one of the nonparametric regression techniques known to estimate a locally weighted average in order to find a nonlinear relationship between a pair of random variables. See Härdle & Linton (1994) for further details of the Nadaraya-Watson nonparametric regression.

[2] Quantile regression model estimates the conditional quantiles of the independent variable. It is one of the alternatives of the linear regression used when the assumptions of the linear regression are violated. See Koenker *et al.* (2017) for further details of the Quantile regression model.

Table 1 - Descriptive statistics of variables used for dates production.

	Small Scale	*Medium Scale*	*Large Scale*	*Full Dataset*
	ha ≤ 2	*2 < ha ≤ 10*	*ha > 10*	
Sample size	7 259	11 317	2 926	21 502
Percentage	33.76%	52.63%	13.61%	100%
Dependent variables				
Y	80.39 (52.24)	32.23 (33.34)	17.44 (21.98)	46.47 (46.47)
LUI	76.75 (29.02)	58.55 (37.67)	45.19 (35.86)	62.88 (36.38)
Independent variables				
Farm size	1.35 (0.53)	5.83 (2.55)	22.88 (23.91)	6.64 (11.27)
Irrigated land	1.03 (0.54)	3.27 (2.65)	9.97 (14.42)	3.42 (6.31)
Specialization	0.85 (0.35)	0.64 (0.48)	0.53 (0.50)	0.70 (0.46)
Age	57.50 (16.12)	56.96 (15.84)	56.18 (15.86)	57.04 (15.94)
Experience	14.66 (4.81)	14.81 (4.29)	14.95 (4.85)	14.78 (4.55)

Note: Values in parentheses represent the standard deviation.

Table 2 - Descriptive statistics for variables used for greenhouse vegetables production.

	Small Scale	*Medium Scale*	*Large Scale*	*Full Dataset*
	GH ≤ 3	*4 < GH ≤ 9*	*GH > 10*	
Sample size	1 509	1 821	1 903	5 233
Percentage	28.83%	34.80%	36.37%	100%
Dependent variables				
Y	21.98 (7.74)	24.82 (3.26)	27.59 (24.46)	25.01 (15.60)
LUI	9.95 (41.48)	6.63 (14.35)	14.70 (22.13)	10.52 (27.52)
Independent variables				
Farm size	0.26 (1.01)	0.27 (0.97)	0.75 (1.32)	0.44 (1.15)
Age	49.77 (16.72)	52.56 (16.75)	50.01 (15.78)	50.83 (16.44)

Note: Values in parentheses represent the standard deviation.

A much clearer picture of the relationship between farm size and farm performances (yield and land use intensity) emerges when examining the relationship by running a Nadaraya-Watson non-parametric regression. The variables are used here in logarithms (not in levels) in order to better fit with data and to alleviate the weights of outliers.

Figure 3 displays the resulted regression fit for performance measures for dates production sector (yields in panel A and *LUI* in panel B). The IR is noticeably observed in which both measures decline with farm size for all ranges. This is the well-established IR results found by most studies on the matter. For this dataset, the

Figure 3 - Nadaraya-Watson non-parametric regression results for performance measures in palm dates production.

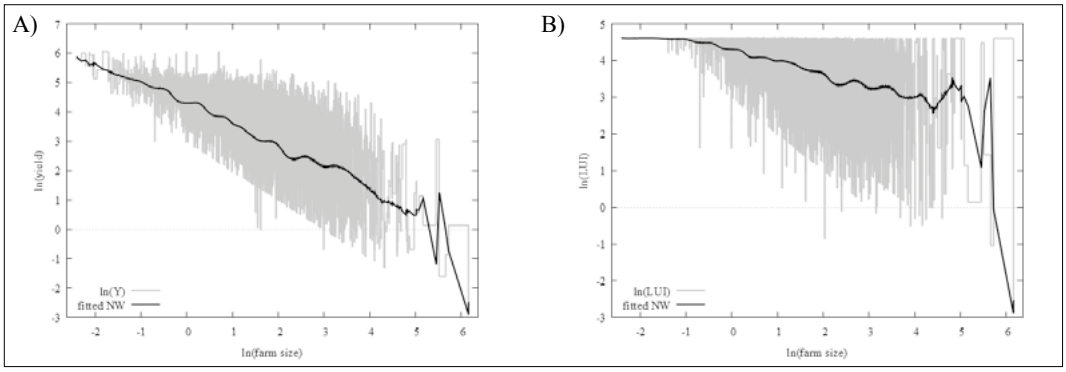
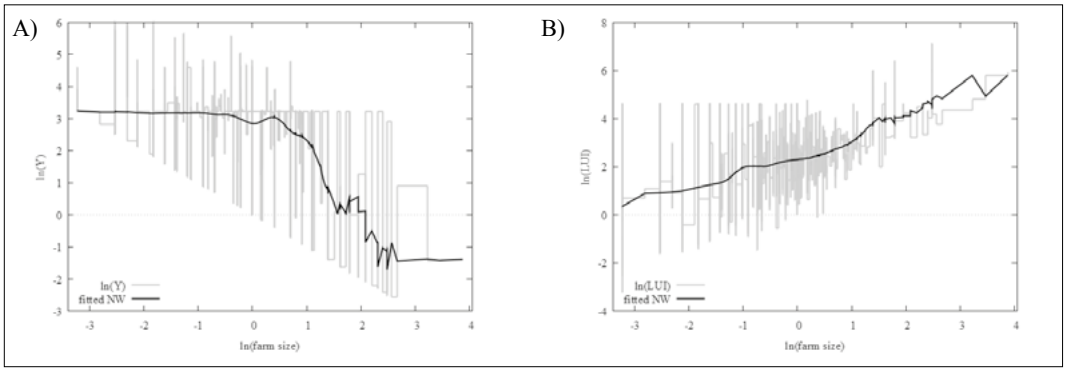


Figure 4 - Nadaraya-Watson non-parametric regression results for performance measures in greenhouse vegetables production.



relationship between farm size and yields (or land use intensity) is relatively steep and downwarding. Figure 4 presents the same procedure results for greenhouse vegetables production sector (yields in panel C and *LUI* in panel D). It is remarkable that the relationship is slightly positive for *LUI* measure (panel D), whereas for yield measure, it is quite neural (no clear effect) for small scale (less than 2 GH), and it becomes more ambiguous for other ranges (without a smooth fit). However, for both farming systems, it is possible that other structural or socioeconomic effects may have an influence on these bivariate relationships; hence, multivariate analysis is required.

Tables 3 and 4 summarize the results of the quantile regressions for the two underlying farming systems. Table 3 represents results of cross section quantile regression of the IR in dates production, and Table 4 for greenhouse vegetables production.

The different types of regressions, whether in the pre-processing of the data or those that are actually reported, always present a high level of robustness and overall significance (by adjusted R^2 and F-tests). The coefficients of the explanatory variables (other than farm size) are generally significant throughout the deciles examined. Their detailed interpretation is of no interest here since their inclusion is only to eliminate their effects in the regression.

The variable of interest here is the farm size for both performance measures (*Y* and *LUI*). The most striking result is that the coefficients of this variable are highly significant with negative magnitudes, and this is for all deciles in the dates sector (Table 3), without any exceptions. This provides an evidence that the IR holds for this sector. While in the greenhouse vegetables sector, this variable shows negative and statistically significant values up to the third decile ($Q_{0.3}$). Beyond that, the magnitudes become

Table 3 - Results of cross section quantile regression of the IR in dates production in Algeria (N = 21 502).

Variables	*Low performance*				*Median*	*High performance*			
	$Q_{0.1}$	$Q_{0.2}$	$Q_{0.3}$	$Q_{0.4}$	$Q_{0.5}$	$Q_{0.6}$	$Q_{0.7}$	$Q_{0.8}$	$Q_{0.9}$
Physical Yield (Y)									
Farm size	-0.87***	-1.04***	-1.12***	-1.25***	-1.43***	-1.47***	-1.56***	-1.52***	-1.12***
Irrigated land	-0.01*	0.01*	0.05***	0.29***	0.54***	0.77***	0.84***	0.75***	0.29***
Irrigation system	-0.06***	-0.04	-0.03	-0.07	0.05	0.16	-0.06	0.10	-0.15
Specialization	3.88***	7.11***	11.87***	17.39***	26.23***	33.82***	43.61***	54.81***	60.31***
Farmers' age	-0.01***	-0.009***	-0.009**	-0.02**	-0.02***	-0.04***	-0.04**	-0.01**	-0.01
Farmers' experience	0.13***	0.13***	0.14***	0.16***	0.19***	-0.0005	-0.18**	-0.53***	-1.95***
Communes	0.003	-0.009	-0.01*	-0.03**	-0.05***	-0.08***	-0.06***	-0.08***	-0.21***
Const.	11.82***	14.44***	16.18***	19.47***	23.04***	31.38***	41.07***	56.42***	95.88***
Land Use Intensity (LUI)									
Farm size	-2.83***	-4.13***	-4.63***	-5.50***	-5.58***	-5.03***	-4.30***	-3.03***	-1.81***
Irrigated land	4.94***	7.22***	8.24***	8.84***	8.19***	6.32***	4.63***	3.03***	1.82***
Irrigation system	0.05	-0.01	-0.14	-0.18*	-0.002	0.02	0.02	0.00004*	0.0003
Specialization	6.51***	9.85***	6.44***	7.09***	10.80***	11.96***	4.11***	0.0007***	0.02***
Farmers' age	-0.04***	-0.07***	-0.05***	-0.02**	-0.01	0.003	0.004***	0.0001***	0.002
Farmers' experience	0.51***	0.86***	0.77***	0.75***	0.97***	1.05***	0.30***	0.0004***	0.0009***
Communes	0.02*	0.03*	0.01	-0.01	-0.06**	-0.01	-0.006*	-0.0002***	-0.004
Const.	17.63***	25.24***	36.59***	46.94***	51.29***	62.61***	89.24***	99.99***	99.97***

*Note: Asterisks indicate the significance levels: *** for 1%; ** for 5% and * for 10%.*

Table 4 - Results of cross section quantile regression of the IR in greenhouse vegetables production in Algeria (N = 5 233).

Variables	*Low performance*				*Median*	*High performance*			
	$Q_{0.1}$	$Q_{0.2}$	$Q_{0.3}$	$Q_{0.4}$	$Q_{0.5}$	$Q_{0.6}$	$Q_{0.7}$	$Q_{0.8}$	$Q_{0.9}$
Physical Yield (Y)									
Farm size	-5.39***	-2.07***	-0.06***	-0.00002	-0.00002	-0.00002	-0.00002	-0.00003	-0.00004
Irrigation system	-0.042***	-0.016***	-0.0008***	-0.00009	-0.00006	-0.00001	-0.00001	-0.00002	-0.00008
Farmers' age	-0.002***	-0.0005***	0.000007*	0.000008	0.000003	0.000006	0.000008	0.00001	0.00008
Communes	-0.001***	-0.003***	-0.0001***	-0.00002	-0.00005	-0.00009	-0.00001	-0.00002	0.00003
Const.	25.58***	25.30***	25.01***	25.00*	25.00*	25.00*	25.00*	25.00**	25.00***
Land Use Intensity (LUI)									
Farm size	0.37***	0.53***	0.72***	0.80***	0.88***	0.95***	0.94***	0.90***	0.72***
Irrigation system	0.10***	0.09***	0.11***	0.12***	0.15***	0.15***	0.17***	0.17***	0.18***
Farmers' age	-0.008***	-0.008***	-0.008***	-0.009***	-0.009***	-0.008***	-0.010***	-0.011***	-0.012***
Communes	0.004**	0.01***	0.01***	0.01***	0.01***	0.02***	0.02***	0.02***	0.04***
Const.	0.23***	0.59***	0.79***	0.99***	1.13***	1.20***	1.53***	1.85***	2.32***

*Note: Asterisks indicate the significance levels: *** for 1%; ** for 5% and * for 10%.*

Figure 5 - Coefficient estimates of farm size in each quantile for dates production.

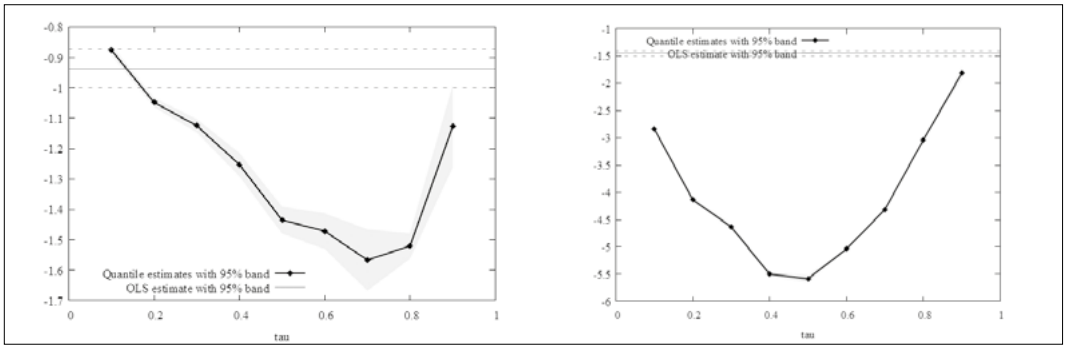
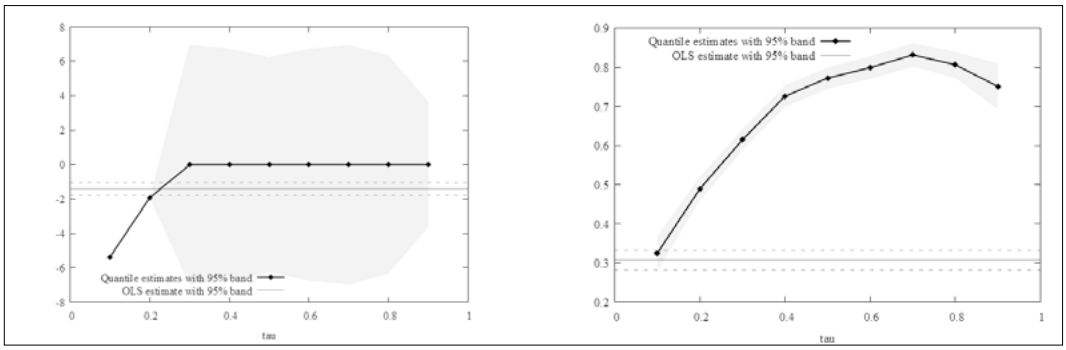


Figure 6 - Coefficient estimates of farm size in each quantile for greenhouse vegetables production.



almost zero along with their respective signification levels from the fourth decile (for the *Y* measure). Nevertheless, for the *LUI* measure, the coefficients keep a high level of significance but surprisingly with positive magnitudes.

A more in-depth examination of the farm size coefficients in both cases should lead to conclusive results on the shape of the relation. To do this, a post-estimation plot is made for the farm size coefficients estimated by the four quantiles regression models. Figures 5 and 6 show the results of such a procedure. Figure 5 displays the coefficient estimates of farm size in each quantile for dates production and Figure 6 for greenhouse vegetables production.

Concerning the dates sector, the effect of the farm size variable on yield (*Y*) has negative magnitudes for all deciles which evolve along the 10 deciles as follows: values are in descending order up to seventh decile ($Q_{0.7}$), i.e., at a maximum slope of –1.56, beyond this level the curve becomes less steep. For the effect of the farm size variable on the land use intensity (*LUI*), the curvature takes almost the same shape, except that here a kind of inflection point appears in the middle, i.e., at the median ($Q_{0.5}$), where the curve becomes less steep from the median with a maximum value of the coefficient at –5.58. However, the two pictures of the evolution of the farm size coefficients taken together provide a visible evidence that the IR takes a curvature of a decreasing hyperbola with the abscissa axis as an asymptote.

However, the analysis and the post-estimation results of the cross-sectional quantile regression for the greenhouse vegetables sector suggest a different picture. The relationship between the farm size and productivity for low performance farms (low productivity) is negative and relatively steep until the third decile ($Q_{0.3}$). Nevertheless, from the fourth decile ($Q_{0.4}$), the relation becomes neutral, where the magnitude will be zero because of the large variability in terms of the standard error of coefficient estimates throughout the remained deciles (having a very large confidence interval). Therefore, the rela-

tionship does not take any clear curvature. It becomes superfluous on a wide spectrum of scales. While the relationship between farm size and land use intensity (*LUI*) is clearly positive with values in ascending order up to the seventh decile ($Q_{0.7}$) becoming less steep at the end, whatever also positive. The two cases here provide visible evidence that IR does not hold, on the contrary, the reversed relationship is likely true.

Our major findings suggest that farm size and farmland productivity (or intensity) are systematically related in a typical traditional farming system, whereas in a highly input-intense modern sector, the relationship becomes positive (or at least ambiguous).

The overall picture emerging from this study is that the IR holds between farm size and the two measures of farm performance in a traditional farming system, while not for a modernizing farming system, at least for Algerian agriculture. Regardless of whether performance is defined in terms of yield or land use intensity, the IR is indeed found to hold for any range of dates farm scales. In a highly input-intense farming system, such as the greenhouse vegetables production, the relationship between farm size and farm productivity is ambiguously positive.

Another consideration should be highlighted reflecting the fact that more attention is needed in the use of farm performance measures to the extent that land productivity measure is problematic and potentially misleading when used in modernizing agricultural contexts (Helfand & Taylor, 2021). In explaining the IR patterns, however approached, the stage of development in the underlying farming sector is crucial, as confirms few previous studies such as Ghose (1979), Dyer (1991) and Rada & Fuglie (2019). They provide a relevant potential explanation for the fact that the IR may hold in a static relatively backward agriculture, and vanish along with advanced technological innovations. The argument is that, in the dynamic context of technical innovation, the greater access to the new inputs by the large-scale labor-hiring farms and their inherent scale advantages lead to the disappearance of the inverse relation in technically advanced farming systems.

These findings, which seem confirmed along a vast set of cases around the world, suggest that the ubiquitous IR relationship reported by previous literature may have been an artifact of the presumption that the relationships observed were linear and omnipresent without a consideration of the stage of development in the underlying farming sector. It appears that the relationship is pronouncedly monotonous in static traditional farming systems, and it is drastically different across farms in a modernizing farming sector, depending on their position on development stages of the modernization process. The policy implications of these findings are also significant. For farms in the highest performances in a modernizing farming sector, this result in fact implies that some land expansion may be beneficial, but lack of management ability will create diseconomies of scale so that better management and technology are needed more than land increases. Furthermore, the argument that a redistribution of land from the large to the small farms will increase yields and hence agricultural output cannot be extended to a farming system experiencing technical changes and moving towards a more input-intensive use.

5. Conclusion

This study examines the relationship between farm size and farm performance over a very large range of Algerian farms than has typically been examined in Africa or the Mediterranean. To our knowledge, this is the first study to examine the farm size-productivity relationship in Algeria. Most prior farm size-productivity studies in different countries rely on household surveys data for which there are relatively few observations. This study is therefore motivated by the need to understand whether the well-established inverse farm size-performance relationship holds when a broader range of farms sample is considered.

The study uses a dataset comprising 26 735 farmers in Biskra region where two farming sectors are considered, namely: date palm sector (as typically a traditional farming sector) and greenhouse vegetables sector (as a relatively modernizing sector). The study employed two farm performance measures, farm productivity

(measured by farm output per hectare) and land use intensity. A bivariate non-parametric regression (Nadaraya-Watson approach) and multivariate quantile regression are used to assess the IR in two farming sectors.

The major finding suggests that farm size and farmland productivity (or intensity) are systematically related in a date palm farming system, whereas in the greenhouse vegetables sector, the relationship becomes positive (or at least ambiguous). This provides evidence that the IR holds for a static traditional agriculture and does not in a modernizing one. Furthermore, when it holds, it follows a monotonic smooth pattern, whereas in a highly input-intense modern sector, the relationship becomes, in the best cases, blurry. Accordingly, the consideration of the nature of the used technology in the underlying sector (i.e., the stage of development in the studied farming sector) is of crucial importance as a contingency factor in analyzing the IR for any farming system.

A natural extension to this study is the deeper analysis of the underlying causes of the farm size heterogeneity regarding farm performance and efficiency in each farming sector. Identifying the factors that accounts for the relationship between farm performance and farm size in Algerian agriculture is of paramount importance to enhance the efficiency of public intervention through the long-standing failures of agrarian reform policies since 1970s.

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Do livestock supports increase livestock production? Province based Panel ARDL analysis for Turkey example

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Abstract

In recent years, there has been a significant change in Turkey's agricultural support policies, especially on livestock supports. The livestock support, with a share less than 5% in total has in early 2000s has reached up to 35% at the end of 2020. In order to understand the impact of increase in livestock supports, 11 years of livestock support and livestock presence in 81 provinces in Turkey were analyzed via Panel ARDL method. The results of the analysis revealed that support to livestock does not affect the number of livestock in the short term, but has a positive effect in the long run. Furthermore, both in the short and long term, the increase in prices in the livestock sector increases the livestock fund. Even though increases in feed prices harm livestock presence in short run as expected, this negative effect disappears in the long run. The production effect of minimum wage variable is added to the model considering the unique situation of Turkey, which effects the production negative in the short run, but positive in the long run.

Keywords: *Livestock supports, Production effects of the livestock supports, Feed price minimum wage, Panel ARDL.*

1. Introduction

Agricultural supports are one of the most controversial issues of international trade. The primary cause of this situation is the distorting effects of agricultural supports on production and trade. Surpluses in the agricultural production causes a decline in prices which results in global imbalances and ineffective use of resources. This situation has a great impact on economies dependent on agriculture. For this reason, agricultural supports were introduced for the first time in 1987 during the OECD Ministerial Committee and member states has made a commitment to minimize distorting effects of these supports (OECD, 2000, p. 6). First ever official attempt to regulate agricultural supports was made by World Trade Organization (WTO).

WTO, considering the distorting side of agricultural supports has agreed to reduce coupled payments related to production level, namely "amber box" supports issuing Agreement on Agriculture at the end of Uruguay round in 1994.[1] Yet, underdeveloped countries were exempt-

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[1] Starting in 1995, developed countries agreed to cut decoupled payments in this context by 20% within 6 years, and developing countries including Turkey by 13% within 10 years.

ed from making any cuts. In addition, member states were not subjected to any limitations on decoupled payments categorized as "green box" supports which have no or minimal impact on production and trade. Another category that WTO member states have agreed on is "blue box" supports. Blue box supports reduce the production effect relatively via limiting the production itself. On the other hand, blue box payments are given without any limitations and reduction commitments if they are made on fixed areas and fixed yield or a fixed number of livestock (WTO, 2016, pp. 18-22).

Following the signing of Agreement on Agriculture (1994), an important transformation process in agricultural supports has begun. Many countries, especially developed ones, have shifted their policy towards agricultural supports, which are thought to be ineffective on production and trade. For instance, market price supports coupled with the production was repealed in the United States of America (USA) with the 1996 Farm Bill, and Production Flexibility Contract Payments were implemented as replacement, whereas the European Union (EU) has mostly abandoned market price supports in order to implement direct payments in 1992 with the Mac Sharry Reforms. Turkey has stepped into this transformation process with introduction of direct income supports in 2000 (Baffes and Gorter, 2005, pp. 79-86).

Agricultural supports carry an utmost importance in Turkey in many aspects. Agricultural sector constitutes approximately 20% of the total employment according to 2020 data. Nearly 7% of Gross Domestic Product (GDP) is coming from the agricultural sector. In view of these facts, it can be stated that Turkey is among the highest agricultural support providing countries in comparison to its GDP. Indeed, according to OECD, the ratio of agricultural supports to GDP in Turkey in 2020 is 1.61%. In scope of agricultural supports, livestock support is also an outstanding issue in Turkey. To be more precise, while livestock support accounted only for 5% of a total of 1.8 billion Turkish Liras (TL) agricultural support in 2002; this ratio has increased up to 35% of a 21.8 billion TL agricultural support in 2020. Of this livestock support, approximately 45%, %20, %12 and %10 is directed to calf support, milk support, input support and sheep/goat support respectively.

A significant part of the livestock support targets cattle (indigenous, cultural, and crossbreed races), buffalo, sheep (merino, indigenous and other races) and goat (angora goat, hair goat, other races) breeding. So called supports are given in accordance with the number of head, therefore it is not possible to foresee a concrete number. In other words, there is not a fixed total amount for support provided in the field of livestock in Turkey. This is where production effect of livestock support comes in. In line with this fact, livestock presence is high when the amount of support has been high. According to 2002 data, the number of cattle, buffalo, sheep, and goat has been 41.8 million, where this number has increased up to 76.3 million in 2020.[2]

There is a variety for reasons of increase in livestock supports in Turkey. First of all, the livestock sector plays an important role in Turkey's agricultural production. According to FAO, in 2018, the livestock sector has accounted for 37% of agricultural production in Turkey. Furthermore, according to the Turk Stat's "Agricultural Enterprise Structure Research" conducted in 2016, livestock husbandry accounts for 63% of all agricultural enterprises in Turkey.[3] Moreover, supply gap in the meat sector constitutes another aspect of this issue (Eroğlu *et al.*, 2020: 117). These important reasons for agricultural supports also lead to discussions about the production effect of agricultural support in Turkey. Therefore, project-based rural development supports which is decoupled from production has started recently in Turkey (Ün, 2020, pp. 337-342).

Government support for livestock in Turkey has increased about 85 times in 18 years and

[2] Turk Stat.

[3] According to the Agricultural Enterprise Structure Research in 2016, 37.2% of the agricultural enterprises in Turkey are engaged in plant production. While 62.3% of the remaining agricultural enterprises are engaged in plant production and livestock husbandry together, 0.5% are engaged in livestock husbandry activities.

reached 35% of the total budget to support agriculture between 2002 and 2020.[4] On the other hand, approximately half of the workforce in Turkey earns minimum wage. That is why, it is inevitable that changes in minimum wage dramatically effect livestock sector since minimum wage is a significant cost item for producers. Moreover, minimum wage can also have a bearing on labor shifts between sectors and thus level of production. Due to these reasons; important indicators affecting livestock sector such as livestock support, livestock price, feed price and minimum wage are worth inquiry.

This study dealing with the production effect of livestock supports, offers different contributions to the literature. Firstly, the study, covering 81 regions in Turkey, offers a broad perspective on the subject. Secondly, the effect of feed and livestock prices on the livestock sector is demonstrated, as an important discussion topic in Turkey. Thirdly, the effects of changes in minimum wage on the livestock sector is discussed, taking Turkey's unique situation into account. Moreover, this paper provides remarkable contributions to the body of literature via its findings on the basis of Turkey example. Above all, insisting on production under threat of increasing input costs and various attitudes of agribusinesses against changes in minimum wages in the short and the long run provides different views both for researchers and policymakers.

2. Literature review

Agricultural support is an important source of income for producers. Even if reforms on income diversification for producers plays a diminishing role for dependence on supports (Lipshits and Barel-Shaked, 2021), these supports are still an important indicator for agribusinesses. At the same time, these supports are as crucial as mechanization, specialization and innovative technologies for increasing production and efficiency (Dhraief *et al.*, 2019). In addition, production effect of agricultural support is essential not only for agricultural policy but also its effects on international trade. Therefore, vast majority of studies focus on production effect of agricultural supports.

In one of the studies that examine this topic, Adams *et al.* (2001) showed that PFC (Production Flexibility Contract) and MLA (Market Loss Assistance) payments increase production in the USA. Goetz *et al.* (2003) concluded that direct supports implemented in Switzerland positively affect production. In addition, it has been revealed that indirect supports provided to producers such as tax reductions are also effective on production. O'Donoghue and Whitaker (2010) indicated the effects of direct supports in the USA on crop and livestock production. Weber and Key (2012) and Becker and Judge (2014) have also reached similar results, concluding that direct supports given in the USA have a positive effect on crop production. Tong *et al.* (2019) conducted another study on foreign trade impact of agricultural supports. They concluded that each 1% decrease in agricultural supports reduced the export of agricultural products approximately by 0.40% between 1999 and 2011 in the USA.

Some studies on the production effect of agricultural supports have been conducted on the Common Agricultural Policy (CAP) of the EU. Frandsen *et al.* (2003) analyzed the implications for crop and livestock production in case of the complete abolition of agricultural supports in the EU. Results showed that if agricultural supports are completely removed, the crop production will decrease between 5% and 60%, and the livestock production will decrease between 4% and 11%. Katranidis and Kotakou (2008) conducted another study on the impact of CAP reforms on cotton production in Greece. The findings of this study show that decoupled payments increased cotton production, but this effect diminished with CAP reforms.

Garrone *et al.* (2019) examined the effect of the CAP supports on agricultural labor productivity. According to the study, decoupled supports increase labor productivity while coupled supports slow down the increase in productivity

[4] Livestock support, which was approximately 90 million TL in 2002, increased to 7.7 billion TL in 2020.

between 2004 and 2014. In other words, even if decoupled supports do not directly affect production, they have the potential to affect production through increased labor productivity. Another study on the impact of agricultural supports concentrated on the effects of reducing decoupled payments by 40%-50% in developed countries. The findings of this study also indicated that, decreasing decoupled payments reduces agricultural production in developed countries by 5% while increasing agricultural product exports in developing countries by 12% (Banga, 2016).

Although the majority of the studies on the production effect of agricultural supports have concluded that agricultural supports affect production, there are some studies which have found no significant relationship between agricultural supports and production. Beckman and Wailes (2005) demonstrated that there was no statistically significant relationship between direct support and production in the USA between 2002 and 2004. Goodwin and Mishra (2006) concluded that there is no statistically significant relationship between the AMTA (Agricultural Market Transition Act) supports and planted area of wheat and MLA supports and planted area of corn in the USA.

Some of the studies focused directly on the production effect of livestock supports. For example Olagunju *et al.* (2020) showed that the CAP reforms made in 2005 had a positive impact on the livestock sector in Northern Ireland. Accordingly, every 1% increase in agricultural supports increase milk supply by 0.41%-1.28%, cattle stock by 0.12%-0.14%, sheep and goats stock by 0.23%-0.26%. Lehtonen and Niemi (2018), concluded that 20% reduction in agricultural supports provided to Finnish farmers as of 2021 will reduce producer incomes in the livestock sector by 20-25%. In other words, the producers in the livestock sector in Finland are largely dependent on agricultural supports. Barnes *et al.* (2016) conducted another study to investigate the impact of agricultural supports on livestock sector in Scotland. The impact of previous CAP reforms on producers' decisions was investigated in a study based on a survey of 1,764 farmers. As a result of the study, approximately half of the participants stated that they would reduce livestock activities in terms of size and intensity if agricultural supports were reduced.

Some studies investigated the effect of agricultural supports on livestock presence by controlling the number of livestock. For instance, an important study was conducted with 701 farmers in 2018 in the Tibetan Plateau of China. Main goal of this study was to reveal the effects of Grassland Ecological Protection Award Policy Supports which aims to protect grasslands, meadows, and pastures by controlling the number of livestock. At the end of the study, it was found that the supports mitigated the number of livestock in small farms whereas amplified them in large farms (Yu *et al.*, 2021). A similar study was carried out by Byrne *et al.* (2020) with 187 farmers in the Inner Mongolia Region of China between 2012 and 2014. As a result of the research, it was determined that there is a positive relationship between the support and the number of livestock. This positive relationship was attributed to the support provided to keep the number of livestock under control could not compensate for the income that the farmers would give up.

The results of the studies on agricultural supports in Turkey show similarities with other studies. Canbay (2021) demonstrated that the agricultural supports provided between 1995 and 2018 expanded crop production. Demirdöğen *et al.* (2016) concluded that input supports have a positive effect on production more than deficiency payments. Işık and Bilgin (2016), who discussed the production effect of market price supports and direct supports, concluded that both of supports increased production level. As a result of the causality analysis of the production effect of agricultural supports applied in Turkey, Yıldız (2017), Doğan *et al.* (2018), Koç and İşlek (2020), and Sağdıç and Çakmak (2021) reached similar conclusions and demonstrated that there is a particularly long-run positive relationship between agricultural supports and production.

Some studies on the production effect of agricultural supports applied in Turkey have also focused on livestock supports. The data collected from 171 farmers in Samsun province were analyzed by Eroğlu *et al.* (2020). They have revealed that livestock support payments increase the supply of beef. Erdal *et al.* (2020) debated the results of livestock supports by applying a survey on 478 livestock enterprises. According

to the findings of the study, livestock supports are an important factor for 65% of livestock enterprises in order to increase their livestock presence. Furthermore, large agribusinesses benefit more from supports. As a result of the causality analysis conducted by Erdal *et al.* (2021) for the relationship between livestock presence and livestock supports for 26 regions in Turkey, a relationship was estimated between both variables in the short and long run. In the short run, there was no significant relationship between feed supports and livestock presence, and in the long run, there was no significant relationship between milk supports and livestock presence.

The majority of studies on the effects of agricultural supports focus on crop production, mainly arguing that there is a positive correlation in between. Even though there is limited research, the same results apply for livestock supports as well.

3. Model, data and empirical findings

3.1. *Model*

The model is given in Equation (1) by taking into account the related economic theory and special cases of Turkey's economy.

$$LLN_{it} = \beta_0 + \beta_1 LSP_{it} + \beta_2 LFP_{it} + \beta_3 LLSP_{it} + \beta_4 LMW_{it} + \varepsilon_{it} \quad (1)$$

In equation 1, LLN_{it}[5] is the dependent variable indicating total the number of livestock. LSP_{it} is livestock payments made for the livestock sector. LFP_{it} is the livestock feed prices one of the fundamental indicators of input costs. $LLSP_{it}$ and LMW_{it} are the livestock prices and minimum wage for Turkey. Sub-indices of i show cities[6] of Turkey and sub-indices of t show time series which are yearly frequented in our paper. We have 891 observations in total (81∗11=891) in our data set including 81 cross-sections and 11-time series. ε_{it} represents the error terms assumed zero means, constant variance, identically and independently distributed.

Livestock payments, LSP, which constitute the main motivation of the article, are expected to increase the number of livestock. Hence, the sign of the β_1 is expected to be positive. The impact of increasing feed prices, LSP, on livestock numbers is anticipated as unfavorable because livestock feed is a crucial and perpetual input cost for the livestock sector. The impact of the increase in animal feed prices, LSP on the number of livestock is usually unfavorable, given that feed is a key and constant cost of input for the livestock sector. So, the sign of the 2 coefficient expected to be negative. Entrepreneurs engaged in livestock husbandry receive the return of their investments and efforts from the livestock products that they obtain from their livestock and by selling the livestock they raise. Therefore, the rising of livestock prices encourages them to amplify their production. In this case, the β_3 sign would be positive.

As emphasized before, we take into consideration special cases of Turkey's economy which is the second main motivation of this paper. The minimum wage is one of the most important macroeconomic variables for the Turkish economy, followed by both workers and employers. Announcement related to minimum wage is done twice a year by the government. According to the 2014 data of the Presidency of the Social Security Institution of Turkey, 41% of the employees work for minimum wages, and this rate is very high when it is compared to the average of EU countries which is approximately 7%. Considering the possible sectoral risks in the livestock sector and the sunk costs that entrepreneurs have to bear, employees would choose to work in other sectors for minimum wage by adopting risk-averse behavior if they find minimum wage y is satisfactory. On the other hand, increasing of minimum wage would cause hesitation in employers to get more employees. In sectors working with low-profit margins, employers may even choose to lay off workers in order to reduce costs. In summary, the sign of β_4 would be in either way.

[5] The L operators in the equation mean that the variables are in logarithmic form.
[6] Turkey has total of 81 cities.

3.2. *Data*

The yearly data set for 81 cities covers the 2010-2020 period. The number of livestock and support payments made for livestock sector by province data are realized by dividing them into Turkey's per capita total GDP[7] and 2003=100 based domestic producer price index. Livestock feed prices data are transformed to real ones by dividing 2003=100 basis prepared feed domestic producer price index. Livestock prices and minimum wage data are realized by dividing 2003=100 based total domestic producer price index and consumer prices index respectively.

The number of livestock by province, livestock prices, per capita GDP, 2003=100 based total and prepared livestock feed domestic producer price indexes and consumer prices index data are taken from the Turk Stat database. Livestock feed prices are provided from the Turkish Feed Manufacturers Association. Support payments by province data are provided from the Republic of Turkey Ministry of Agriculture and Forestry. Minimum wage data are taken from the Republic of Turkey Ministry of Labor and Social Security website. Empirical analyses are performed with the logarithmic form of variables.

3.3. *Empirical findings*

Before summarizing the empirical results of the paper, descriptive statistics of variables are reported in Table 1. Table 1 indicates that variables, which are the total number of livestock, and livestock supports varying in both time dimension and cross-sectional dimension have bigger standard deviations more than variables varying only in the time dimension, which are livestock feed price, livestock price, and minimum wage.

The panel ARDL approach is applicable if stationarity and cointegration conditions hold. The stationarity condition is meet when the dependent variable is I(1) and independent variables are I(0) or I(1). Cointegration condition means the existence of cointegration between variables. Therefore, we tested the stationary of variables and we checked the presence of cointegration. After we observed that necessary conditions are satisfied, we estimated our model via the panel ARDL approach (Khan *et al.*, 2020).

Before estimating the model, the stationarity of variables has to be satisfied (Ahlfeldt *et al.*, 2014; Juodis, 2018; Salim *et al.*, 2019). Two groups of unit root tests can be applied according to the presence of cross-section dependency (Baltagi, 2005; Barbieri, 2006; Kahia *et al.*, 2016). While the first generation unit root tests (Harris and Tzavalis, 1999; Levin *et al.*, 2002; Im *et al.*, 2003; Maddala and Wu, 1999; Hadri, 2000; Choi, 2001; Breitung, 2000) assume that there is no correlation among panel members, the second generation unit root tests (O'Connell, 1998; Choi, 2002; Phillips and Sul, 2003; Chang, 2002, 2004; Pesaran, 2003; Bai and Ng, 2005; Moon and Per-

Table 1 - Descriptive statistics.

	LLN	*LSP*	*LLSP*	*LFP*	*LMW*
Mean	1.6508	2.9309	1.1547	0.4590	2.6009
Median	1.7117	2.9536	1.1507	0.4596	2.5729
Maximum	2.6270	4.0938	1.2583	0.4740	2.6946
Minimum	0.3077	1.6233	1.0356	0.4442	2.5178
Std. Dev.	0.4118	0.4474	0.0668	0.0093	0.0643
Observations	891	891	891	891	891

[7] Agriculture, forestry, and fisheries GDP could also be used in that realization process, however, this data is publishing one year delay and for the 2010-2019 period the correlation coefficient between agriculture, forestry, and fisheries GDP and per capita GDP is approximately 98%. That is why we decided to use the per capita GDP series.

Table 2 - First generation panel unit root results.

	LLC	*IPS*	*ADF*	*PP*
LFP	-13.3934***	-4.4875***	209.1560***	317.9170***
ΔLFP	-14.5188***	-8.2967***	363.3260***	307.3210***
LLSP	-28.6676***	-17.2143***	624.1870***	146.7010
ΔLLSP	-7.1255***	-4.5280***	244.6570***	215.6530***
LMW	-2.7051***	8.6630	26.2140	8.2487
ΔLMW	-24.9978***	-10.4100***	431.9490***	968.4760***

*Notes: *,** and *** represent 10%, 5% and 1% significance levels, respectively. Δ operator corresponds to the difference operator. L operator shows logarithmic form. Panel unit root equations contain the constant term from deterministic components.*

ron, 2008; Pesaran, 2007) take into consideration cross-section dependency.

At this stage cross section dependencies are tested to decide whether first generation or second generation panel unit root tests will be applied. For testing cross section dependency, Breusch and Pagan (1980) CDLM1, Pesaran *et al.* (2008) CDLM (Bias-corrected scale LM), Pesaran (2004) CDLM and CDLM2 tests are applied. However, the variables of livestock feed prices LFP, livestock pricesand $LLSP$ minimum wage LMW are varying only in the time dimension that is why cross section dependency is not tested for these variables directly first generation unit root tests are applied to investigate the level of stationary.

Table 2 pictures first generation panel unit root test outputs. Livestock feed prices and livestock prices are level stationary (I(0)), the minimum wage is first differenced stationary (I(1)). To check the stationarity of total livestock number and livestock payments series, we applied Pesaran's (2007) second generation panel unit root test since they contain cross sectional dependence (see Table 3). Livestock number and livestock payments series are first differenced stationary, I(1), with respect to Pesaran's (2007) panel unit root test as reported in Table 4.

As emphasized earlier variables must have cointegration relationships to be performed Panel ARDL approach. Kao cointegration test (Kao, 1999) reported in Table 5, and most of Pedroni cointegration tests (Pedroni, 1999; 2000) report-

Table 3 - Cross sectional dependency tests results.

	LLN		*LSP*	
	Stat.	*p-value*	*Stat.*	*p-value*
Breusch-Pagan LM Test	27612.0700	0.00	13823.1000	0.00
Pesaran scaled LM Test	302.7645	0.00	131.4696	0.00
Bias-corrected scaled LM Test	298.7145	0.00	127.4196	0.00
Pesaran (2004) Test	164.1275	0.00	99.2441	0.00

Note: The test statistics have a chi squared (χ^2) distribution with 3240 degrees of freedom.

Table 4 - Second generation panel unit root results.

Variables	*Test Stat.*	*Variables*	*Test Stat.*
LLN	-2.096	ΔLLSP	-2.599 ***
LLSP	-1.942	ΔLLN	-3.303***

*Notes: Critical values are taken from Pesaran (2007); *,** and *** represent 10%, 5% and 1% significance levels, respectively.*

Table 5 - Kao cointegration test result.

	t-Stat.	*p-value*
ADF	-10.1495	0.0000
Residual variance	0.0029	
HAC variance	0.0025	

Table 6 - Pedroni cointegration test results.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Stat.	p-value	Weighted Stat.	p-value
Panel v-Statistic	1.2476	0.1061	0.7501	0.2266
Panel rho-Statistic	8.6670	1.0000	8.6396	1.0000
Panel PP-Statistic	-3.0851	0.0010	-2.6618	0.0039
Panel ADF-Statistic	-3.0402	0.0012	-2.5602	0.0052
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Stat.	p-value		
Group rho-Statistic	13.0165	1.0000		
Group PP-Statistic	-7.0777	0.0000		
Group ADF-Statistic	-2.8524	0.0022		

ed in Table 6, results show that there exists cointegration relationship among variables. In brief, necessary conditions are held to predict our model via the Panel ARDL approach.

Based on Pesaran *et al.* (1999) a standard Pool Mean Group (PMG) Panel ARDL model is shown in equation 2.

$$\Delta(y_i)_t = \sum_{J=1}^{p-1} \gamma_j^i \, \Delta(y_i)_{t-j} + \sum_{J=0}^{q-1} \delta_j^i \, \Delta(X_i)_{t-j} + \Phi^i\left[(y_i)_{t-1} - \left\{\beta_0^i + \beta_1^i (X_j)_{t-1}\right\}\right] + \varepsilon_{it} \quad (2)$$

y is the dependent variable of the equation which is the total number of livestock in our case. X contains a set of independent variables which are livestock payments, livestock feed prices, livestock prices, and minimum wage in our model. γ and δ are short run coefficients of lagged dependent and independent variables respectively. β represents long run coefficients and Φ is the error correction term indicating the equilibrium speed from short run to long run.

PMG Panel ARDL results are summarized in Table 7. According to Table 7, the error correction term is -0.0233 and statistically significant at 1% level. This means approximately 0.2% of short run imbalances are eliminated in the first period. This finding indicates that the equilibrium rate of the model is quite slow. Livestock payments coefficients are positive both in the short and long run. However, the short run coefficient is statistically insignificant. Accordingly, the livestock payments made for the livestock sector have positive effects on the production level in the long run on the other hand enterprisers cannot convert these payments into production in the short run. It should be noted that production processes require long periods in the livestock sector. Hence the support payments' effects would be observed in a long time period and it can be expressed that our findings are reasonable. Coefficients of livestock feed prices, representing input costs, are negative as expected but it is statistically significant only in the short run equation. People dealing with the livestock sector would prefer to stay in the sector due to limited opportunities in the Turkey market even if livestock feed prices rise. In other words, traders keep producing by taking into account the reduction in profit in the face of increasing input costs since they do not have any other options. Livestock prices' coefficients are significantly positive. Consistent with expectations, rising livestock prices increase the total number of livestock.

For the effect of minimum wage on the livestock sector, we got interesting findings. In the short run, the negative and significant coefficient is observed whereas in the long run and positive and significant coefficient is taken. Actually, obtained results related to minimum wage are logical considering the general economic structure of Turkey. Labor forces adopting a risk-averse attitude would hesitate to enter the livestock sector when the minimum wage is relatively satisfactory. Because livestock sector contains a lot of risks and it needs the amount of investment (mostly irreversible) in the beginning times. People would choose to work with minimum wage without taking any risks and bearing any

Table 7 - PMG Panel ARDL regression results.

Long Run Equation				
Variable	*Coefficient*	*Std. Error*	*t-Stat.*	*p-value*
LSP	5.2153	1.3427	3.8841	0.0001
LFP	-4.7982	5.3584	-0.8954	0.3711
LLSP	2.5909	0.8050	3.2187	0.0014
LMW	4.6106	1.1120	4.1460	0.0000
Short Run Equation				
ECC	-0.0233	0.0073	-3.1778	0.0016
C	-0.5837	0.1970	-2.9636	0.0032
ΔLSP	0.0061	0.0250	0.2434	0.8078
ΔLFP	-1.6052	0.4052	-3.9615	0.0001
ΔLLSP	0.1730	0.0377	4.5890	0.0000
ΔLMW	-0.5949	0.0777	-7.6595	0.0000
Mean dependent var	0.031409	S.D. dependent var		0.0450
S.E. of regression	0.039982	Akaike info criterion		-3.3600
Sum squared resid	0.641008	Schwarz criterion		-0.7245
Log likelihood	1986.874	Hannan-Quinn criterion		-2.3527

costs in the short run. However, from short run to long run the picture reversed and minimum wage impact on the livestock sector becomes significantly positive. Even if, the workforce is oriented towards areas with minimum wage, employers can reduce their worker demand. Since in Turkey, those working with minimum wage comprise approximately 41% of the total number of employees, this reaction of employers would cause to lack of employment threat. In the long run, entrepreneurs would move to the agriculture and livestock sectors, considering fear of unemployment in other sectors, if the minimum wage is relatively high.

4. Conclusion

Turkey, which employs approximately one-fifth of its workforce in the agricultural sector, is among the highest agricultural support providing countries in comparison to its GDP in the world. On the other hand, livestock supports have an important share in agricultural supports. Especially during the last decades, the share of livestock supports in total agricultural supports has increased significantly. In this respect, the production effect of livestock supports is an important issue that needs to be covered.

In this paper, the relationship between livestock supports and livestock production is empirically analyzed on a province basis with yearly-frequented data covering 2010-2020. The results of Panel ARDL method are extremely remarkable. Findings show that the relationship between livestock supports and production is statistically insignificant in the short run. Therefore, increase in livestock and establishment of additional facilities require a time period. Practically, it is difficult for producers to respond to the increases in supports in the short run. In other words, producers can not react instantly to livestock supports due to infrastructural constraints in the short run. Furthermore, short run uncertainties about the livestock supports may cause hesitation for producers in reacting quickly. Although, the effect of supports on livestock presence is insignificant in the short run, it has a positive and significant effect in the long run. The results indicate that livestock supports affect livestock production positively in the long run. To put it in another way, livestock payments are an important indicator for farmers in the long run.

Coefficient of feed prices representing input costs is negative as expected in the short and long run but statistically significant only in the short run equation. The results show that increases in the price of feed, as a substantial input, harm livestock sector in the short run. Producers, whose profitability decreases with the increase in costs, not only reduce their production scales but also diminish livestock presence in the short run. Considering the costs of scaling down or – even worse – disengagement from the market, decisions of producers vary in the long run. Decisions ofIn addition, the rigidity of labor transfer between sectors in Turkey results in farmers turning to policies that will compensate for their income losses in the long run rather than reducing livestock presence.

One of the variables that directly affect livestock presence is the price of livestock. Findings reveal that increases in livestock prices have a positive effect on the number of livestock in the short and long run. Yet, in the long run, production effect of livestock price is greater than it is in the short run since scale and time constraints faced by the producers limit the production. The results are extremely important in terms of showing that not only livestock supports but also livestock prices effects producer behaviour.

It is inevitable that changes in the minimum wage will have some effects on the agricultural and livestock sectors in Turkey, where nearly half of the workforce earns minimum wage. The results obtained in this study regarding the effect of minimum wage on the presence of livestock is extremely striking. Accordingly, results are negative in the short run and positive in the long run. Employees in Turkey would run away from the sectors such as livestock and agricultural industry due to unique sectoral risks, high amount of irreversible investment costs and not decent working conditions if minimum wage is not satisfactory for them. Meaning, increase in minimum wage makes other sectors more attractive for working; mainly, service industries where no investment risks have to be taken. This can also be described with migration phenomenon from rural to urban. Such situations explain the negative short run effects of increasing minimum wage on livestock industry.

On the other side, a relatively high level of minimum wage would drive employers away in hiring more employees; even in some cases, they would fire existing employees in order to optimize their profits. In such a scenario, employees would choose to work in livestock and agricultural industry only to avoid potential risk of unemployment which is again related to the fact that service industry does not provide enough employment opportunities at minimum wage level. This forms another motivation for working in the livestock industry. From this point of view, increasing the minimum wage assists amplification of production in livestock industry only on the long run.

The findings have important implications for policy measures. First of all, livestock supports are an important policy tool for directing production and producers. It shows that increasing livestock supports to close supply gap achieves its main purpose; as it is expected. However, not only livestock supports but also livestock prices are effective in the production decision of producers. In other words, livestock support and price policy can be used effectively in the livestock sector. Findings also show that changes in inputs such as minimum wage and feed price effect production negatively in the short run. In order to eliminate the negative effects of increases in input prices, alternative policies such as feed supports and tax advantages should be implemented for alleviating cost pressure on the producers.

The livestock sector has a great importance for Turkey. In this sense, this study, which is conducted for the first time covering 81 provinces in Turkey, reached comprehensive and strong results on the impact of agricultural support, livestock prices and costs over the livestock sector. Although livestock supports and other variables have various consequences on livestock production; other effects, especially created by livestock supports are substantial subjects of this study. In this context; input prices, grazing rents and environmental impacts of livestock supports are significant study areas awaiting explanation.

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Local partnerships for the development of coastal regions: A review of Fisheries Local Action Groups with focus on the Mediterranean

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Abstract

In the last programming period of the European Maritime Fisheries Fund, Fisheries Local Action Groups (FLAGs) have been in charge of meeting the objectives of Union Priority 4, aimed at boosting territorial cohesion and employment in European coastal areas. These local partnerships have hence received support for the elaboration of local development strategies that should promote both territorial and sectorial projects, balancing the interests of the different stakeholders involved. This article provides for a literature review of the scientific contributions on FLAGs, organizing the main findings according to the six dimensions of the Porter's Diamond Model in the context of the cluster analysis on coastal communities' competitiveness. Moreover, by focusing on FLAGs from Italy, Spain and France, the paper discusses the orientation towards sectoral and territorial interests in the Mediterranean. It emerges that while the literature has mostly emphasized their territorial functions, FLAGs – especially those in areas with relatively higher incidence of employment in fisheries-related sectors – have prioritized projects of sectorial scope.

***Keywords**: Fisheries Local Action Groups, Community-led local development, Fisheries diversification, Cluster, Coastal communities.*

1. Introduction

Set up in 2007 under Axis 4 of the European Fisheries Fund (EFF), Fisheries Local Action Groups (FLAGs) are local partnerships that bring together the private sector, local authorities and civil society organizations. Since 2014 FLAGs have been responsible for the implementation of community-led local development (CLLD) in European fisheries, an area-based approach initiated by Axis 4 of the EFF and subsequently included into Union Priority 4 (UP4) of the European Maritime and Fisheries Fund (EMFF), whose general objective is to increase employment and territorial cohesion in coastal and inland communities which depend on fishing and aquaculture (European Parliament, 2014). Inspired by the LEADER approach applied to rural areas since 1991, CLLD is described as a bottom-up process that "turns traditional 'top

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down' development policy on its head" (European Commission, 2014) and reflects the change from an exogenous to an endogenous approach of territorial development in the EU (Phillipson & Symes, 2015). The endogenous approach rests on the assumption that the well-being of a territory can be best influenced by the human, physical and intangible resources locally available, through the elaboration of development actions that should be based on the extensive involvement of the local community in their design and implementation (Ray, 1999). As such, FLAGs are most advantageously placed to animate local actors by means of multi-sectoral local development strategies which address the needs of coastal communities (Miret-Pastor *et al.*, 2020). Through the involvement of stakeholders from multiple sectors, the 348 FLAGs (as of 2021), distributed across 19 EU Member States, are responsible for the implementation of both sectoral and territorial development – hence tackling those social impacts of the Common Fishery Policy (CFP) that used to be neglected in favor of biological and economic objectives (Piñeiro-Antelo *et al.*, 2019).

Concerning the interaction between sectoral (i.e. for fisheries and aquaculture development) and territorial functions of FLAGs, Miret-Pastor *et al.* (2020) highlight the fact that four out of five objectives that FLAGs can declare are linked with strategies for territorial development, which is in line with the goal of the UP4 itself. Nevertheless, FLAGs can still finance projects related to sectoral development, in particular through the first objective of the CLLD strategies listed in Article 63 of the EMFF ("Adding value, creating jobs, attracting young people and promoting innovation at all stages of the supply chain of fishery and aquaculture products"). In the literature, the debate over the sectoral or territorial nature of EU funds for fisheries dependent areas has been raised long before the establishment of FLAGs (Symes, 2005). Phillipson & Symes (2015) advocate for a "middle way" in the role that FLAGs should play, thus balancing territorial and sectoral projects depending on the socio-economic attributes of the area where they operate, in terms of its dependency on the fishing sector.

The necessity to improve the performance of European fishing systems in the three domains of sustainability (social, economic, environmental) has been laid out in various policy initiatives making part of the European Green Deal – namely the EU Biodiversity Strategy for 2030, the Farm to Fork Strategy and the Circular Economy Action Plan. Keeping fishing mortality at or under the MSY (European Commission, 2020b), preventing illegal, unreported and unregulated fishing (European Commission, 2020c), and tackling marine plastic pollution caused by fishing gears (European Commission, 2020a) are some of the actions proposed in these documents. In this regard, FLAGs could play an important role for the sustainable transition of European fisheries. Indeed, it has been estimated that the majority of FLAGs have supported at least one project contributing to the Green Deal objectives, especially those related to the promotion of systems with reduced food miles, education about ecosystems and biodiversity, eco-tourism and sustainable fish stocks management (FARNET, 2020).

In the literature that has investigated the application of CLLD in the EU through FLAGs, some aspects of these organizations have been associated with the key elements of Social-Ecological Systems (SESs). The sustainability of SESs has been extensively studied by means of a holistic framework, developed over several years and continuously updated (Ostrom, 2007, 2009; McGinnis & Ostrom, 2014), which has often been applied in the case of fisheries (Basurto *et al.*, 2013; Leslie *et al.*, 2015; Partelow & Boda, 2015). Linking FLAGs and SESs, Furmankiewicz *et al.* (2021) claim that the establishment of localized cross-sectoral partnerships for the promotion of bottom-up decision-making processes in the EU should be related to the influential works by Elinor Ostrom on the importance of cooperation at the local level for the management of common-pool resources. Similarly, Linke & Bruckmeier (2015) review the characteristics and benefits of co-management schemes and analyze the potential of FLAGs to develop fisheries co-management in Europe. While investigating on FLAG's potential to promote fishing tour-

ism in Greek small-scale fisheries, also Kyvelou & Ierapetritis (2020) utilize the term SES to convey the embeddedness of traditional fishing activities within the local socioeconomic, cultural and environmental context.

Although FLAGs' interventions are not limited to one specific branch of the fleet, it is argued that the small-scale fishery (SSF) sector tends to be the "natural partner of most FLAGs", since these organizations tend to be located in coastal areas characterized by the strong presence of artisanal fisheries (FARNET, 2017). There exists a solid bond between this type of fisheries and the development of coastal communities (Pita *et al.*, 2020), since the total economic value of artisanal fishing should include "non-commodity outputs" such as the contribution to coastal employment, food security and cultural heritage, among others. These aspects characterize the so-called "multifunctionality" of SSFs (Mulazzani *et al.*, 2019) and have led authors to conclude that the economic viability of this type of fisheries cannot be easily summarized through measures of financial profitability (Schuhbauer & Sumaila, 2016). For instance, Mulazzani *et al.* (2017) have applied the cluster approach to analyze the competitiveness of six coastal communities in the Mediterranean mostly reliant on SSFs. Their work is based on the analytical framework presented by Malorgio *et al.* (2017), which allows for the inclusion of a variety of external factors that may affect the performance of SSFs-based territories (e.g. presence of related and supporting industries, demand and inputs conditions, role of governmental institutions and others). Such factors have been derived from the so-called "Diamond Model" first developed by Porter (1998) in his attempt to explain the evolution of successful industrial clusters. Nevertheless, as demonstrated by Malorgio *et al.* (2017), the multidimensionality of the Porter's Diamond makes it instrumental in studying the role of SSFs in coastal communities, since it encompasses other approaches that are more specific (i.e. Blue Growth or ecosystem services). For these reasons, not only can CLLD be contextualized within the SES framework, but it could be argued that also the cluster approach to the development of coastal communities provides a useful tool for understanding the contribution of FLAGs to both sectorial and territorial development.

Since no review has yet been performed on FLAGs, this article attempts to address this gap in order to understand (rather than the effectiveness these organizations had in implementing CLLD strategies) which aspects of FLAGs have been mostly emphasized in the literature. In addition, we want to focus on the differences that characterize the Mediterranean FLAGs from Italy, Spain and France, especially with reference to their organization and strategy. The choice over these three countries is based on their homogeneity with regard to the socio-economic relevance of the Blue Economy, in terms of its contribution to both Gross Value Added and employment at the national level.[1] The study has hence been motivated by the following research questions: 1) Which characteristics of FLAGs have been emphasized in the literature with regard to the six dimensions of the Porter Diamond? 2) Concerning the FLAGs of the Mediterranean basin from Italy, Spain and France, are sectoral and territorial interventions equally prioritized? Results from the two research questions provide for an understanding of the various strategies pursued by FLAGs to foster the socio-economic development of coastal areas taking into account the perspective of both the scientific community and the FLAGs themselves, therefore examining the relation between the two within the Mediterranean region. Considering that the EMFF programming period (2014-2020) has come to an end, the results from this study may provide useful insights for the application of CLLD in the European Maritime, Fisheries and Aquaculture Fund (EMFAF) period 2021-2027.

[1] Suffice it to say that in the other countries facing the Mediterranean Sea the relative weight of the Blue Economy tends to be much larger. Taking for instance the relevance of employment, its contribution to national jobs reaches 9.8% in Croatia, 10.3% in Cyprus and 15.3% in Greece, well above the EU level (2.3%) (European Commission, 2021).

2. Methodology

First, a literature review has been performed in order to identify the scientific literature that has studied FLAGs. To do so, the search TITLE-ABS-KEY ("fisher* local action group*") was entered in the Scopus database in February 2022, which resulted in 24 articles already published on the subject. Each of the articles was then analyzed with the aim of extrapolating its methodology, scope of the research, number of FLAGs investigated, geographical area and findings. In order to summarize the main findings related to FLAGs, it has been decided to organize the results section following the analytical framework presented by Malorgio *et al.* (2017) and applied by Mulazzani *et al.* (2017) in their comparative analysis of Mediterranean coastal communities. As previously discussed, the variety of interventions pursued by FLAGs and discussed in the literature can fit within the several dimensions of the cluster analysis on costal communities' competitiveness. The six dimensions, derived from Porter's Diamond Model, include *i*) Context for fishermen strategy and rivalry, *ii*) Factors' condition, *iii*) Related and supporting industries and services, *iv*) Demand conditions, *v*) Government, *vi*) History and chance.

The second part of the article, focusing on the Mediterranean FLAGs from Italy, Spain and France, is based on the information available on the FLAGs factsheets and provided by the FARNET Support Unit. In particular, for each FLAG the following information were extracted: Country, Surface area, Population density, Total employment in fisheries (Fishing, Aquaculture, Processing), Total public budget allocated to the FLAG for 2014-2020, Presence of fisheries actors in the partnership/general assembly, Presence of public actors in the main decision-making body/board and Strategy. Concerning the information contained in the variable Strategy, at the beginning of the 2014-2020 EMFF period FLAGs were asked to indicate those subthemes that would be included in their development strategies. FLAGs could choose up to five fields among thirty subthemes, which belong to the objectives of the UP 4 listed in Article 63 of the EMFF: 1) Adding value to fisheries; 2) Diversification; 3) Society and culture; 4) Environment and 5) Governance and management. For each of these macro themes, the variable Strategy indicates how many times they have been declared by the FLAG. The dataset includes those (62) FLAGs that fully reported on each and every single of the above-mentioned variables, coming from Italy (43), Spain (12) and France (7). Concerning the Mediterranean basin, the sample analyzed in the study covers 81% of the Italian FLAGs and the totality of French and Spanish ones. In addition to a qualitative comparison of the selected FLAGs, it is proposed to analyze the FLAG orientation towards sectoral activities in order to understand the relation between the priorities declared by the partnership and its organization. As previously stated, this topic has already been raised in the literature. For instance, the framework by van de Walle *et al.* (2015) on the role of FLAGs for the resilience of fishing communities can be used to understand whether the organization has been more oriented towards sectoral, territorial development, or a mix of both.[2] In this article, it has been decided to concentrate our analysis on those FLAGs that showed a strong inclination towards sectoral activities. Since all the FLAGs investigated have reported at least one sectoral action, we estimate a logit model where the dependent variable is a dummy taking value 1 if the FLAG declared a minimum of two sectoral activities belonging to the category "Adding value to fisheries" and 0 otherwise. The explanatory variables include the area covered by the FLAG, the ratio of fisheries-related FTEs over the population, the 2014-2020 budget, the percentage of public actors in the FLAG decision-making body, the percentage of fisheries actors in the partnership and the country.

[2] More specifically, the framework categorizes FLAGs' interventions along an axis which goes from actions focusing on sectoral development – *i*) Sector structure and organization, *ii*) EFF local antenna, *iii*) Small scale fisheries outreach, *iv*) Supply chain integration – to territorial development, *v*) Benefits from blue growth, *vi*) Catalyst for innovation/redevelopment – passing through those interventions where an overlap of both domains takes place, *vii*) Place of sector within a territory, *viii*) Ensuring benefit from local economic development, *ix*) Entry point to local governance.

3. Results

Table 1 shows the information regarding the 24 articles that resulted from the literature review. As expected, most of the articles focus on those countries where the number of FLAGs is higher, namely Spain (8 articles), Poland (6) and Italy (5). Moreover, it emerges that in the majority of cases qualitative methods of analysis have been preferred, especially through the use of questionnaires and in-depth interviews with FLAGs members (16 articles) and reviews of technical documentation (12). After presenting the main findings according to the six dimensions of the Porter's Diamond, the sectoral/territorial interpretation of FLAGs in the literature is related to the analysis of these partnerships in the Mediterranean Sea, in particular in Italy, Spain and France.

Table 1 - Summary of the information provided by the reviewed articles.

Article	*Methodology*	*Scope*	*FLAGs included in the study*	*Country*	*Findings related to FLAGs*
Cortese *et al.* (2021)	Questionnaire to consumers, descriptive statistics and Multiple Correspondence Analysis	Understand consumer behavior with reference to local fish consumption	1	Italy	Consumers pay attention to the sustainability of their diet and the environmental impact of fishing techniques. These aspects should be considered by FLAGs with the aim of promoting gastronomic tourism
Czarkowski *et al.* (2012)	Literature review, legal and strategic documents	Discuss the potential of recreational fishing for tourism development in two Polish provinces	4	Poland	FLAGs should provide the assistance in the management of EU funds for the development of infrastructure associated with recreational fisheries
De Boni *et al.* (2018)	Application of the multiple criteria decision aiding framework Promethee II, questionnaires to FLAGs' members	Propose a decision tool to assess the sustainability of FLAGs' coastal development plans	6	Italy	Funds distribution should vary among FLAGs, as projects must adapt to the environmental and socio-economic features of the area. It is better to fund projects in different sustainability fields
Distaso *et al.* (2020)	Interviews with FLAGs' directors, Analytic Hierarchy Process Methodology	Evaluate the role of the local FLAGs at improving the quality of life in one Italian region	6	Italy	FLAGs should organize activities to increase social capital and provide diversification opportunities
Freeman & Svels (2022)	Quantitative assessment through surveys and semi-structured interviews with local stakeholders and FLAG members	Study the impact of FLAGs on women's empowerment	113	EU-wide, focus on Estonia, Croatia, Spain	FLAGs are active in promoting the empowerment of women in fishing communities (especially in the domain of diversification projects) but in many cases they are still dominated by male perspectives, thus underrepresenting women's contribution to SSFs survival
Furmankiewicz *et al.* (2021)	Review of technical documentation, content analysis and text mining	Analyze whether CLLD strategies in Poland address issues related to climate change mitigation and adaptation	36	Poland	FLAGs' strategies do not sufficiently include efforts for mitigation and adaptation. Communities are only aware of local impacts on fishing activities and disregard the involvement in European initiatives

Article	*Methodology*	*Scope*	*FLAGs included in the study*	*Country*	*Findings related to FLAGs*
Felicidades-García & Piñeiro-Antelo (2021)	Review of technical documentation	Analyze cooperation projects in Galicia, in terms of their scope and weight within local development strategies	7	Spain	There is an increase in cooperation projects by FLAGs, but their number is still too limited. Plus, efforts should be made to extend their geographical coverage
Kurowska *et al.* (2014)	Hellwig's taxonomic method to combine socioeconomic indexes into four levels of local development	Assess the impact of FLAGs on the socioeconomic development of Polish coastal regions	9	Poland	The socioeconomic development level in FLAGs areas increased between 2004 and 2012
Kyvelou & Ierapetritis (2020)	Review of technical documentation, survey and interviews to FLAGs' members and other stakeholders	Evaluate the benefits and challenges of establishing marine spatial plans promoting fishing tourism	17	Greece	FLAGs should collaborate with marine spatial planning authorities and other marine sectors for the creation of multi-use schemes, especially fishing tourism due to its environmental and socioeconomic value
Linke & Bruckmeier (2015)	Literature review on co-management, policy documents analysis, talks and interviews with FLAGs' members and other stakeholders	Identify those conditions that allow the implementation of co-management schemes in European fisheries	Not specified	Denmark, Finland, Sweden	FLAGs have the potential to empower local fishing communities, provided that they integrate knowledge from all relevant stakeholders. Involving FLAGs in higher-level decision-making processes is key
Miret-Pastor *et al.* (2018)	Review of technical documentation, questionnaire sent to FLAGs' managers, descriptive statistics	Analyze fisheries diversification projects in Spain and evaluate their effectiveness	24	Spain	Most of FLAGs' leaders acknowledge the importance of diversification projects for the development of coastal areas. However, actions should not be limited to tourism and include social and environmental issues
Miret-Pastor *et al.* (2020)	Review of technical documentation	Study the use of EFF funds in Spain to provide for diversification opportunities by connecting the tourism sector, recreational and professional fishing	31	Spain	Fishing tourism projects are still scarce. The following points should be addressed by FLAGs: fishermen involvement, use and improvement of existing infrastructures, communication at the community level, participation in governance processes and training to share knowledge with different actors
Miret-Pastor *et al.* (2020)	Review of technical documentation	Study the distribution of project funds on UP4 objectives among FLAGs from eight European countries	131	Denmark, Estonia, Finland, Ireland, Latvia, Poland, Spain, Sweden	Most of the expenditures addressed three objectives (adding value, diversification, socio-cultural promotion). But new indicators to measure the impact of FLAGs' projects should be developed

Article	*Methodology*	*Scope*	*FLAGs included in the study*	*Country*	*Findings related to FLAGs*
Mulazzani *et al.* (2017)	Consultation of an interdisciplinary research team and local stakeholders	Build a model based on the ecosystem service framework and the Bayesian network approach to simulate the socio-ecological outcomes under different scenarios	1	Italy	The application of the proposed model by FLAGs represents an opportunity to empower the local community due to its participatory approach
Padín *et al.* (2016)	Tourist surveys and interviews with FLAGs' members and local skippers	Assess two fishing tourism projects in Galicia	2	Spain	FLAGs' members highlight the positive effects of fishing tourism on fishermen's environmental awareness, social image and diversification opportunities
Pawlewicz *et al.* (2014)	Surveys, audit visits and interviews with FLAGs' members and other institutional representatives	Analyze the activities performed by Polish FLAGs concerning environmental protection	41	Poland	Despite FLAGs' potential, the number of projects to protect the natural heritage in Poland is low. The influence of the public sector and the lack of involvement of private parties represent an obstacle
Phillipson & Symes (2015)	Interviews with FLAG's members and other stakeholders from the local community and fishing sector, review of technical documentation	Examine how FLAGs projects can balance sectoral and territorial development	1	United Kingdom	The targets of EFF Axis 4 funds should be redefined. A typology of fisheries dependency is proposed to help FLAGs plan their investments conditional on the place of the fishing sector within the local economy
Piñeiro-Antelo & Lois-González (2019)	Review of technical documentation, interviews with members of the local fishing sector	Analyze the contribution of CFP funds to the generation of social innovation	1	Spain	The FLAG generated social innovation locally, but it was limited by community resistance, unequal representation of interests and pressures from the administration
Piñeiro-Antelo *et al.* (2019)	Review of technical documentation, interviews with FLAGs' members and project managers	Assess the activity of two FLAGs, in terms of their ability to be socially inclusive, sectorally balanced and autonomous in the distribution of funds	2	Spain, Portugal	FLAGs have promoted positive social innovations, but they were limited by the scarcity of funds, the influence of local administrations and the unequal weight given to their members
Piñeiro-Antelo *et al.* (2020)	Review of technical documentation, interviews with FLAGs' members and participation to a FLAG workshop	Study the role of FLAGs in territorial governance processes in the context of the Evolutionary Governance Theory framework	13	Ireland, Spain	FLAGs have been effective in empowering local actors and create synergies among different economic sectors, but their influence depended on the existing governance system, especially in terms of pressures from local authorities

Article	*Methodology*	*Scope*	*FLAGs included in the study*	*Country*	*Findings related to FLAGs*
Romeo & Marcianò (2019)	Interviews with vessel owners and FLAG's members, budgetary analysis, multi-criteria analysis in a fuzzy environment	Assess the economic performance of the main fishing gear types active in the FLAG area	1	Italy	FLAGs should perform microeconomic analysis of the local fleet to help plan local development strategies
Szamrowski *et al.* (2014)	Surveys, audit visits and interviews with FLAGs' members and other institutional representatives	Analyze the activities performed by Polish FLAGs regarding environmental protection	4	Poland	The number of projects aimed at protecting the natural heritage in Warmia and Mazury is low. Most of the funds are allocated to the objective of increasing the competitiveness of fisheries areas
Thuessen & Nielsen (2014)	Focus groups with LAGs and FLAGs' board members and coordinators	Study the contribution of the EU LEADER approach in a multi-level governance setting at the LAG and FLAG level	3	Denmark	LAGs and FLAGs represent an opportunity to develop local development strategies in bottom-up decision-making processes
van de Walle *et al.* (2015)	Interviews with FLAG's members and review of the FLAG technical documentation	Describe the projects that the Pays d'Auray FLAG has pursued to respond to pressures on the local fishing sector	1	France	FLAGs represent an important forum to mitigate the fragmentation among different fisheries actors and to advocate for the needs of the local fishing sector

Context for fishermen strategy and rivalry

This dimension includes the performance of the local fishing fleet and the relationships both among fishermen and within the value chain. The work by Romeo & Marcianò (2019) constitutes the only example of a study on FLAGs with the aim of assessing the performance of the fleet. The article provides for a methodology to aggregate scores of financial indicators derived from budgetary analysis of the vessels into a measurement of the economic performance of the main gear types adopted in the area, thus helping the local FLAG planning a development strategy that addresses the issues and potentials of the different fishing systems. With regard to the nature of the relationships within the fishing industry, it has been emphasized that FLAGs represent a forum to overcome the fragmentation of the fishing sector (van de Walle *et al.*, 2015) and promote regional cooperation (Felicidades-García & Piñeiro-Antelo, 2021).

Related and supporting industries and services

A recurring topic raised in the literature is the importance of improving the connection between the fishing and tourism sectors. In their analysis of fishing tourism projects in Galicia, Padín *et al.* (2016) claim – based on interviews with local FLAGs' managers – that these initiatives are especially beneficial in enhancing the social image of fishermen, changing it "from a predatory role to a resource manager", and spreading environmental awareness among both tourists and the fishing sector. Kyvelou & Ierapetritis (2020) investigate the benefits and problems related to the co-existence of artisanal fisheries and tourism and present fishing tourism as an effective diversification strategy for Greek small-scale fisher-

ies. The authors stress the role that FLAGs could play in the establishment of marine spatial plans through a multi-use approach that guarantees the coexistence of different economic sectors. Miret-Pastor *et al.* (2020) illustrate practical examples of activities that may connect recreational and professional fishing and claim that the number of projects that unite these two sectors in Spain is still too limited. While evaluating the distribution of Spanish diversification funds in the period 2007-2014, Miret-Pastor *et al.* (2018) report FLAGs' opinion that restoration and gastronomic events are the two diversification activities that generated the highest profits for the fishing industry. Lastly, Czarkowski *et al.* (2012) encourage Polish FLAGs to provide assistance in managing EU funds for the promotion of recreational fishing in lakeland regions, in terms of infrastructures designed for anglers.

Demand conditions

The elaboration of adequate strategies for the development of a successful marine cluster should also take into account the level and characteristics of local as well as tourist demand. As previously discussed, sectorial aspects like marketing strategies and consumer analysis have been only partially investigated in the literature concerning FLAGs, stressing once again the territorial development function of these organizations. The only exception is represented by Cortese *et al.* (2021), whose objective is to provide for an analysis of consumer behavior in the area of one FLAG in Southern Italy. The study, meant to help planning local programmes of gastronomic tourism, highlights the association that tourists make between small-scale fishing activities and the sustainability of the production process. A tourist survey is present also in Padín *et al.* (2016), although in this case the objects of the analysis are two diversification projects of fishing tourism. Regarding the strategies to improve the attractiveness of the cluster, van de Walle *et al.* (2015) claim that one of the key factors in the case of the Pays d'Auray FLAG was the presence of "active fishing harbours and working shellfish farms", hence warning – following Martindale (2014) – against those forms of tourism that tend to reduce the fishing industry to some sort of cultural heritage rather than a dynamic economic activity.

Factors conditions

This dimension is related to the availability and quality of those inputs that contribute to the development of a successful coastal cluster, like natural and physical capital and labor. The literature that has investigated on the link between FLAGs and the management of such factors includes a limited number of articles and is mainly focused on investments for the enhancement of environmental assets and climate change mitigation, which belong to the fourth objective of Article 63 of the EMFF. In their analysis covering eight EU Member States, Miret-Pastor *et al.* (2020) show that FLAGs have assigned to environmental projects the lowest priority among the five objectives of the UP4, with Swedish FLAGs constituting one exception due to their large geographical coverage, which allows them to have access to the larger funds needed to address complex issues like environmental management. Investments in the area of environmental protection are explored also in Szamrowski *et al.* (2014) and Pawlewicz *et al.* (2014), where it is argued that the level of funds dedicated to these activities by Polish FLAGs is too low. Furmankiewicz *et al.* (2021) have reviewed Polish FLAGs' development strategies to study the relevance given to climate change mitigation and adaptation activities. After showing that these issues have been only marginally discussed, the authors advocate for interventions favoring the development of environmental awareness on the most concrete effects of climate change among local stakeholders and the tangible benefits deriving from investments in renewable energy.

Government

The capacity of institutions to influence the development of maritime clusters should be broadly conceived, as it embraces a variety of activities such as financial support, environmental legislation and community empowerment. In this regard, the literature tends to stress the positive

contribution that FLAGs have made to the implementation of CLLD across Europe. For instance, in their analysis of Irish and Galician FLAGs, Piñeiro-Antelo *et al.* (2020) claim that these organizations have fostered the evolution of local territorial governance, by giving greater prominence to local actors and generating synergies among different sectors. However, the authors also stressed that FLAGs' effectiveness and acceptance is heavily influenced by the already existing territorial governance framework. Likewise, the weight of local elites and public administrations in the choices over funds allocation has been reported as a limiting factor in Piñeiro-Antelo *et al.* (2019) and Szamrowski *et al.* (2014). In this regard, van de Walle *et al.* (2015) argue that it is the overrepresentation of fishermen within the board composition that has successfully allowed the Pays d'Auray FLAG to mobilize the concerns of the local fishing industry, at the expenses of other sectors whose interests are already widely represented. Similarly, Thuessen & Nielsen (2014) hold that that the establishment of (F)LAGs has developed multilevel governance settings in Denmark "in the form of leverage, democratization and bottom-up decision making".

History and chance

Even if it is believed that historical events external to FLAGs (e.g. indirect drivers of change like economic crises and political instability) should be considered during the elaboration of local development strategies (Mulazzani *et al.*, 2017), no general conclusions can be drawn from the reviewed articles over the influence of history and chance on FLAGs. Nevertheless, in several studies the discussion on FLAGs is contextualized within external factors of change like anthropogenic pressures (van de Walle *et al.*, 2015), declining fishing profitability (Kyvelou & Ierapetritis, 2020) or the inclusion of Axis 4 in the CFP (Piñeiro-Antelo *et al.*, 2019).

FLAGs in the Mediterranean basin - Italy, Spain and France

With regard to the regional analysis on FLAGs, Table 2 provides some information concerning the structure and organization of these partnerships in Italy, Spain and France. When looking at the geographical extension of FLAGs, it emerges that the seven French groups in the Mediterranean basin tend to be characterized by a relatively wider coverage in territories with scarce population densities. Moreover, in these areas the frequency of fisheries-related jobs seems lower if compared to Italy and especially Spain. Indeed, Mediterranean Spanish FLAGs are the ones that have received the greatest allocation of funds, thus reflecting the socio-economic relevance of the Blue economy in the country (4.9% of national jobs in terms of employment and 3.0% of national GVA) (European Commission, 2021). The presence of public actors in the decision-making board – whose excessive control on the organization's activities has already been discussed in the literature review – is another characteristic that tends to vary among the three countries, reaching its peak in French FLAGs (43%). On the contrary, substantial homogeneity can be found when looking at the priority that FLAGs have assigned to the UP4 objectives. With respect to their strategy, the relatively low attention to environmental issues – as already highlighted in the literature review – tends to be a common characteristic of FLAGs in the region. On the contrary, the theme "Adding value to fisheries" has been declared at least once by all the 62 FLAGs investigated and also the theme "Diversification" has been frequently included in the strategy (77% of FLAGs). In absolute terms, actions belonging to the theme "Adding value to fisheries" have been declared the highest number of times (119), followed by "Diversification" (61), "Society and culture" (52), "Governance and management" (51) and "Environment" (29). Indeed, it emerges that FLAGs have prioritized sectoral interventions over territorial ones. Nevertheless, it is important to remark that there is a relevant number of FLAGs that have declared a number of actions under "Diversification" at least equal to or greater than those falling under "Adding value to fisheries" (32.6% of FLAGs in Italy, 75% in Spain and 42.9% in France).

To complete our investigation of Mediterranean FLAGs in Italy, Spain and France, it is sug-

Table 2 - Descriptive statistics of the variables contained in the FLAGs' factsheets of the selected countries. Only coastal FLAGs in the Mediterranean are included.

	Italy	*Spain*	*France*
N. FLAGs analyzed (% coverage)	43 (*81%*)	12 (*100%*)	7 (*100%*)
Average population density	495	468	288
Average surface area (km^2)	619	450	1055
Average frequency of fisheries FTEs in the population	0.60%	0.91%	0.36%
Average public budget allocated to the FLAG for 2014-2020	1,683,439 €	2,485,936 €	1,451,059 €
Average presence of public actors in decision-making body	33%	28%	43%
Average presence of fisheries actors in partnership	32%	32%	37%
FLAGs with at least one environmental subtheme declared	17/43	6/12	4/7
FLAGs with at least one diversification subtheme declared	32/43	11/12	5/7
FLAGs with at least two sectoral subthemes declared	30/43	3/12	4/7

Table 3 - Results of logistic regression analysis to explain the sectoral orientation of FLAGs.

Variables	*Coefficients*	*SE*
Constant	.442207	1.444075
Surface area	.0002399	.0004698
FisheriesFTEs/Population	3.434852	1.595712 *
Public budget	-9.02e-08	4.61e-07
% of public actors	-.0033469	.0281803
% of fisheries actors	-.034999	.020311
France	1.09413	1.085201
Spain	-.1641071	1.015635

gested to analyze the relationship between the main characteristics of the organization and the preference towards sectoral interventions rather than territorial ones. Considering the small sample size (62 FLAGs), we apply the Firth's (1993) penalized maximum likelihood estimator, which allows for a reduction in both the bias and the variance that affect maximum likelihood estimates of logit models for small samples (Rainey & McCaskey, 2021).

It results that the only independent variable which is statistically significant at the 5% significance level (p-value = .031) is the ratio of fisheries-related FTEs over the population of the FLAG territory. As expected, an increase in the frequency of local workers employed in Fishing/Aquaculture/Processing sectors is estimated to lead to a higher chance of a strong presence of sectoral priorities in the FLAG strategy. None of the other variables seem able to predict the sectoral/territorial dimension of FLAGs in the selected countries of the Mediterranean Sea.

4. Discussion

Results from the literature review have stressed the role that FLAGs could play in the development of successful maritime clusters according to the Porter's Diamond Model. In particular, it seems that scientific contributions on FLAGs have highlighted the importance of these partnerships in the establishment of linkages and collaborations between the fishing sector and other industries and services of the Blue Economy in the area where the FLAG operates. According to Article 3 of the EMFF Regulation, such a territory should be "an area with a sea, river or lake shore, including ponds or a river basin, with a significant level of employment in fisheries or aquaculture, that is functionally coherent in geographical, economic and social terms and is designated as such by a Member State". Considering that the additional selection criteria that Member States have adopted in their operational programmes tend to require some local characteristics of economic disadvantage with respect to the rest of the regional territory, FLAGs have the potential to provide for diversification opportu-

nities in fisheries-dependent communities with declining socio-economic conditions.[3]

Connecting the previous results from the two research questions, it can be said that there is an evident contrast between the role of FLAGs that has been most commonly emphasized in scientific articles and the actions that these organizations have prioritized during the 2014-2020 programming period. If on the one hand territorial actions are the ones that received most of the attention in the literature (as demonstrated by the interest on themes like environmental protection, community empowerment and fishing tourism), on the other it is clear that FLAGs have prioritized projects of sectorial scope. Nevertheless, as already stressed by Miret-Pastor *et al.* (2020), this type of analysis is limited by the fact that the interpretation of the definitions of the five objectives of Article 63 of the EMFF tends to vary among countries, hence FLAGs from different Member States may declare diverse UP 4 objectives for projects that are actually similar in their scope.

It is argued that further attempts to analyze FLAGs' activities and organization should take into account the relevance of the Blue Economy in the territories under investigation. In this regard, the last EU Blue Economy Report (European Commission, 2021) includes detailed socio-economic data describing the evolution of its established sectors (Marine living resources, Marine non-living resources, Marine renewable energy, Port activities, Shipbuilding and repair, Maritime transport and Coastal tourism). Explaining the development strategies that FLAGs from different countries have established should probably take into consideration also the long-term dynamics within the sectors of the Blue Economy. For instance, combining data on local opportunities for diversification (especially in the tourism sector) with the information on the FLAGs' composition and development strategies may help explain the partnerships' prioritization of either territorial or sectorial interests. This suggests the validity of the cluster approach to the study of maritime communities due to its inclusion of several dimensions that may affect the competitiveness of the local economy where the FLAG intervenes.

5. Conclusions

The present paper provides for a literature review of those scientific articles that have analyzed the role of FLAGs for the sustainable development of coastal communities. It has been attempted to organize the main findings from the literature according to the six dimensions of the Porter's Diamond, thus interpreting the FLAG as a factor that can contribute to the emergence of successful maritime clusters in the European Union. Although in the literature it is possible to find examples covering all the dimensions of the diamond, issues related to the ability of FLAGs to establish links with other industries and services of the costal economy (in particular the tourism sector) received special attention. Overall, most of the articles tend to focus on the territorial dimension of FLAGs, hence stressing the four non-sectoral objectives that FLAGs can receive support for according to Article 63 of the EMFF on the implementation of CLLD strategies. However, when looking at the priorities declared at the beginning of the 2014-2020 programming period by FLAGs belonging to the Mediterranean basin from Italy, Spain and France, it results that sectoral interventions connected to the theme "Adding value to fisheries" were given precedence. In order to link the choice over sectorial or territorial functions with the characteristics of the FLAGs from the three selected countries, data provided by the FLAGs' factsheets from

[3] As an example, the Italian operational programme for the programming period 2014-2020 (Mipaaf, 2015) requires fisheries and aquaculture areas to present at least one of the following socio-economic attributes to be eligible for CLLD funding: *i*) a reduction in the fishing fleet of more than 10% in relation to the value in 2007, in terms of either gross tonnage or engine power and/or a reduction in the value of production of more than 10% in relation to the value of 2007, *ii*) population density equal to or lower than the regional average, *iii*) unemployment rate equal to or higher than the regional average.

FARNET were used to explain the preference towards sectoral interventions. In this regard, the relevance of employment in fisheries-related sectors in the territory where the FLAG operates seems to be the only significant variable positively affecting the prioritization of sectoral activities. Further research may address this point by extending this type of analysis to other countries of the Mediterranean or the European Union. Considering that Member States are currently facing the challenge of translating the new EMFAF regulation into their national operational programmes, predicting the likely allocation of funds for which FLAGs will receive support (now under Priority 3, "Enabling a sustainable blue economy in coastal, island and inland areas, and fostering the development of fishing and aquaculture communities") may translate into a more effective application of CLLD in European maritime regions. To conclude, it can be claimed that the bottom-up approach to territorial governance through FLAGs represents an important contribution to the endogenous development of coastal regions in the European Union, but the effectiveness of these partnerships is highly dependent on the context where the FLAG operates. The use of the Porter's Diamond to guide the definition of local development strategies may thus constitute a valuable tool at FLAGs' disposal. Nevertheless, improving the coordination between the private and public sectors and strengthening the role of local partnerships in terms of operational planning represent two significant points to be addressed in order to fully capitalize on the socio-economic and environmental potential of coastal communities. The renewed support aimed the sustainable development of maritime regions expressed by the EMFAF and the other European Funds can promote this transition.

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Caractérisation des exploitations agriculture-élevage et origine de l'innovation dans les principaux bassins laitiers de l'Algérie

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Abstract

The study focuses on dairy cattle farming systems and the sources of innovation for breeders in the Setif and Souk-Ahras dairy basins recognized by cereals, dairy cattle breeding and irrigated crops. A sample of 140 family farms was selected and surveyed between 2017 and 2018. A typology of livestock systems was constructed using of a PCA and AHC. The results show three groups. G1 retains 68% of breeders with small farms, combining polyculture with dairy cattle breeding; G2, 30% of breeders, the farm is medium-sized and the productive orientation is mixed farming and dairy cattle breeding; G3, made up of large grain farmers and mixed cattle breeders (milk/meat). The cattle breeds exploited are Red Holstein and Montbeliard, 74% dominant. The origin of innovation relating to breeding practices comes mainly from local sociotechnical networks, whereas formal extension by public services is ineffective (0.64%). It appears that group1 occupies the first position in terms of acquiring information on innovations, followed by G2 and 3. Socio-technical networks operate from 27 to 33% in the 3 groups. The veterinarian contributes 25% in G1 and 2; at 41% in G3.

***Keywords**: Family farm, Agricultural-livestock production system, Technical advisor, Innovations, Algeria.*

1. Introduction

Les systèmes intégrés agriculture-élevage existent depuis 8 à 10 millénaires et sont souvent considérés comme un moyen prometteur pour résoudre les problèmes de durabilité des systèmes de production agricole. De nombreux auteurs affirment que les synergies entre les cultures et le bétail peuvent améliorer le cycle des nutriments et la fourniture de services éco systémiques dans les systèmes agraires. Ces auteurs ont analysé les effets des interactions à la ferme et ont affirmé l'avantage potentiel de développer les interactions cultures-élevage à l'échelle du territoire. Néanmoins, le potentiel et les avantages du développement de synergies au-delà de l'exploitation n'ont pas été clairement identifiés (Moraine *et al.*, 2017). Le système mixte élevage-agriculture, dans les petites exploitations, est le modèle dominant dans les pays du sud (Rangel *et al.*, 2020), mais sa diversité et hétérogénéité à l'échelle des systèmes de production et d'élevage constitue un

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facteur d'adaptation des exploitations agricoles à leur environnement et aux ressources disponibles (Lemaire *et al.*, 2014). Néanmoins, il semble globalement que la spécialisation est plus durable que la diversification, puisque les exploitations agricoles spécialisées obtiennent de meilleures résultats (Attia *et al.*, 2021).

En Algérie, comme dans les autres pays du sud, la diversité des systèmes dans la zone semi-aride est une organisation et adaptation de la production aux conditions physiques, climatiques et aux facteurs structurels des exploitations agricoles, qui sont plus limitant dans nos conditions que dans les pays du Nord. La diversité semble constituer ainsi une forme résiliente face aux contraintes de l'exploitation agricole dans des contextes de production hétérogènes. Bien qu'au sein des systèmes mixtes les facteurs fondamentaux de leur résilience soient connus, les facteurs qui conditionnent la diversité des niveaux de performances et d'efficience sont encore peu identifiés. Des études dans les régions semi-aride de l'Algérie montrent la diversification des activités agricoles, caractérisée par une production céréalière aléatoire, un élevage bovin de races exogènes et des cultures en irrigué (Djenane, 1997; Madani *et al.*, 2002; Benniou, 2008).

Notre hypothèse postule que parmi les facteurs qui sont à l'origine du changement au sein des systèmes de décision des agriculteurs-éleveurs, le type d'innovation et son origine constituent des éléments clé et méritent d'être analysés pour pouvoir orienter le conseil technique et les politiques de développement. En effet, à travers la compréhension et l'analyse des pratiques et des objectifs des éleveurs avec l'identification et l'analyse de leurs systèmes de production, un conseil plus adapté et pertinent peut-être produit par le conseiller technique.

Pour répondre à notre hypothèse nous avons pris l'exemple de la filière lait en Algérie, nous nous sommes focalisés sur la diversité du fonctionnement des systèmes intégrés agriculture-élevage et la source des innovations adoptées par les éleveurs dans deux bassins laitiers potentiels.

L'innovation est définie comme étant l'ensemble des activités et des processus associés à la production, à la distribution de produits, à l'adaptation et à l'utilisation de connaissances techniques et institutionnelles-organisationnelles (Albarrán-Portillo, 2015). García-Martínez *et al.* (2016) indiquent qu'elle constitue un système intégré pour améliorer la productivité agricole et la résilience des agroécosystèmes, impliquant les différents composants de la gestion dans une relation synergique. Il s'agit d'un outil qui augmente la compétitivité, la viabilité et l'efficacité des exploitations agricoles. Traoré *et al.* (2020) estiment que les innovations en agriculture se caractérisent par une grande variété de technologies, de pratiques agricoles, de systèmes d'organisation et de gestion. Le choix de celles-ci et leurs effets sur la production constituent des enjeux clés pour favoriser le développement de l'élevage et l'augmentation de la compétitivité des petites exploitations agricoles (Toro-Mujica, 2011; Cuevas-Reyes *et al.*, 2013; Espinosa-García *et al.*, 2015 ; García *et al.*, 2016). Savoir comment une innovation a été générée et diffusée auprès des agriculteurs est reconnu comme un facteur clé de son succès ou de son échec (De Pablos Heredero *et al.*, 2015; García-Martínez *et al.*, 2016). Les agriculteurs évaluent avec leurs propres critères son intérêt lorsqu'elle est exogène. Les ressources dont ils disposent déterminent leurs capacités à mettre en œuvre les changements nécessaires à une innovation. La motivation à changer est déterminante ainsi que l'influence de l'environnement et les capacités des agriculteurs à innover (Faure *et al.*, 2018). Selon Chiappini *et al.* (2015), l'innovation tend à intégrer les différentes dimensions liées à la durabilité économique, technologique, sociale et culturelle. L'innovation est qualifiée par 'accotée' lorsqu'elle est soutenue par les politiques de développement rural. Ils soulignent que, lors de l'introduction des innovations dans les exploitations agricoles, une anomalie dans la gouvernance rurale se manifeste par indifférence territoriale. Les approches politiques ascendantes sont proposées pour le développement local où la responsabilité du développement territorial est confiée aux acteurs locaux (Amin et Thrift, 1994, cité par Chiappini *et al.*, 2015).

Les innovations retenues pour répondre à notre hypothèse concernent uniquement les innovations relatives aux techniques de l'élevage ayant trait à l'alimentation, la reproduction, la gestion du troupeau, l'hygiène et la prophylaxie.

Durant plusieurs décennies, les dispositifs

et programmes de développement engagés par l'Etat algérien pour une filière lait locale dynamique, incitent particulièrement à développer l'élevage bovin laitier. L'importation de matériel animal à haut potentiel génétique, en provenance d'Europe principalement, a été clairement privilégiée, pour améliorer le rendement technique de l'élevage laitier. Or cette option n'implique pas forcément qu'il s'agit de produire à niveau comparable de ceux des pays exportateurs, disposant de ressources alimentaires suffisantes et de qualité, pratiquant des systèmes spécialisés, disposant de maitrise et d'appui techniques.

D'ici 2050, à travers le monde, on s'attend à un doublement des demandes en denrées alimentaires et ces demandes ne pourront être satisfaites que si les petits exploitants contribuent à l'augmentation de la production (FAO, 2011). L'agriculture familiale à petite échelle a une fonction en termes de sécurité alimentaire, biodiversité et conservation des ressources. Elle contribue à la préservation de l'emploi et des revenus de la population rurale, à l'utilisation des terres, à la planification et la conservation des zones rurales et des savoirs locaux (Bessaoud *et al.*, 2017). En Algérie, sur les cinq décennies écoulées visant l'augmentation de la production de lait cru, la promotion de la collecte du lait et la construction de mini laiteries, ont permis d'atteindre des performances qui varient entre 2500 et 3500kg sur des potentialités laitières de 7000kg et plus par vache/lactation. La production quotidienne de lait dans les élevages mixtes varie entre 15 et 25kg par vache à Souk-Ahras et entre 15 et 35kg par vache à Sétif (MADR, 2017). Il y a lieu de dire que ce niveau de production laitière et sa diversité est liée non seulement à un déficit fourrager, mais exprime aussi, une diversité de systèmes de production agro-pastoraux plus orientés vers la valorisation des coproduits des céréales que vers l'optimisation du potentiel de l'animal. Par conséquent, comme les agents de développement sont peu outillés face à ce type de systèmes, l'amélioration de la productivité des élevages ainsi que la mise en place d'un appui technique, sont encore peu conformes avec les attentes des éleveurs.

Les programmes de sensibilisation, d'appui et de formation au profit des acteurs dans les techniques de productions, de gestion adaptée aux systèmes spécifiques et la notion de durabilité dans la préservation des ressources naturelles sont absents. Ce qui fait, que les éleveurs se basent pour les techniques de gestion sur leurs conditions socio-économiques et leurs savoirs faire, sans percevoir l'utilité des séances de vulgarisations et de formations organisées par les institutions techniques et de développement étatiques.

Le manque de participation des acteurs par les institutions techniques, de développement, de recherche et de formation étatique est flagrant, lors de l'élaboration des programmes de vulgarisation et de formation. En sus, de l'absence totale d'un feed-back.

2. Méthodologie

2.1. *Caractéristiques de la zone d'étude*

Les bassins laitiers sont situés au cœur des hautes plaines céréalières du Nord-Est de l'Algérie, à climat semi-aride, qui représente la majeure partie du territoire de l'élevage bovin laitier. Ils regroupent 52000 et 77000 vaches laitières respectivement à Souk-Ahras et à Sétif (MADR, 2016). Les deux bassins participent à 17% dans la collecte de lait à l'échelle nationale. Ils se distinguent par une diversité de systèmes de productions organisés sur des étages bioclimatiques subhumides au nord et semi-arides au sud. Les conditions agro-climatiques sont assez proches. L'association céréaliculture-élevage est prédominante dans les exploitations agricoles. Les races Holstein et Montbéliarde sont dominantes à 74%. L'accès aux facteurs de production est comparable.

2.2. *Méthode*

Le questionnaire de l'étude est structuré en deux sections. La première section est destinée aux éleveurs et la deuxième section est assignée aux conseillers techniques des services vulgarisation étatique. Le questionnaire des éleveurs comprend quatre grands axes : 1) Information globale sur l'exploitation agricole : structure, système d'élevage et de culture, équipements de production, données techniques, relations avec l'environnement ; 2) Identification de l'éleveur ; 3) Profil de gestion de l'éleveur ; 4) Utilisation,

appréciation et origine du conseil agricole en vulgarisation formelle et informelle sur les innovations retenues concernant les quatre principaux domaines techniques de l'élevage: alimentation, reproduction, gestion du troupeau, hygiène et prophylaxie.

Des entretiens exploratoires auprès de 10 exploitations agricoles, prises au hasard, ont été accomplis en 2016 afin de tester le questionnaire. La pré-enquête nous a permis de corriger, d'amender et de valider le questionnaire de l'étude.

L'étude a été réalisée entre 2017 et 2018, à travers une enquête, auprès d'un échantillon de 140 exploitations agricoles. Le choix des exploitations agricoles retenues repose sur les critères suivants : 1) Des élevages disposant de 6 vaches laitières et plus, d'un agrément sanitaire, d'une carte professionnelle d'agriculteur et adhérant au réseau de collecte de lait de la région ; 2) L'accord de l'éleveur pour réaliser l'enquête. La méthode d'échantillonnage est aléatoire systématique : 1) La liste des éleveurs à enquêter est disponible ; 2) Ils sont choisis selon le nombre de personnes devant être sélectionnées avec un 'pas' de sondage de 5 ; 140 individus ont été retenus sur les 700 de la liste. Nous avons prélevé 68 exploitations agricoles à Sétif et 72 exploitations agricoles à Souk-Ahras. L'échantillon est jugé représentatif car toutes les personnes avaient une chance égale d'être sélectionnées. Les informations collectées sont analysées dans la même base de données à l'aide du logiciel LeSphinxIQ2 2017Version7.3.2.3.

3. Résultats

3.1. *Le facteur humain*

L'âge du chef de l'exploitation agricole varie entre 23 et 77 ans, dont 52% étaient âgés de moins de 45 ans. Cela indique une prédisposition des jeunes à prendre la relève et adopter le métier d'éleveur. La strate d'âge de 45 à 62 ans gère 33% des exploitations agricoles. Cela préfigure l'importance du facteur âge dans les approches susceptibles d'être développées en matière de conseil agricole. Les éleveurs âgés de plus de 63 ans représentent 15%. Les éleveurs instruits forment 72%. Le niveau d'instruction a une incidence sur la facilité de l'entretien et la concertation entre éleveurs et techniciens pour innover. Il influence aussi le degré d'acceptation du conseil agricole.

L'ancienneté dans la profession qui exprime l'importance de la dimension de l'héritage socioculturel, est dominante : 34% des éleveurs exercent depuis 26 ans et plus, 29% étaient en métier depuis 11 à 25 ans et 37% depuis 5 à 10 ans. Les enquêtés perçoivent l'élevage comme une profession lucrative à 95%. Il s'agit aussi d'un héritage familial à perpétuer en assumant sa prise en charge pour 49%, alors que 92% sont aussi des fils d'éleveurs. Le poids de l'héritage socioculturel dans le transfert du métier de père en fils est affirmé. L'élevage constitue la première source de revenus pour 74% des éleveurs qui le pratiquent à plein temps, ce qui situe l'importance de l'élevage bovin laitier dans l'économie de l'exploitation agricole. L'élevage est la seconde source de revenus pour 26%, après la céréaliculture, 33% ont un commerce comme activité extra agricole et 86% préservent l'élevage bovin laitier avec une relève encadrée.

3.2. *Le foncier et son affectation*

Les exploitations agricoles exploitent 73% de la surface agricole utile totale pour pratiquer la céréaliculture, les cultures maraichères et l'arboriculture. On distingue trois catégories d'exploitations agricoles selon la surface fourragère principale (SFP). La première catégorie est constituée de 68% d'exploitations agricoles, disposant de moins de 3ha de SFP (20% de la SAU), et un rendement moyen de 47Qx/an. La deuxième catégorie regroupe 30% d'exploitations agricoles possédant moins de 10ha de SFP (27% de la SAU), dont le rendement moyen est de 152Qx/an. La troisième catégorie est composée de 2% d'exploitations agricoles. Celle-ci réserve 46% de la SAU aux fourrages avec un rendement moyen de 467Qx/an.

3.3. *Typologie des exploitations agricoles*

Le pouvoir discriminant de la typologie est de 89% pour l'Analyse en Composante Principale et la Classification Hiérarchique Ascendante. La valeur moyenne de l'Alpha de Cronbach est de 0.87 et l'inertie est de 4,72.

Tableau 1 - Détail des classes.

Groupe	*1 (95) 67.86%*	*2 (42) 30%*	*3 (3) 2.14%*	*Total (140) 100%*
SAU (ha)	14.78	34.02	102.33	22.43
SFP (ha)	2.93	9.21	46.67	5.75
SFI (ha)	1.81	6.02	26.67	3.61
Matière fraiche estimée (qx)	47.17	152.14	466.67	87.65
Effectif BVL (têtes)	13.41	23.76	87.67	18.11
Effectif VL (têtes)	8.83	16.55	68.67	12.43
Chargement	3.11	4.20	0.58	3.38
Effectif Génisses (têtes)	1.83	4.05	17.00	2.82
Age à la réforme (an)	5.81	5.48	5.33	5.70
Red-Holstein (têtes)	3.66	8.71	40.00	5.96
Prim' Holstein (têtes)	1.04	2.50	0.00	1.46
Montbéliarde (têtes)	3.07	4.36	20.67	3.84
Nombre de traite-J	1.79	1.98	2.00	1.85
PL-Tech-Kg-VL-J	18.39	26.62	41.67	21.36
Rendement-VL-An-Kg	4756.37	6630.95	10733.33	5446.82

Groupe 1 : les exploitations agricoles de petite taille associant les cultures à la production de lait : ce système représente 68% d'exploitations agricole, et est caractérisé par une période de lactation de 250J/vache/lactation et 2 génisses de renouvellement. Un complément de revenu est issu des activités extra agricoles pour 33% des exploitants. La surface fourragère irriguée (SFI) est de 1,81ha, soit 62% de la SFP pour nourrir 9 vaches laitières. La charge animale est élevée, soit 3,11UGB/ha de SFP. La production laitière moyenne est de 18.39kg/vache/J (Tableau 1). La traite est mécanique à l'aide d'un chariot trayeur chez 60% des exploitations agricoles, alors que 40% traient manuellement. Seuls 6% des exploitations possèdent une cuve de réfrigération. Le cheptel est conduit en stabulation entravée. Les vaches laitières sont en atelier pour 34% des élevages avec une salle de vêlage aménagée. Les veaux sont placés en nurserie dans 13% des élevages. Un manque en équipement agricole est remarqué. Un matériel d'irrigation est disponible chez 3%, une récolteuse de fourrages chez 4% et un tracteur chez 1%.

Groupe 2 : les exploitations agricoles de taille moyenne combinant les cultures à une production laitière : ce type regroupe 30% d'exploitations agricoles ; ce groupe est caractérisé par une période de lactation de 250 à 305 J/vache/lactation et 4 génisses. La SFI est de 6ha (60% de la SFP) avec 4,2UGB/ha de SFP. On compte 17 vaches laitières par exploitation produisant 27kg de lait/vache/J (Tableau 1). La traite est mécanique par chariot trayeur. Le lait est stocké en cuve de réfrigération. 48% des troupeaux est en stabulation entravée alors que 52% du cheptel est libre. Les vaches laitières sont en atelier avec une salle de vêlage et les veaux sont placés en nurserie. L'équipement agricole disponible est constitué de tracteurs, de matériel d'irrigation et de récolteuse de fourrages. Une ration alimentaire pour vaches laitières est préparée au niveau de 6% d'exploitations.

Groupe 3 : les exploitations agricoles diversifiées de grande taille : présent chez 2% d'exploitations associant élevage et culture et atelier bovin mixte (lait/viande) ; ce type est caractérisé par une période de lactation de 305J/vache/lactation et 17génisses. La SFI est de 27 ha (57% de la SFP) et une charge de 0,58UGB/ha de SFP. Les troupeaux regroupent 69 vaches laitières produisant 42kg/vache/J (Tableau 1). La traite est pratiquée par chariot trayeur et le lait est stocké en cuve de réfrigération. Le cheptel est libre et dispose d'aire d'exercice. Les vaches laitières sont conduites en atelier. Les veaux sont élevés en nurserie suivi de leur engraissement dans l'exploitation agricole. Les tracteurs, les équipements d'irrigation, de récolte/conser-

Tableau 2a - Acquisition de l'information sur les innovations.

Innovations	*Acquisition de l'information en %*			
	*Conseiller**	*Vétérinaire*	*Père*	*Eleveur*
Alimentation				
Rationnement	2,9	9,2	25	90
Aliment concentré et sous-produits	2,1	7,1	25	85,7
Assolement fourrager	5,7	0	12,9	60
Calendrier fourrager	0,7	0	1,4	2,1
Calcul du bilan fourrager	0,7	0	0	2,1
Ensilage	1,4	2,9	20,7	63,6
Pierre à lécher (CMV)	4,3	22,2	2,9	50,7
Abreuvement libre	0	6,4	35,7	43,6
Reproduction				
Insémination artificielle	0	92,1	0	5
Surveillance des chaleurs	0	89,3	3,6	17,9
Synchronisation des chaleurs	0	72,8	0	10,7
Diagnostic de gestation	0	90	0,7	12,1
Tarissement	0	37,1	42,1	35
Contrôle et maîtrise de vêlage	0	62,1	15	44,3
Planning d'étable	0,7	5	0	2,9
Bilan de fécondité	0,7	5	0	2,1
Gestion du troupeau				
Identification des animaux	0	100	0	0
Réforme de VL	0	56,5	28,6	48,6
Choix des génisses de renouvellement	0	29,3	30	67,1
Choix des reproducteurs	0	3,6	28,6	81,4
Outils d'enregistrement	0,7	57,1	0	12,9
Hygiène et prophylaxie				
Hygiène des bâtiments d'élevage	0	79,3	12,9	50,7
Hygiène de traite	0	42,9	22,9	67,9
Hygiène des mamelles	0	53,6	25,7	55,7
Hygiène du matériel de traite	0	47,9	29,3	57,9

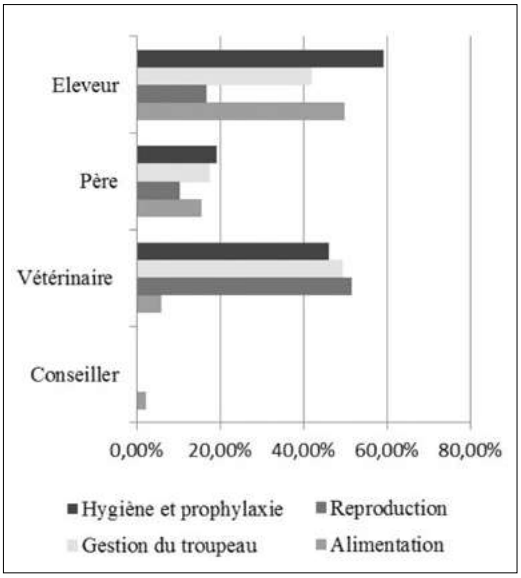
** Conseiller technique en vulgarisation agricole des services de l'Etat.*
La réponse à la question posée est à choix multiple.

vation de fourrages et de préparation de ration pour vaches laitières sont disponibles.

3.4. *Diffusion de l'innovation*

Les investigations préalables nous ont permis de cerner l'origine de l'innovation dans les élevages. Nous avons retenu les modalités suivantes : le conseiller technique des services publics, pour sa mission officielle et son rôle dans le conseil aux exploitations agricoles; le vétérinaire comme une source potentielle d'interaction permanente avec les éleveurs; et l'ensemble des individus non reconnus par le système de vulgarisation formel, mais qui constituent un réseau sociotechnique d'échange de l'information tech-

Figure 1 - Transfert du savoir et savoir-faire relatifs aux innovations.



nique, tels que le père et les éleveurs du même territoire et du réseau de connaissances locales (Tableau 2a). Il ressort que le service public est inopérant (0,64%). La vulgarisation informelle, par les réseaux techniques de proximité, l'éleveur voisin ou ami, interviennent majoritairement dans le transfert du savoir et savoir-faire relatifs aux pratiques d'élevage ; leur part constitue 58% en hygiène et prophylaxie, 50% en alimentation, 42% en gestion du troupeau et 16% en reproduction. Le père, assiste sa relève dans 8 à 23% des cas. Le vétérinaire collabore en reproduction chez 57%, en hygiène et prophylaxie chez 56%, en gestion du troupeau chez 49% et en alimentation chez 6% (Tableau 2a et Figure 1).

Pour l'acquisition de l'information, les grands agriculteurs-éleveurs du G3 ont recours à 72% aux organisations professionnelles et aux coopératives agricoles, à 67% au vétérinaire et à 43% au réseau sociotechnique pour l'alimentation. Le vétérinaire intervient à 50% en reproduction, chez 27% en gestion du troupeau et chez 20% en hygiène et prophylaxie (Tableau 2b, Figure 2).

Les agriculteurs-éleveurs moyens du G2 acquièrent l'information pour l'alimentation du vétérinaire à 43%, du réseau sociotechnique à 39%, des organisations professionnelles et coopératives agricoles à 32%. Le vétérinaire contribue à 26% dans la gestion du troupeau et à 23% dans l'hygiène et la prophylaxie. La part du réseau sociotechnique dans l'hygiène et la prophylaxie est de 34% et de 21% pour la gestion du troupeau. Les organisations professionnelles et coopératives agricoles participent à 50% en hygiène et prophylaxie, 32% en alimentation, 30%

Tableau 2b - Acquisition de l'information sur les innovations par type d'exploitation.

Innovations %	*Alimentation*	*Reproduction*	*Gestion du troupeau*	*Hygiène-prophylaxie*
Groupe 1				
Vétérinaire	5	11	3	24
Père	11	13	13	10
Eleveur	38	29	20	34
Autres sources	31	49	50	40
Groupe 2				
Vétérinaire	43	5	26	23
Père	14	6	8	7
Eleveur	39	14	21	34
Autres sources	32	24	30	50
Groupe 3				
Vétérinaire	67	50	27	20
Père	0	0	7	2
Eleveur	43	0	23	33
Autres sources	72	15	0	0

Autres sources : Organisations professionnelles (OP), Coopératives agricoles (CA).

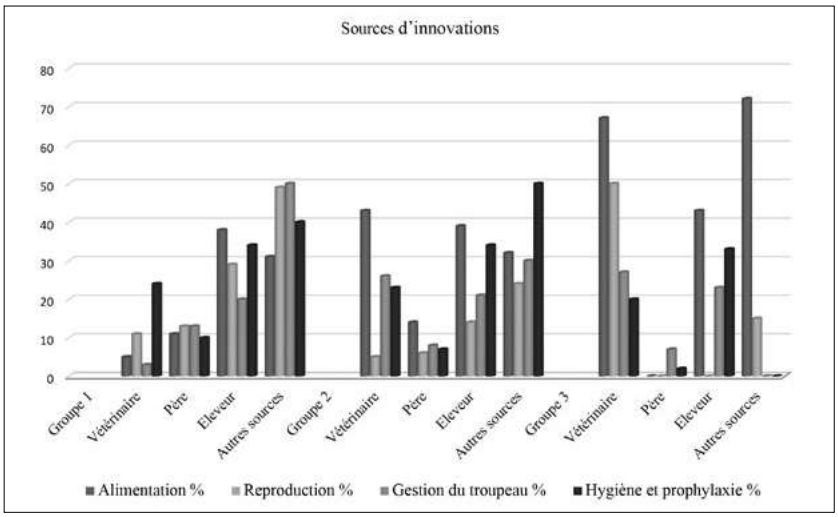


Figure 2 - Source d'innovations par groupe d'éleveurs.

en gestion du troupeau et 24% en reproduction (Tableau 2b, Figure 2).

Les petits agriculteurs-éleveurs du G1 ont davantage recourent aux organisations professionnelles et coopératives agricoles pour la gestion du troupeau (50%), la reproduction à 40% et l'alimentation à 31%. Puis le réseau sociotechnique participe pour l'alimentation à 38%, l'hygiène et prophylaxie à 34%, la reproduction à 29% et la gestion du troupeau à 20% (Tableau 2b, Figure 2).

4. Discussion

4.1. *La contrainte du foncier agricole : dominance de la petite exploitation*

Dans les trois systèmes identifiés, l'élevage bovin est associé à l'agriculture et, dès que c'est possible, à d'autres spéculations animales. Ils expriment la palette des situations possibles de mise en place d'un atelier bovin laitier dans les territoires semi arides céréaliers. La présente typologie confirme une tendance lourde et générale, celle de l'orientation mixte de l'exploitation agricole, quelle que soit sa taille. Les exploitations de petites tailles sont dominantes à 68%. Une prépondérance de la culture céréalière est observée, car les prix sont élevés et garantis par l'Etat. La généralisation de l'association céréales-élevage bovin laitier permet à de petites exploitations agricoles de diversifier les productions pour réduire les aléas du climat et du marché, tout en maintenant la fertilité des sols (Coly *et al.*, 2011; Soukaradji *et al.*, 2017). Notre étude confirme une tendance nationale où la petite exploitation de moins de 10 ha domine chez 70% des exploitations agricoles. La catégorie moyenne constitue 25% des exploitations et dispose de 10 à 50 ha de terres agricoles. La catégorie des grandes exploitations (50 ha et plus) est réduite et ne représente que 2% des exploitations agricoles (MADR, 2003). Selon Jamin *et al.* (2007) l'hétérogénéité des exploitations est un obstacle à la modernisation rapide de l'agriculture ; celle-ci est liée aux modes d'accès au foncier, la diversité des ressources du milieu, la différence d'âge et le niveau d'instruction des agriculteurs. Le choix d'intégrer les cultures à l'élevage bovin laitier dénote des stratégies d'adaptation aux contextes de production et à l'environnement socio-économique. Les exploitants ont tendance à cultiver leurs terres en céréales pour dégager du temps à l'activité extra agricole et réaliser un revenu supplémentaire. Nos résultats confirment ceux de Jamin *et al.* (2007) en Afrique de l'Ouest et du Centre, Lawali (2011) au Niger, Akouehou *et al.* (2013) au Benin, Bélières (2014) au Mali et Soukaradji *et al.* (2017) au Niger sur les petits exploitants qui ont recours aux activités extra agricoles. Ce type de stratégie est répandu dans l'ensemble des systèmes mixtes de production agricole en Afrique (Lawali, 2011) et dans le monde (Herrero *et al.*, 2010; Soukaradji *et al.*, 2017).

4.2. *Diversité des systèmes de production*

Dans les trois systèmes identifiés nous avons constaté une corrélation positive entre surface agricole utile, surface fourragère principale, surface fourragère en irriguée, production de fourrage, production de lait et rendement laitier. Les grands exploitants détiennent une superficie sept fois plus importante que celle des petits éleveurs et de trois fois plus que celle des éleveurs moyens. Pour la production fourragère, la différence entre les trois types, est très significative. Le troisième type a un rendement trois fois plus important que celui du deuxième type et dix fois plus que celui du premier type.

La différence est aussi significative pour la production de lait par vache, liée aux inégalités en disponibilités fourragères surtout, en sus, des autres paramètres. Les grandes exploitations agricoles se distinguent par une indépendance en facteurs de production et par une autonomie en couverture des besoins alimentaires des vaches laitières. La FAO (2011), estime que les grands exploitants qui jouissent d'un pouvoir d'achat élevé et d'un capital foncier, sont ouverts aux nouvelles technologies permettant le maintien et l'amélioration de la productivité agricole ; nos résultats confirment ce constat.

Face aux incertitudes du climat, des politiques publiques et des marchés, l'autonomie fourragère constitue la seule alternative pour la viabilité économique et la pérennité des exploitations agricoles (Belland, 2011). Lemaire *et al.* (2014) postulent pour les systèmes intégrés cultures-élevage, comme étant une forme clé d'intensification écologique, indispensable pour parvenir à la sécurité alimentaire future et à la durabilité environnementale. Nos résultats confirment que la diversité des systèmes de production céréales-élevage dans la zone semi-aride de l'Algérie est une forme générale d'organisation unifiée, mais chaque système dispose de sa stratégie particulière; les grandes exploitations agricoles ont plus d'aptitude à diversifier les productions (cultures, élevages et produits de l'élevage), qui leur procure plus d'autonomie alimentaire que les petites exploitations dans un environnement fortement soumis aux aléas climatiques et économiques ; par contre les stratégies globales cherchent dans tous les cas à approfondir l'articulation entre cultures et élevages pour garantir la résilience des systèmes. Le rôle de l'élevage laitier dans ce cas est de garantir des revenus plus réguliers que ceux issues des cultures et de l'élevage à viande, et permet aux petites exploitations d'approvisionner en cash la trésorerie quotidienne de la famille. Sraïri *et al.* (2018) affirment que la disponibilité du foncier et du financement issus de l'élevage permettent de sécuriser l'association céréalicultures-élevage bovin au Maroc.

Nous ajouterons à ces explications en somme techniques que cette situation de coexistence de trois types d'exploitations agricoles, qui est également synonyme de rendements et de productivité différenciés des exploitations, ne mène pas, comme le voudrait la théorie économique, à la suppression pure et simple des exploitations les moins performantes. Alors que cela semble et est effectif dans le milieu industriel, la concurrence ne fonctionne pas linéairement dans le monde agricole. Cela s'explique à notre humble avis par le caractère stratégique de l'activité agricole. Il s'agit d'une activité nourricière, et priver une partie de la population de la nourriture ne répond pas à l'éthique et aux principes fondateurs d'une nation. Or dans les pays du Sud, en Algérie notamment où le déficit alimentaire est structurel, ce sont les pouvoirs publics et non le marché qui maintiennent ces exploitations en vie dans l'espoir d'accroitre la production, donc de réduire la contrainte alimentaire. La situation étant claire pour tous, du moins pour les pouvoirs publics qui sont à charge de la sécurité alimentaire et pour les grands et moyens exploitants qui sont sur le terrain les prétendus garants de cette sécurité alimentaire, c'est à jeu à somme non nulle que ces deux parties semblent se soumettre.

4.3. *Des niveaux de performances hétérogènes*

L'analyse des performances des exploitations agricoles sert à déterminer les plus efficientes et résilientes dans un contexte donné et à indiquer les facteurs à prioriser dans l'amélioration des contextes. La taille des exploitations est souvent citée comme un facteur important des

performances technique et économique. Pour Leblanc (2012) augmenter la taille des fermes laitières est à prioriser pour accroître leurs efficacités ; les petites peuvent être aussi performantes que les grandes. Or le nombre de têtes par exploitation agricole n'est pas le seul indicateur de performances. Aussi, l'alimentation des vaches laitières est souvent citée comme facteur limitant. Les résultats des études, à travers le monde, divergent concernant le type d'alimentation pour des exploitations agricoles performantes (Leblanc, 2012). L'élevage bovin laitier dans les exploitations agriculture-élevage est dépendant du territoire pour son alimentation, particulièrement en fourrages verts. Il ne constitue qu'un atelier de production parmi d'autres, qui sont parfois en concurrence. Les éleveurs adoptent une stratégie d'assolement basée sur l'association des céréales et des fourrages. En milieux semi-arides, la conduite des céréales dépend des stratégies de fonctionnement global de l'exploitation agricole, plus que d'un choix technique spécifique des céréales ; la stratégie la plus rentable est celle permettant la durabilité de l'exploitation en premier lieu (Benniou, 2008). L'alimentation des vaches laitières est basée sur le foin et la distribution annuelle de paille, de concentré et de sous-produits agricoles. Les éleveurs ont ainsi conçu des systèmes d'élevage bovin caractérisés par un niveau de production laitière adapté aux caractéristiques et à la qualité des ressources alimentaires disponibles.

Les systèmes de production bovins mixtes ont été fortement adoptés par les exploitations agricoles dans les zones tropicales d'Amérique centrale et au Sud du Mexique, au Nord du Brésil, y compris la Colombie, le Venezuela, l'Équateur et le Pérou (Rojo *et al.*, 2009; Rangel *et al.*, 2020). Leur flexibilité couplée à la capacité de générer la trésorerie, permet à ce système d'être le plus répandu en Amérique latine, en Afrique et en Méditerranée (Rangel *et al.*, 2020).

Les objectifs du système mixte varient en fonction des préférences de l'agriculteur, la météo, la consommation des ménages, le marché local et la part des revenus générés des ventes de viande et de lait, ce qui permet une grande variété de modèles de production (Urdaneta *et al.*, 2008; Albarrán-Portillo *et al.*, 2015; Rangel *et al.*, 2020). Le modèle d'organisation prédominant de la petite ferme familiale signifie que la gestion est gérée par la famille, qui fournit la principale force de travail (Espinosa-García *et al.*, 2018; Rangel *et al.*, 2020). Les petites exploitations agricoles représentent respectivement 19% et 12% de la production mondiale de viande et de lait (FAO, 2011). Dans notre situation, les petites et moyennes exploitations agricoles affectent la main d'œuvre familiale aux travaux agricoles, ce qui corrobore ces résultats. Les grandes exploitations agricoles, au vu de leur capacité d'autonomie fourragère et de leurs moyens financiers, les éleveurs maintiennent les veaux produits pour l'engraissement afin de tirer profit de la valeur ajoutée liée à l'élevage de jeunes.

4.4. *Une innovation essentiellement issue des réseaux informels*

Plusieurs auteurs affirment que les exploitations des pays développés ont montré un niveau technologique moyen élevé, une faible dépendance aux revenus externes et une faible marginalisation (García *et al.*, 2016; Rangel *et al.*, 2020). Les niveaux élevés d'adoption de la technologie sont associés à une compétitivité, durabilité et viabilité des exploitations (Salas-González *et al.*, 2013; De Pablos Heredero *et al.*, 2015; Rangel *et al.*, 2020). Les résultats réalisés par Ferguson *et al.* (2013) et Rangel *et al.* (2020), stipulent que le niveau d'innovation dépend des flux de connaissances et de la qualité des liens entre producteurs et autres agents de la chaîne de valeur.

Selon l'OCDE, (2011) la plupart des petits exploitants n'ont pas d'assistance technique appropriée pour l'adoption d'innovations (Salas-González *et al.*, 2013). Rangel *et al.* (2020) estiment que les petits exploitants au Mexique reçoivent une très faible assistance technique qui concerne 3 à 10%. Nos résultats montrent un plus faible niveau d'appui technique formel qui touche 0,64% des éleveurs. Valdovinos *et al.* (2015) indiquent que les facteurs financiers internes et externes à l'exploitations agricoles, ainsi qu'un accompagnement du conseiller technique sont indispensables à l'adoption des innovations. Toutefois, même si le conseil en

agriculture représente un levier pour induire le changement, il ne permet pas de faciliter toutes les formes d'innovations et ne facilite pas celles qui demandent de créer de nouvelles relations entre des acteurs hétérogènes, au sein d'une filière ou d'un territoire (Faure *et al.*, 2018).

En Afrique, depuis les années 70, des tentatives d'innovations ont été réalisées en milieu rural pour accroitre la productivité agricole et pallier aux effets des aléas climatiques (FAO, 2011; Traoré *et al.*, 2020). Bien que le potentiel agronomique de ces technologies soit démontré, les taux d'adoption sont faibles (Traoré *et al.*, 2020). Selon le même auteur, la FAO (2010) et FARM (2016) affirment que l'une des raisons principales de la faible adoption des innovations est la contrainte financière. Les faibles revenus des paysans entravent leurs capacités à investir, ce qui limite la productivité des systèmes de culture et les revenus des producteurs (Traoré *et al.*, 2020).

Une gestion économe et autonome des exploitations agricoles garantit une efficacité économique et des revenus décents aux agriculteurs. Elle permet une baisse des charges, une diminution des coûts pour la collectivité tout en valorisant le travail. Elle se fonde sur une équité sociale qui permet de valoriser le travail et les emplois avec un partage équitable des richesses tout en respectant les normes de durabilité agricole (Bouzaida and Doukali, 2019). Différentes études montrent le rôle très important du processus de gestion et de décision au niveau des petites exploitations agricoles, sur leur rentabilité et leur adoption d'innovations. Cependant, ce phénomène est peu évalué, ses effets sont multifactoriels et hiérarchiques. Cette situation rend difficile le développement de modèles statistiques permettant d'analyser l'arbre à problèmes (Solano *et al.*, 2006; Rivas *et al.*, 2014; Cuevas-Reyes *et al.*, 2013; Torres *et al.*, 2015; García-Martínez *et al.*, 2016).

L'innovation est surtout recherchée par les acteurs de la filière lait et non par l'Etat. Certaines innovations sont fréquemment adoptées. Il s'agit pour l'alimentation du rationnement, du concentré, des sous-produits, de l'assolement fourrager, de l'ensilage et du complexe minéraux-vitamines. Pour la reproduction, il s'agit de l'insémination artificielle, de la surveillance et la synchronisation des chaleurs, du diagnostic de gestation, du tarissement, du contrôle et la maitrise de vêlage. Pour la gestion du troupeau, il s'agit de l'identification des animaux, de la réforme de vaches laitières, du choix des génisses de renouvellement et des reproducteurs avec les outils d'enregistrement. Pour l'hygiène et la prophylaxie, il s'agit de l'hygiène des bâtiments d'élevage, des mamelles, de la traite et de son matériel (Tableau 2a). Les outils de gestion de l'alimentation et de la reproduction ne sont pas adoptés.

Il paraît que les petits éleveurs sollicitent les organisations professionnelles et les coopératives agricoles pour la gestion du troupeau, la reproduction, l'hygiène-prophylaxie et le réseau sociotechnique pour l'alimentation. Les prestations de services sont gratuites. Les éleveurs moyens ont surtout recours aux organisations professionnelles et coopératives agricoles pour l'hygiène-prophylaxie, au vétérinaire et au réseau sociotechnique pour l'alimentation. Les grands éleveurs ont essentiellement recours au vétérinaire, organisation professionnelle et coopérative agricole pour l'alimentation et au vétérinaire pour la reproduction. Les prestations de services du vétérinaire sont payantes. Cela réaffirme le constat de la contrainte financière face à l'adoption des innovations.

5. Conclusion

Notre analyse prend appui sur un travail empirique circonscrit sur deux bassins laitiers de l'Algérie, Sétif et Souk-Ahras, mais transposable et adapté à la situation de l'Algérie. Les agriculteurs-éleveurs sont confrontés à un faible appui des institutions techniques et des services de vulgarisation étatique, mais aussi, à un accès difficile au financement et une filière lait qui ne contribue pas à diminuer le niveau de risque. Les éleveurs éprouvent de grandes difficultés à prévoir le futur et à se projeter dans l'avenir. Ils disposent de faibles marges de manœuvres par insuffisance du foncier agricole, de force de travail et de financement.

La situation actuelle des exploitations agricoles ne permet pas de nous renseigner suffisamment sur les objectifs des éleveurs. L'évolution

du passé des exploitations n'est pas assez connue et nous ne pouvant pas déterminer clairement, le cycle de vie et les trajectoires d'adaptation de celles-ci, pour maintenir leurs productions et faire face aux contraintes intra et extra exploitation. L'approche globale de la stratégie de production et l'usage des ressources nous semble plus efficient pour améliorer la production et la durabilité des exploitations agricoles.

Nous constatons que les organisations professionnelles et les coopératives agricoles sont assez impliquées dans le transfert des innovations auprès des éleveurs. Cela constitue l'adoption d'un nouveau mode de coopération et d'entente entre les acteurs pour défendre leurs intérêts. Les sources d'information sur les innovations sont diversifiées selon le type d'exploitation et la nature du conseil technique, ce qui incite à mieux redéfinir la conception des stratégies futures d'organisation du conseil pour le rendre plus efficace.

Les innovations adoptées par les exploitations agricoles œuvrent dans des territoires ruraux, en absence de gouvernance. Nous avons vérifié l'introduction de nouvelles techniques en pratiques d'élevage, en absence de soutien financier par les politiques de développement rurale. Donc, nous devons réfléchir à une gouvernance rurale adéquate au contexte locale dans les futurs plans de développement rural. Ceci dit aussi, un appui aux innovations par une décision politique de soutien ; avec une sensibilisation, participation et responsabilisation de la communauté rurale. Ainsi, nous agissons sur les exploitations agricoles dans leur territoire pour un développement rural.

Les agriculteurs justifient l'insuffisance de leur production par la faiblesse des moyens qui leurs sont octroyés et réclament plus de subventions, l'Etat essaye de desserrer l'étau en élargissant la base productive en promouvant à chaque fois de nouveaux, souvent de petits agriculteurs et même parfois de gros investisseurs qui, malheureusement, n'ont pas encore un effet de coupure avec la situation de déficit qui perdure depuis plusieurs décennies.

Les gros exploitants sont le véritable moteur de la régulation du système de subventions mis en place. Conscients de la rareté de la ressource, notamment foncière et mus par la maximisation de leurs revenus, les néo-investisseurs interviennent sur ce système en changeant à leur gré les variables, dont eux seuls, ont le contrôle : réduire l'effectif du cheptel, changer les assolements, approvisionner le marché informel, etc. Or, chacune de ces variables peut avoir un effet immédiat sur le fonctionnement du système d'ensemble. C'est autant dire que, le terme stratégie n'a pas le même sens pour tous les acteurs intervenant pourtant dans le même champ d'activité et c'est dire également, qu'un système ne peut être stable, que s'il est bâti sur des engagements durables, c'est-à-dire, porté par des acteurs d'égales forces.

Malgré les contraintes rencontrées et certaines limites de l'étude, les concepts d'innovation et d'aide à la décision demeurent nouveaux ; et les enquêtes ont permis une sensibilisation préliminaire des agriculteurs-éleveurs à ces notions. Nous sommes convaincus que, les résultats de notre travail, ne constituent qu'un début d'un long et difficile chemin à entreprendre pour l'implication du conseiller technique des services de vulgarisation de l'Etat dans le processus d'adoption des innovations et d'aide à la décision des agriculteurs-éleveurs dans la gestion des exploitations agricoles.

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Rain-fed agriculture risks and management strategies adopted by farmers in two agro-ecological zones in Al-Hasakeh province of Syria

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Abstract

Based on survey data of 319 rain-fed farmers in Al-Hasakeh, Syria, this study analyses rain-fed farmers' risk attitudes and farmers' perceptions of risk and risk management. Furthermore, it analyzes, using multiple regression analysis, the relationship between socio-economic characteristics and farmers' risk attitudes. The results demonstrate that precipitation shortage was the most important risk source that threaten farmers in both zones. Moreover, risks of diseases and pests and natural disasters were highly perceived by farmers in zone 1. Farmers in zone 2 were more concerned about fire damages and lack of government support. The financial strategy related to the producing at lowest possible cost is perceived as an important strategy to manage risk by farmers in both zones. Spraying for diseases and pests and liquidity are perceived as the most effective risk management strategies by farmers in zone 1, whereas farmers in zone 2 considered liquidity and choose good quality materials as an important strategy. The results also show that some farm and farmers' characteristics (e.g. age, experience, education, household size, farm size, family labour, extension contact, off-farm work and Co-op Member) significantly impact the risk attitudes of the farmers in both zones.

Keywords: *Rain-fed crops, Agro-ecological zone, Risk perceptions, Risk management, Syria.*

1. Introduction

Agriculture plays an important role in supporting the Syrian economy at a time when climate changes, changes in Syrian agricultural policies and trade liberalization are a source of risks facing the Syrian farmers (Almadani, 2014).

Syria is a Mediterranean country with a Mediterranean climate, characterized by rainy winters and hot and dry summers. As a result, the dates and distribution of rainfall are a determining factor for agricultural production and agricultural activities (NAPC, 2010). Syria has been divided into five agro-ecological zones (settlement zones) according to the annually rainfall precipitation and the expected probability of rainfall in each zone. Accordingly, these settlement zones used by the government to define the land use appropriateness for cropping pattern that entailing specific support provided by government of Syria for farming within each zone (MAAR, 2016).

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Syria had a declining rate of rainfall from 2003 to 2008 because of the repeated droughts, which influenced adversely both crop production, especially the rain-fed crops. Therefore, the Government has established the Project of Artificial Rainfall, which induced the amount of rain by 6-16% (NAPC, 2010).

Risk is a multidimensional concept with no agreed terms for definitions but rather seen from the perspective of various authors (Fawole and Ozkan, 2018). The risk is the possibility of a loss, or the possibility that the results will be contrary to what the individual expected (AOAD, 2004). The terms "risk" and "uncertainty" can be defined in different ways, and one of these common concepts is that risk is incomplete knowledge in which the probabilities of possible outcomes are known, while uncertainty arises when it is impossible to know these possibilities (Hardaker *et al.*, 2015). Risk attitude refers to the behaviour of the decision maker (the farmer) and how much he or she is willing or unwilling the risk (Pennings *et al.*, 2002).

There are different types of agricultural risks in Syria, namely the price, marketing, production, financial and policy change risks. Farmers face these risks by following a set of measures classified into two main groups, the first is the *ex ante* risk management strategies like crop and income diversification, specialization, precautionary savings and production/marketing contracts. The second group of strategies is the *ex post* risk coping strategies like consumption smoothing, informal and formal credit, asset liquidation and working out of agriculture, supporting programs and welfare policies (Yassin, 2011).

Since risk and risk attitudes of farmers play an important role, many researchers have studied risk in agriculture and their management. The National Agricultural Policy Center in Syria (NAPC) recommended in the last annual report (2010) to give risks, particularly drought, more concern and superiority among the scientific research in the country. The study of risks in rain-fed crops in Syrian in general and Al-Hasakeh Governorate in particular is still of little importance in agricultural research. Therefore, this study aimed to shed light on the risks facing rain-fed farmers in the first and second settlement zones, and the strategies for controlling them. This research can provide useful information regarding risk analysis for farmers in the study area at farm level.

2. Literature reviews

The study of risk is of great importance to the agricultural sector. Previous studies dealt with the sources of risk and management strategies by farmers through the survey of their opinions, and farmers' attitudes towards risk. For example, in Bangladesh, Rahman *et al.* (2020) showed that rice farmers suffer from high production costs and low profit margins due to high labor wages, low soil and water quality, air pollution, low productivity of cultivated crops, and frequent disasters. As a result, these farmers are forced to resort to agricultural loans, which cause their exposure to financial risks. The study concluded that diversification of income sources and contract farming as the most important strategies to mitigate the effects of financial risks.

Raghavendra and Suresh (2018) concluded that the late monsoons, erratic rainfall, and disease and insect infestation were the primary risks for rain-fed soybean farmers in India. The study showed that crop diversification, crop insurance, micro-irrigation, and diversification of cultivated varieties were perceived as the most relevant among farmers.

The results obtained by Ahmad *et al.* (2019) revealed that wheat farmers in Pakistan are generally risk-averse. Rain, storms, hail, high input prices, and wheat diseases were the most important risk sources.

Climate change is a worldwide phenomenon. Drought is one of the most important of these changes that hit many countries. Most world countries, especially in the arid and semi-arid regions, have been seriously devastated by the consequences of climate change (Alrusheidat *et al.*, 2016). Agricultural sector in Syria is the largest sector of the economy, which is responsible for providing the largest portion of food for the population and achieving food security. Agricultural production in Syria is characterized by its dependence on rainfall, where 40-70% of winter crops (mainly wheat and barley) are rain-fed consequently they are highly exposed to the risk of drought as a result of rainfall fluctuations (Yassin, 2011).

Some studies dealt with agricultural risks in Syria, where Almadani (2014) indicated that wheat-cotton farmers are more likely risk-averse than pistachio farmers who could better be described as risk-neutral farmers. Rainfall shortage and fuel price increase are the most important risk sources that threaten both wheat-cotton and pistachio cultivation. On the other hand, farming as a secondary occupation and faming forsaking were the most preferred strategies to cope with risk. The geographical location, education level and information resources have a considerable exploratory power for wheat-cotton farmers' risk attitude and perceptions of risk and risk management. Other studies have shown that agricultural risks in Syria are mainly related to production and price risks and the risks of policy change, as these risks different in intensity and impact according to zones (Farming Systems). Diversification of income sources and cultivated crops are the main strategies adopted by farmers (Yassin, 2011). There is no specific system for agricultural risk management in Syria. the only way applied to help Syrian farmers in case of emergencies is reschedule or respite the credits they got (NAPC, 2007).

3. Data and methodology

3.1. *Study area and sampling design*

The study was conducted in Al-Hasakeh Governorate, which is located in the Northeast part of Syria and spreads over all agro-ecological zones and vulnerable natural disasters such as droughts. The reason for choosing this region is being one of the most important areas in the cultivation of rain-fed crops, which constitutes about 32.72% of Syria's total rain-fed area and agriculture is the main source of income for the population.

This study is based on a survey of rain-fed crop farmers carried out in 2017/2018-2018/2019 in the first and second settlement zones.

(1) First settlement zone: A zone with annual rainfall over 350 mm. It is divided into two areas:
- A-The area of annual rainfall rate over 600 mm. Where rain field crops could be successfully planted.
- B-The area of annual rainfall rate between 350-600 mm. and not less than 300 mm. during the 2/3 of the relevant year i.e. it is possible to get two seasons every three years and its main crops are: Wheat, Legumes and Summer Crops.

(2) Second settlement zone: zone with annual rainfall 250-350 mm. and not less than 250 mm during 2/3 of the relevant year i.e. it is possible to get two barley seasons each three years, and could be planted beside barley, wheat, legumes and summer crops (MAAR, 2016).

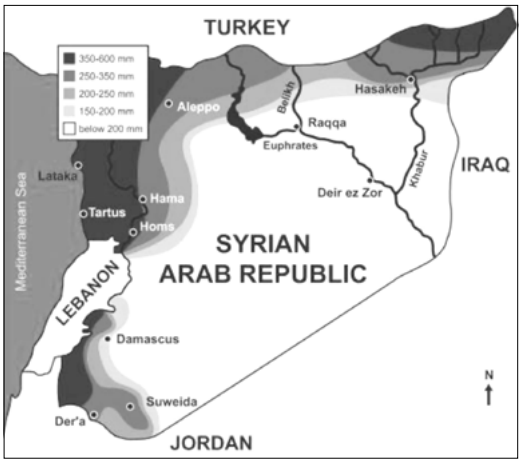
The target population in this study is the rain-fed crop farmers, and the number of available farmers was 39194. The sample size was calculated from the following formula given by (Krejcie and Morgan, 1970):

$$s = X^2NP\,(1 - P) / d^2(N - 1) + X^2\,P\,(1 - P) \quad (1)$$

where:
s = required sample size
X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)
N = the population size
P = the population proportion (assumed to be .50 since this would provide the maximum sample size)
d = the degree of accuracy expressed as a proportion (.05).

Based on the above equation, the sample consists of almost 380 farmers. We had recovered 380 surveys, of which 61 surveys with missing

Figure 1 - Map of study area in Al-Hasakeh Governorate, Syria.



Source: FAO, 2003.

data were removed. Hence, our final sample size counted 319 respondents.

Stratified random sampling was used. In the first sampling stage, 98 villages were selected (58, 40 from the zone 1 and 2 respectively). In the second stage, the rain-fed farmers in these villages were divided into two layers according to agro-ecological zones of the study area; 191 from the zone 1 and 128 from the zone 2.

3.2. *Data collection: instrument and process*

Data for this study were obtained mainly from primary sources. A structured questionnaire was prepared to achieve this study. Most of the questions were of the closed type, mainly in the form of five-point Likert-type scales. The questionnaire included questions about the following: i) farmers' perceptions of risk (including questions on different risk sources); ii) farmers' perceptions of various risk management strategies. In addition the questionnaire includes information regarding socio-economic characteristics of farmers.

Farmers face various risks, each respondent was asked to indicate their degree of agreement or disagreement using a five-point Likert scale (1 = not important; 5 = extremely important) to express how significant they perceived each source of risk. Likewise, a Likert scale was used to determine the importance of various risk management strategies. We used 23 Likert-scale questions for risk sources, and 25 for risk management strategies.

The face-to-face interviews with the farmers were conducted with the help of trained extension service workers who work in the extension units that are spread in the study area. Extension unit plays an important role of agricultural risk management (Yassin, 2011). This made the data collection process easier and the farmers showed more cooperation with the extension agents.

3.3. *Statistical Methods*

3.3.1. *Descriptive statistics*

Descriptive statistics are used to describe data and to summarize the information about the respondents. Farmers' characteristics were examined using (frequency distribution, arithmetic mean and standard deviation).

3.3.2. *Testing the difference between groups*

The *t*-test and chi-square, are used to reveal the statistical significance between the means of two groups.

3.3.3. *Risk attitude*

Self-assessment scale method was used to assess farmers' attitudes to risk through four sets of statement using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The following statement was used to assess farmers' risk attitude: 'I am willing to take more risks than others with respect to: production, marketing, finance and investment.' (Bishu *et al.*, 2018).

3.3.4. *Regression analysis*

Multiple regression analysis was used to assess the relationship between the socioeconomic characteristics and the risk attitudes of farmers. The equation can be written as follows:

$$Yi = b0 + b1AGE + b2EXP + b3EDU + b4HSIZE + b5FSIZE + b6FLAB + b7EXT + b8OFFW + b9COOP + e \quad (2)$$

where:
Y_i: is risk attitude for farmer *i*
b_i: is the regression coefficient
AGE: is the age of respondent (years)
EXP: is the experience of rain-fed farming (years)
EDU: Education of respondent (1=Illiterate, 2= literate, 3=Primary, 4=Secondary, 6=Institute, 7=University)
HSIZE: is household size (Person)
FSIZE: is farm size (hectare)
FLAB: Family labour (measured by five-point Likert-scales, 1=very infrequently, 2 = infrequently, 3= sometimes, 4= frequently and 5= very frequently)
EXT: is extension contact (Measured by a dummy variable with 0 indicating there is no extension contact, and 1 indicating farmers has extension contact)
OFFW: is Off-farm work (Measured by a dummy variable with 0 indicating there is no off-farm work, and 1 indicating farmers has off-farm work)
COOP: is Membership of cooperative (Measured by a dummy variable with 0 indicating farmer is not member, and 1 indicating farmer is member).

4. Results and discussions

4.1. *Socio-economic characteristics of the farmers*

The main characteristics of the rain-fed farmers groups are compared in Table 1. The age group distribution indicates that the majority of the farmers in both regions were between 40-60 years old. The survey also showed that the majority of the sampled farmers (87%) have spent more than fifteen years in the rain-fed farming with average experi-

Table 1 - Socio-economic characteristics of the rain-fed farmers (n=319).

Item	*Unit*	*Overall (n=319)*	*Agro-ecological zone*		*Test of difference*[a]
			1 (n=191)	*2 (n=128)*	
Farmer age	%				1.178[ns]
Less than 40 years old		18.8	20.9	15.6	
40-60 years old		57.4	57.1	57.8	
More than 60 years old		23.8	22.0	26.6	
Experience in farming	%				1.288[ns]
Less than 15 years		12.9	12.6	13.3	
15-20 years		46.7	42.9	52.3	
More than 20 years		40.4	44.5	34.4	
Education	%				7.45[ns]
Illiterate		20.1	23.6	14.8	
literate		9.7	7.9	12.5	
Primary		32.0	30.4	34.4	
Secondary		22.9	20.9	25.8	
Institute		11.6	13.6	8.6	
University		3.8	3.6	3.9	
Farm size	hectare	11.38	13.09	8.82	8.466[**]
Household size	person	6.74	7	6.35	2.615[*]
Off-farm work	%				0.186[ns]
Yes		60.8	61.8	59.4	
Family labour	%				4.191[ns]
Very infrequently		15.7	13.6	18.8	
Infrequently		13.2	11.5	15.6	
Sometimes		27.0	28.8	24.2	
Frequently		32.9	35.6	28.9	
Very frequently		11.3	10.5	12.5	
Land ownership status	%				2.390[ns]
Private		80.3	81.7	78.1	
Rental		11.5	9.4	14.8	
Other		8.2	8.9	7.1	
Extension contact	%				0.601[ns]
Yes		48.0	49.7	45.3	
Membership of cooperative	%				7.575[*]
Yes		28.8	34.6	20.3	
Production system	%				34.07[**]
Hard wheat		26.6	28.3	24.2	
Soft wheat		21.3	26.7	13.3	
Barley		24.1	13.6	39.8	
Chickpea		7.2	9.9	3.1	
Lentil		10.0	9.9	10.2	
Cumin		10.7	11.5	9.4	

*[a]: Test of differences based on chi-square and independent t test; *P<0.05, **P<0.01. [ns]: not significant.*
Source: Field survey.

ences of about 24 and 23 years in zone 1 and 2 respectively.

Data reflect an increase in education for farmers. As the percentage of farmers who received various forms of education exceeded about 75% in both zones, without significant differences between them.

The average farm size of the farmers in the zone 1 was 13.09 ha. In contrast, farmers in the zone 2 had an average farm size of 8.82 ha. This result indicates that the zone 1 farmers hold average farm sizes larger than zone 2 farmers ($P < 0.01$).

There also appear to be significant differences in household size between the zone 1 and zone 2 farmers. The average household size for the zone 1 and 2 was found to be 7 and 6.35 respectively and was significantly different ($P < 0.05$) between the two zones. Almost 61% of the farmers earned income by non-farm jobs.

The work of some family members outside the farm constitutes an additional source of income that can increase the farmers' ability to bear various risks, as the results in Table 1 indicated that 46% and 41.4% of the family members of farmers in the zone 1 and 2 respectively work outside the farm frequently and very frequently.

Approximately 80 % of the farms were under a private ownership type. Farm land rental rate was relatively high among the farmers in the zone 2. Regarding the farmers' extension visit, the highest share was in zone 1 (49.7%).

Around 34.6 % of the farmers in zone 1 were members of a cooperative, which was significant more than for the zone 2 farmers ($P < 0.05$). Wheat (47.9%) and barley (24.1%) were the major crops in the research area, followed by Cumin (10.7%), lentil (10.0%) and chickpea (7.2%).

4.2. *Risk attitude*

Table 2 and 3 show statistics for respondents' answers about each statement in zone 1 and 2 respectively. Generally, the findings show the lower of average score for risk assessment statements for farmers in zone 2 compared to farmers in zone 1; indicates that those farmers are more towards risk aversion attitude. This may be due to the precipitation shortage in zone 2 compared to zone 1; this poses a greater threat to agricultural production in zone 2.

4.3. *Farmers' perception of various risk sources*

Rain-fed farmers were asked to rate (on a 5-point Likert scale) the potential of the risk to affect their income/profit. In total, 23 risk sources were considered. Cronbach's alpha coefficients calculated for the zone 1 and zone 2

Table 2 - Responses of the rain-fed crop farmers about statements of self-assessment scale in the zone 1 (n=191).

Risk category	*Relative risk aversion[a] (%)*					*Mean*	*SD*
	1	*2*	*3*	*4*	*5*		
Production	6.28	39.27	6.28	28.27	19.90	3.16	1.30
Marketing	0.00	28.27	7.85	55.50	8.38	3.44	0.99
Financial	4.19	20.42	29.36	41.36	4.19	3.21	0.96
Investment	6.28	40.84	24.61	24.08	4.19	2.79	1.01

[a] Relative risk: 1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree.
Source: Field survey.

Table 3 - Responses of the rain-fed crop farmers about statements of self-assessment scale in the zone 2 (n=128).

Risk category	*Relative risk aversion[a] (%)*					*Mean*	*SD*
	1	*2*	*3*	*4*	*5*		
Production	0	37.50	12.50	46.09	3.91	3.16	0.98
Marketing	3.13	25.00	25.00	44.53	2.34	3.18	0.94
Financial	11.72	31.25	24.22	28.90	3.91	2.82	1.09
Investment	3.13	53.90	37.50	3.91	1.56	2.47	0.70

[a] Relative risk: 1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree.
Source: Field survey.

Table 4 - Ranking of perceptions of sources of risk by sampled farmers in first and second agro-ecological zone in Al-Hasakeh, Syria.

Sources of risk	*Overall (n=319)*			*Agro-ecological zone 1 (n=191)*			*Agro-ecological zone 2 (n=128)*			*Test of difference[b]*
	Mean[a]	*SD*	*Rank*	*Mean[a]*	*SD*	*Rank*	*Mean[a]*	*SD*	*Rank*	
Precipitation shortage	4.26	0.64	1	4.15	0.63	1	4.43	0.61	1	3.91***
Lack of funding	4.00	0.66	3	3.91	0.70	4	4.14	0.57	5	3.17**
Lack of government support	3.88	0.74	9	3.67	0.71	13	4.21	0.68	3	6.75***
Unexpected variability of product prices	3.96	0.78	5	3.83	0.72	6	4.16	0.82	4	3.73***
Natural disasters such as heat, flood, storm	4.01	0.56	2	3.93	0.57	3	4.14	0.51	5	3.43***
Debt situation	3.94	0.68	6	3.90	0.68	5	4.03	0.65	7	1.64ns
Production cost	3.97	0.61	4	3.91	0.60	4	4.06	0.62	6	2.16*
Diseases and pests	3.88	0.79	9	3.96	0.71	2	3.75	0.89	12	2.27*
Fire damages	3.92	0.78	7	3.72	0.78	11	4.22	0.68	2	5.91***
Marketing/sale	3.89	0.76	8	3.77	0.84	8	4.06	0.59	6	3.33**
Credit availability	3.79	0.84	10	3.74	0.79	10	3.85	0.91	9	1.07ns
Lack of automated harvesting	3.71	0.72	12	3.82	0.78	7	3.57	0.62	13	2.95**
Lack of agricultural machinery	3.78	0.71	11	3.71	0.65	12	3.89	0.78	8	2.14*
Unexpected variability of input prices	3.78	0.79	11	3.75	0.70	9	3.82	0.92	10	0.68ns
Security disturbances	3.63	0.80	13	3.53	0.75	15	3.78	0.85	11	2.65**
Future interest rates	3.50	1.07	14	3.51	0.95	16	3.50	1.23	14	0.10ns
Buyers (government, merchant)	3.48	0.74	15	3.54	0.77	14	3.39	0.69	15	1.78ns
Wages of labour	3.33	0.93	16	3.41	0.84	17	3.21	1.04	17	1.79ns
Difficulties for finding labour	3.20	0.90	17	3.15	0.79	18	3.26	1.05	16	1.04ns
Brokers' dominance	3.00	0.96	19	3.15	0.96	18	2.76	0.91	21	3.63***
Cultivation of new varieties	3.06	0.91	18	2.99	0.90	19	3.16	0.92	18	1.62ns
Sale of crop residues	2.75	0.79	20	2.53	0.71	20	3.07	0.79	19	6.34***
Competition from neighbour countries	2.29	0.90	21	2.32	0.87	21	2.24	0.94	20	0.85ns

*[a] Likert scale is employed from 1 (not important) to 5 (extremely important). [b] The mean scores of zone 1 and zone 2 farmers are significantly difference at * P<0.05, ** P<0.01 and *** P<0.001 based on independent samples t test. [ns]: not significant.*
Source: Field survey.

farmers were 0.74 and 0.70 respectively. Table 4 shows the average scores of farmers' perceptions of each source of risk and the standard deviations of the scores.

Precipitation shortage has been identified as the top rated source of risk by the farmers in both zones. The standard deviation of this risk source in each zone is less than 1, indicating a high level of consensus among the farmers. This result is expected due to dependence of agricultural in these two zones on rain water. The production risks related to *diseases and pests*, *natural disasters* and *production cost* were ranked second, third and fourth, among the farmers in zone 1

with mean scores of 3.96, 3.93 and 3.91, respectively. The results reflect that farmers affected by the floods and dust storms that hit the zone during the previous period.

Fire damages, lack of government support and *Unexpected variability of product prices* were ranked second, third and fourth, among the zone 2 farmers. Zone 2 farmers rated the importance of these risks higher than the zone 1 farmers. As of June 8, 2019, the SANA listed on its website the fires that Al-Hasakeh Governorate witnessed during the season 2018-2019 have affected about 17,000 hectares of land cultivated with wheat and barley crops. The volume of support provided by the government (loans, fertilizers, prices, and seeds) also decreased during the crisis period (2011-2020) compared to the support provided before the crisis. Economic sanctions were imposed on Syria, which had a great impact on the agricultural sector, and were a major cause of the increase in the prices of production inputs.

Debt situation and *lack of funding* were ranked the fifth most important source of risk in zone 1 and 2 respectively. This source of risk associated with the ability of the farmer to repay his financial obligations; in order for him to be able to continue his work in agriculture and avoid possible bankruptcy, this also indicates the farmers' keen interest for the financial liquidity on the farm in order to meet the costs of production in light of the high prices arising from the crisis conditions. In addition, *Unexpected variability of product prices*, *lack of automated harvesting*, *marketing/sale*, *Unexpected variability of input prices*, and *credit availability* were considered important risk sources by all farmers. Sources of risk that obtained low mean scores included *competition from neighbour countries*, *sale of crop residues*, *cultivation of new varieties*, *brokers' dominance*, *difficulties for finding labour*.

Comparisons of risk perception between the farmers in the zone 1 and zone 2 showed significant differences in most sources of risk. this result may be attributed to the fact that the sources of risk differ according to the different geographical area, farm type, the environmental impact and the country's political and economic situation (Aditto, 2011).

4.4. *Perception of risk management strategies*

The results of the perceptions of the various risk management responses by the farmers in both zones are discussed in Table 5. According to farmers in the zone 1 and 2, the most important risk strategy was to *producing at lowest possible cost* (4.02, 4.14) respectively. Nearly 54% and 45% of zone 1 and zone 2 farmers reported using this strategy. Farmers in zone 1 perceived *spraying for diseases and pests*, *liquidity-keep cash in hand*, *adopt crop rotation*, *choose good quality materials*, *adopt new technology*, *storage (spread sales over time)*, *leasing farm machinery*, *growing more than one crop* as important strategies to reduce the risk, with scores of 3.79, 3.70, 3.65, 3.61, 3.58, 3.52, 3.48 and 3.46 respectively. In the zone 2 famers, the most effective strategy was to *keep cash in hand* (4.06) followed by the *choose good quality materials* (3.89), *spraying for diseases and pests* (3.84), *growing more than one crop* (3.83), *storage (spread sales over time)* (3.75), *farmer working off-farm* (3.68), *adopt crop rotation* (3.62), *adopt new technology* (3.58), *use of skilled labour* (3.41). Farmers generally did not see *farming forsaking* and *production contracts* as important strategies. Only 15% and 12% of the farmers in zone 1 and 2 respectively had used this strategy to manage risk. This indicates that most farmers do not consider leaving agricultural work as a way to reduce the risk, which confirms their close association with this work, which constitutes their main source of livelihood. The low ranking of *production contracts* could be caused by the lack of an integrated contract farming system in Syria.

Farmer working off-farm and *family members working off-farm* showed significant differences in importance between the farmers in the zone 1 and zone 2 ($P < 0.001$ and $P < 0.01$ respectively). Zone 2 farmers perceived the importance of these two strategies higher than zone 1 farmers. This is because the farmers in the zone 2 get less farm income compared to the zone 1. Cronbach's alpha coefficients for risk strategies in relation to both zones were found to be 0.82 in the zone 1 and 0.77 in the zone 2.

Table 5 - Ranking of perceptions of risk management strategies by sampled farmers in first and second agro-ecological zone in Al-Hasakeh, Syria.

Risk management strategy	*Overall (n=319)*				*Agro-ecological zone 1 (n=191)*				*Agro-ecological zone 2 (n=128)*				*Test of difference*[c]
	Mean[a]	*SD*	*Rank*	*%*[b]	*Mean*[a]	*SD*	*Rank*	*%*[b]	*Mean*[a]	*SD*	*Rank*	*%*[b]	
Producing at lowest possible cost	4.07	0.72	1	48	4.02	0.70	1	54	4.14	0.72	1	45	1.40^{ns}
Liquidity-keep cash in hand	3.84	0.79	2	38	3.70	0.68	3	32	4.06	0.91	2	41	1.73^{ns}
Leasing farm machinery	3.45	0.94	9	64	3.48	0.93	8	71	3.40	0.95	11	61	0.69^{ns}
Farmer working off-farm	3.39	1.01	10	44	3.23	1.01	10	50	3.68	0.95	7	49	3.98***
Assurance of bank loans	3.07	1.14	12	15	3.01	1.13	12	14	3.16	1.15	15	21	0.26^{ns}
Storage of production inputs	3.21	0.84	11	47	3.10	0.78	11	50	3.36	0.89	12	43	2.69**
Family members working off-farm	3.01	1.11	14	34	2.84	1.15	16	39	3.25	1.02	13	32	3.30**
Sale of farm assets	2.67	1.06	19	25	2.67	0.95	20	23	2.67	1.21	20	26	0.01^{ns}
Spraying for diseases and pests	3.81	0.82	3	49	3.79	0.82	2	58	3.84	0.82	4	41	0.56^{ns}
Growing more than one crop	3.61	1.01	7	45	3.46	1.00	9	50	3.83	0.97	5	48	3.24**
Adopt crop rotation	3.64	0.92	5	45	3.65	0.97	4	49	3.62	0.85	8	45	0.33^{ns}
Adopt new technology	3.58	0.80	8	33	3.58	0.78	6	37	3.58	0.82	9	28	0.05^{ns}
Use of skilled labour	3.06	1.07	13	31	2.82	1.00	17	34	3.41	1.06	10	34	4.97***
Diversification of farm activities	2.82	1.12	16	20	2.94	1.18	14	26	2.65	0.99	21	13	2.24*
Storage (spread sales over time)	3.62	0.89	6	43	3.52	0.91	7	42	3.75	0.86	6	49	2.19*
Markets diversification	2.81	0.98	17	32	2.74	0.95	19	36	2.91	0.98	17	25	1.47^{ns}
Selling to the consumer	2.84	0.94	15	28	2.97	0.91	13	35	2.65	0.95	21	20	3.02**
External marketing	2.73	0.92	18	3	2.59	0.99	21	5	2.78	1.14	19	1	1.58^{ns}
Production contracts	2.57	0.97	20	8	2.55	0.91	22	10	2.60	1.05	22	13	0.41^{ns}
Choose good quality materials	3.72	0.79	4	50	3.61	0.82	5	49	3.89	0.80	3	44	2.99**
Consult with farmers	2.88	0.79	9	33	2.75	0.75	18	33	3.07	0.83	16	31	3.47**
Adhere to the agricultural extension	3.00	0.98	15	42	2.84	1.01	16	39	3.23	0.90	14	37	3.49**
Join cooperative society	2.82	0.85	16	37	2.82	0.88	17	40	2.82	0.80	18	25	0.06^{ns}
Offer incentives to labour	3.01	1.02	14	22	2.91	1.03	15	24	3.16	0.98	15	27	2.18*
Farming forsaking	2.36	0.98	21	13	2.42	0.78	23	15	2.27	1.09	23	12	1.33^{ns}

*[a] Likert scale is employed from 1 (not important) to 5 (extremely important). [b] The percentage of farmers using each risk management strategy. [c] The mean scores of zone 1 and zone 2 farmers are significantly difference at * P<0.05, ** P<0.01 and *** P<0.001 based on independent samples t test. [ns]: not significant.*

Source: Field survey.

4.5. *Determinants of attitudes based on socio-economic characteristics*

Socio-economic characteristics were regressed against each of zone 1 and 2 farmers' risk attitudes. For all multiple regressions, preliminary analyses were carried out to verify there was no violation of the multiple regression assumptions (normality, linearity, multicollinearity and homoscedasticity). The goodness-of-fit of the models is indicated by R^2 and adjusted R^2. The two models have relatively high R^2 and adjusted R^2, and explained roughly (78%, 59%) of the total variance for zone 1 and 2 respectively.

The results suggest that, for both zones, farmers' education level was positively and significantly related to their attitudes toward risk ($p < 0.01$), indicating that farmers with a higher level of education were found to be less risk-averse. This result is congruent with the conclusion that high educated individuals have been positively associated with risk taking (Aditto, 2011; Almadani, 2014; Bishu *et al*., 2018). This finding contrasts with Al-Tahat (2016), Ullah *et al.* (2015) who argued that more educated farmers tended to exhibit more risk-averse behavior. Farming experience was positively related to zone 1 farmers' risk attitude. This suggests that the more experienced farmers were less risk-averse.

Farmer's age in the zone 1 showed a negative significant relationship with risk attitude. This implies that older farmers were more risk-averse than younger farmers. This finding agreed with Adubi (1992), Aditto (2011), Ullah *et al.* (2015). However, Al-Tahat (2016) showed a positive relationship between a farmer's age and the risk aversion of the farmers in his study.

The household size of zone 2 farmers had a significantly negative relationship with risk attitude. This suggests that farmers with smaller households in this zone are likely to be less risk averse than the larger household farmers. Dadzie and Acquah (2012) and Ullah *et al.* (2015) also reported similar result for the effect of household size on farmers' risk aversion. While the effect of household size was positive and significant for farmers in the zone 1. The finding is consistent with Al-Tahat (2016) who argued that farmers become less risk averse as family size increases.

Table 6 - Results of multiple regressions for farmers' risk attitude scale against socio-economic variables of zone 1 farmers (n=191) and zone 2 farmers (n=128).

Socio-economic variables	*Risk attitude scale*	
	Agro-ecological zone 1	*Agro-ecological zone 2*
Intercept	1.235***	0.922***
Farmer age	-0.013*	0.035***
Farming Experience	0.047***	0.001
Education	0.078**	0.145**
Household size	0.048*	-0.089**
Farm size	0.056***	0.036*
Family labour	-0.106**	0.011
Extension contact	0.123	-0.254**
Off-farm work	0.294**	0.206*
Co-op Member	-0.241**	0.136
F- statistics	76.18***	21.44***
R-Squared	0.79	0.62
R-squared adjusted	0.78	0.59
Durbin-Watson statistics	1.97	1.56
Jarque-Bera statistics[a]	3.15 (0.20)	0.97 (0.61)
ARCH heteroscedasticity statistics[a]	0.17 (0.67)	1.47 (0.23)

** P<0.05, ** P<0.01 and *** P<0.001. [a]: numbers in parentheses are P-values.*

Farmers with larger farms were risk takers relative to those who have smaller farms size. This may be because farmer of a large farm size allows a wide range of diversity in crops production, thus avoiding the dependency on one kind of products (Al-Tahat, 2016). This finding disagreed with Almadani (2014) and Ullah *et al.* (2015).

The Table 6 shows that family labour in zone 1 had an inverse relationship with farmer risk attitude and was statistically significant. This stands to imply that the higher the family members who have off-farm work the less risk preferring the farmers will become. Similarly, Wheat-cotton farmers in Al-Hasakeh who have family members with off-farm work were less likely to accept risks (Almadani, 2014). Perry and Johnson (2000) deduced that the higher the family members who have off-farm work the higher the willingness to take risk due to their income which serves as a substitute in risk threat period.

It is surprising that extension contact is statistically significant and negatively related to risk attitude only in zone 2. This implies that the farmers with more extension contact will be more risk averse. The finding is inconsistent with Ayinde (2008), Ayinde and Obalola (2017) who found that the extension work tends to increase the farming household willingness to take risk.

Off-farm work had a positive and significant coefficient with the risk attitude in both zones. This indicate farmers who have off-farm work were found to be less risk-averse. The result is in agreement with Ullah *et al.* (2015). Higher off-farm incomes may indicate a greater risk bearing capacity and represents a form of diversification that would have an impact on farmers' risk attitude (Velandia *et al.*, 2009).

Membership of cooperative society is negative and significant at 1% level for the zones 1. This indicate that the cooperative society in this zone is not effective. This may be due to the decline in the role of cooperative societies in providing services to farmers, given that they are affected by the circumstances of the crisis in Syria.

5. Conclusions and recommendations

The results indicated that there are significant differences between farmers in the zone 1 and zone 2 in terms of their perception of the sources of risk and its management strategies.

The risks related to the precipitation shortage were the most important and ranked first for farmers in both zones. And it was found that the risks of natural disasters, lack of funding, production cost and debt situation were the most important for farmers in the zone 1. While the risks of fire, lack of government support, unexpected variability of product prices, lack of funding and natural disasters were most important to the farmers of zone 2. The producing at lowest possible cost was the most important and ranked first for farmers in both zones. It was also found that both the strategy of spraying for diseases and pests, keep cash in hand and adopt crop rotation were the most relevant risk management strategies in zone 1. While the farmers zone 2 considered keep cash in hand, choose good quality materials, spraying for diseases and pests, and growing more than one crop were the most important from their point of view. The farmers in zone 1 gave less importance for farmer and family off-farm working; This may be the result of the higher agricultural income that they obtain compared to the farmers in zone 2. Differences in risks and their related management strategies between the study zones are related mainly to the different agro-ecological zones.

In terms of the relationships between risk attitudes and farmer socioeconomic characteristics. Our results suggest that farmers' experience, education, household size, farm size and off-farm work have a positive influence on farmers' risk attitude by lowering their risk aversion. The extension service and cooperative societies should be made more effective, where the results showed a negative and significant effect of agricultural extension and cooperative societies, perhaps due to the security conditions in Syria that affected the work of extension units and cooperative societies.

The result of this study can provide decision makers in Syria with the most important agricultural risks facing farmers in rain-fed zones at the farm level, as well as the most important strategies used by them. Therefore, agricultural policy makers should take in to account the differences between agro-ecological zones when setting pol-

icies, and provide higher support to the farmers of the zone 2, for whom production risks are more important. The results of the study can also be a useful reference for the most important agricultural institutions that were established in Syria for the purpose of supporting the agricultural sector, for example, Agricultural Extension, Peasant Associations, and Agricultural Cooperative Bank. As the function performed by these institutions as risk management institutions needs further reform and development in light of the increasing climatic changes in recent times and the conditions that farmers are currently experiencing.

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Table olive farmers' sources of risk and risk management strategies

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Abstract

Like in all Mediterranean countries, Table olive farming has an important tradition and production potential in western Turkey, and thus it is critical to assess the risk sources and risk management strategies that farmers perceive. This study identifies perceptions of risk sources and managements strategies in the region, clarifying their relative importance, as farmers perceive them, using a survey conducted among 121 selected purposefully farmers. Sociodemographics of farmers and households were identified using basic descriptive statistics, such as arithmetic means and percentages. According to factor loadings, financial and marketing risk sources are most prominent among farmers, and human-induced and production technology issues represent the most important risk management strategies. In table olive production, it will be beneficial to develop strategies such as increasing the number of trees, improving agricultural activities, increasing the awareness level of farmers on issues such as climate change and the use of new technologies.

Keywords: *Olive production, Uncertainties, Sustainability, Rural development, Food security.*

1. Introduction

Due to the nature of agricultural production, managing risk and uncertainty is integral to generating income. Climate change, financial crises, price fluctuations, and uncertainty have become common agendas during plant and animal production, and more generally, during agricultural production. The Covid-19 epidemic, which emerged worldwide during 2020 and remains in effect, further emphasized the importance of agricultural production, with sustainability in agricultural production moving closer to the center of the agenda. Risks have negative implications, especially lower earnings and income, and as a result, dramatic consequences, such as financial collapse, food insecurity, and human health problems, can occur. Anticipating high returns should represent a positive reward for taking risks, and farmers bear many such risks (van Winsen *et al.*, 2013; Wauters *et al.*, 2014; Komarek *et al.*, 2020), including production, price and market, financial, human capital (i.e., personal or idiosyncratic), and institutional risks (Komarek *et al.*, 2020; USDA, 2021a). Environmental risks also belong with these others (Velandia *et al.*, 2009; Adnan *et al.*, 2020).

Duong *et al.* (2019) conducted a literature search for farmers' perceptions of agricultural risks within the framework of the PRISMA protocol, finding that the most important risk sources are air-related issues, biosecurity, human capital, market, financial, corporate, and technology risks. However, the risk management strategies that

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farmers use most are crop and animal diversification, monitoring and prevention of pests and diseases, own off-farm work, agricultural insurance, off-farm investments, debt reduction, adoption of new technologies, development of agricultural production opportunities at minimum cost, expansion studies, cooperatives with other farmers, cooperation with the government and improvement activities, and education and training.

Komarek *et al.* (2020) identify the top five risk sources in agriculture. First in agricultural production are risks to both crop and animal production that arise from biological processes because there exists a relationship between diseases and pests, in conjunction with weather and climatic conditions (e.g., temperature and oil), and among other efficiency limiting and reducing factors, excessive heavy metals and salinity in soil represent salient production risk factors. Second are market risks, especially uncertainties regarding prices, costs, and market access. Unexpected changes to weather and their effects on agricultural income, shocks to energy prices, and asymmetry concerning access to information cause significant volatility in agricultural commodity prices. Developments to international trade, liberalization, and/or protectionism are among other important sources of market risk. Such risk factors also affect market access both positively and negatively in more than one geographical location, and thus processes during which many risks occur at various times, such as increases to prices, weather events, and difficulties encountered when accessing a market, also develop (Holden and Shiferaw, 2004; Harvey *et al.*, 2014; Lazzaroni and Wagner, 2016). Third are risks from changes to policies and regulations implemented by public and/or other non-governmental organizations that operate in the agricultural sector. Legal regulations and social norms are salient to farmers when asked about change, and farmers can be involved variously in support mechanisms by concentrating more on market-oriented production (Harwood *et al.*, 1999). Fourth are personal risks that affect human health directly and mechanisms that affect a farm. Injuries caused by agricultural machinery and diseases, and/or deaths from various causes and the negative effects of pesticides and pests on humans and animals, appear within this scope (Antle and Pingali, 1994; Lopes Soares and Firpo de Souza Porto, 2009; Masuku and Sithole, 2009; Arana *et al.*, 2010; Tukana and Gummow, 2017). Health risks represent prominent causes of changes to agricultural production and thus income (Dercon *et al.*, 2005). Family events (e.g., marriage and divorce), health problems, death, and customary and legal rules also affect agricultural production, and thus, the interaction of personal and organizational risks are also very important (Meinzen-Dick *et al.*, 2014). Fifth are a farm's cash flow, budgeting, income-expense balancing, and fixed and variable financial liabilities within the scope of financial risk (Gabriel and Baker, 1980; de Mey *et al.*, 2016). Fluctuations to interest rates and regulations regarding credit use and conditions also fall under financial risk factors.

Farmers have preferences when managing potential risks, and they commonly use a combination of strategies. Precise analyses regulate only one risk source, and others deal with multiple risk sources, with some strategies more common than others (USDA, 2021b). First, by using business diversification and product modeling, income distributions from different crop and animal productions can be balanced, with optimization achieved when one decreases and another increases. Second, financial leverage ensures optimum use of loans. Greater debt is riskier than some equity. Many factors affect critical instruments, such as optimum leverage, farm profitability, credit cost, risk sensitivity, and tolerance, and the degree of income uncertainty. Third, vertical integration is effective at managing ideal inputs and outputs. A firm with a vertical working system achieves effective time management by holding ownership and control of goods during two or more stages of production and/or marketing. Fourth, contracts reduce risks by securing market prices, and hence sales and other exchange factors, in advance. Contracts that define the price, quality, and volume of a product to be produced and delivered are called marketing or advanced contracts, and those that determine which stakeholders will provide inputs to be used and production processes are called production contracts.

Duong *et al.* (2019) argue that primary risk topics that research assesses include perceptions of agricultural risk sources (Flaten *et al.*, 2005; Morton, 2007; Waage and Mumford, 2008; Bergfjord, 2009; Müller *et al.*, 2011; Morera *et al.*, 2014; Hardaker *et al.*, 2015), risk management strategies (Aldy *et al.*, 1998; Messerli *et al.*, 2006; Atreya, 2007; Lin, 2011; Gillespie and Mishra, 2011; Jin *et al.*, 2015; Ruiz *et al.*, 2015; Gautam *et al.*, 2017), links between perceived risk sources and risk management strategies (Alamerie *et al.*, 2014; Patrick and Ullerich, 1996; Fielke and Bardsley, 2014; Gebreegziabher and Tadesse, 2014; Chang and Tsai, 2015), socioeconomics that affect farmers' risk perceptions and management (Sjöberg, 2000; Hall *et al.*, 2003; Akcaoz and Ozkan, 2005; Flaten *et al.*, 2005; Legesse and Drake, 2005; Stockil and Ortmann, 1997; Botterill and Mazur, 2004; Borges and Machado, 2012; Kisaka-Lwayo and Obi, 2012; Ríos-González *et al.*, 2013; Wheeler and von Braun, 2013; Ullah *et al.*, 2015; Kabir *et al.*, 2016; Kiama *et al.*, 2016; Lu *et al.*, 2017), and barriers to management of agricultural risks (Legesse and Drake, 2005; Mannon, 2005; Panneerselvam *et al.*, 2011; Ilbery *et al.*, 2013; Toma *et al.*, 2013; Gebreegziabher and Tadesse, 2014; Harvey *et al.*, 2014; Awan *et al.*, 2015; Baruwa *et al.*, 2015; Mardero *et al.*, 2015; Ullah *et al.*, 2015; Woods *et al.*, 2017).

On the topic of table olives, few studies assess the risk sources that producers perceive and the risk management strategies available to them. Fleskens (2008) argues that olive plantations in the Mediterranean are generally in sloping and mountainous areas. Increased use of mechanization during table olive cultivation, and both chemical inputs and drip irrigation systems, are leading developments, especially in recent years. Twenty-eight olive plantation systems were created, with regional typologies developed for six study areas, analyzed using cluster analysis, including Tras-os-Montes (Portugal), Cordoba and Granada / Jaen (both in Spain), Haffouz (Tunisia), Basilicata/Salerno (Italy), and Western Crete (Greece). Six olive growing systems were established, including very extensive, conventional comprehensive, semi-intensive low input, semi-intensive high input, dense, and organic. Stroosnijder *et al.* (2008) presented the OLIVERA project, which analyzes the future of olive production systems on sloping land in the Mediterranean basin. The study suggests that existing production systems (known as SMOPS for Inclined and Mountain Olive Production Systems) are being threatened, with sources of risk falling into three categories – environmental (e.g., erosion hazards), social (i.e., youth migration), and economic (e.g., high labor costs). Thus, an unsustainable phenomenon is evident. During the project, an expanded survey was conducted at five facilities in Portugal, Spain, Italy, and Greece, demonstrating the diversity and multifunctionality of SMOPS. Four systems require greater attention in the future – traditional, organic, semi-dense, and intensive. Çukur *et al.* (2011) argue that the most important risk source during olive cultivation is seasonality, with other sources including yield loss, climatic conditions, diseases, and pests. Increasing internal controls, providing technical support for continuity of production, developing olive production systems, and using new techniques and tools are suggested as risk strategies for these risk sources. Northcote and Alonso (2011) outline parameters that underlie diversification of farm activities among olive farmers located in Western Australia. Gomez-Limon *et al.* (2012) analyze the eco-efficiency assessment of olive farms in the Andalusia region of Spain, and Pergola *et al.* (2013) investigate alternative production management for olive groves. Villanueva *et al.* (2014) assess the supply of agricultural public goods in the context of irrigated olive groves in Southern Spain, and Palese *et al.* (2013) argue that for traditional olive cultivation to survive, approaches that increase olive farmers' income should be used, and the multi-functional role of this production system should be accepted; thus, policy tools are inevitable. They propose a sustainable innovation management model that includes recycling of urban wastewater, distribution through drip irrigation systems, and use of soil management techniques based on recycling polygenic carbon resources (e.g., cover crops and pruning mate-

rial) in olive orchards. Allahyari *et al.* (2017) investigate farmers' technical knowledge on integrated pest management (IPM) during olive production. Arenas-Castro *et al.* (2020) predict climatic changes that might reduce the suitability and production of olive varieties in Southern Spain, with results suggesting that climate change will reduce areas available for important olive varieties, and drier and warmer climatic conditions in summer and autumn will be drivers of change. Gkisakis *et al.* (2020) develop a decision support tool to evaluate the environmental performance of olive production based on energy use and greenhouse gas emissions, an important tool developed to ensure sustainable olive cultivation. Orlandi *et al.* (2020) apply statistical models to determine the most appropriate meteorological variables for olive fruit production in post-pollination periods. Olive pollen time series from 1999 to 2012 were analyzed across 16 Italian provinces, with findings suggesting that although the minimum and maximum temperatures in the spring and summer (i.e., March to August) correlated negatively with olive production, precipitation always had a positive correlation.

On the other hand, although it is defined that there are many production-based studies such as the components that affect the yield and periodicity in the production of both table and olive oil, no evaluation has been made on these literatures with the thought that the focus of the study will be moved away. According to the literature review, it is clarified that a certain number of studies have been carried out to determine risk sources and risk management strategies in olive production. On the other hand, no study is found that reveals the sources of risk in table olive production and the risk management strategies for them in detail and comprehensively. It is thought that this study makes up for this deficiency in the literature, albeit to a certain extent. The current study assesses similarities between the risk sources and risk management strategies that farmers perceive during production of table olives. After the Introduction, the materials and methods used in the study are discussed, followed by results, a discussion of findings, and a conclusion.

2. Materials and methods

2.1. *Study area*

Manisa, Turkey's most important olive producing region, is located in the upper level and has achieved significant specialization in table olive farming (Ozturk *et al.*, 2021). Table olive cultivation in the region represents an important culture and lifestyle. When olive cultivation data from Manisa are examined based on district, the highest production is from Akhisar (Çolak and Çulha, 2020). According to the latest data, 12 table olive varieties were registered and/or applied for PDO (protected designations of origin) and PGI (protected geographical indication) in Turkey (TURKPATENT, 2021), including Akhisar Domat Zeytini, Akhisar Uslu Zeytini, Antalya Tavşan Yüreği Zeytini, Aydın Memecik Zeytini, Aydın Yamalak Sarısı Zeytini, Edremit Körfezi Yeşil Çizik Zeytini, Gemlik Zeytini, Hatay Halhalı Zeytini, Milas Yağlı Zeytini, Samanlı Zeytini, Tarsus Sarıulak Zeytini, and Yarımada Hurma Zeytini. Two varieties of table olives have geographical indication records in the Akhisar region, which is one of Turkey's most important centers of table olive production. Besides being an important source of income, table olive production has become a cultural heritage, tradition, and habit in the region.

2.2. *Data collection*

A survey was administered among 121 olive farmers, and when selecting farmers to participate, attention was paid to a high degree of experience with table olive farming. It is predicted that the preliminary observations and evaluations made in the research area, the survey to be made with 121 table olive producers and the objective results to be obtained from them will produce as objective and realistic findings as possible for the whole region. Thus, this number is thought to have the ability to represent most of the producers in the region. Besides continuous and discrete data, answers and data obtained from the survey questions were collected using yes-no options. Descriptive statistics, such as arithmetic means and percentages, were used during analysis and evaluation of the data. The literature review sug-

gests that no consensus exists regarding the most appropriate methods for determining risk sources and risk management strategies on farms. However, extant studies suggest that rating methods that use Likert-type scales can be applied with precision. Most such studies have farmers rate sources of risk and risk management strategies using a five-point scale (i.e., 1= not important at all; 5=very important) (Aditto *et al.*, 2012). In the current study, a 5-point, Likert-type scale was used to assess risk sources and risk management strategies that producers on table olive farms perceive (i.e., 1=not effective at all; 2=ineffective; 3=unstable; 4=effective; 5=very effective).

2.3. *Analytical approach*

This study uses factor analysis to assess similarities between the risk sources and risk management strategies that farmers perceive. Such risk sources and risk management strategies are discussed and explained in detail. The main reason for presenting this methodology in the study is to reveal the sources of risk and risk management strategies in table olive cultivation, which is the basic setup of the study, in detail and comprehensively. While the method used offers a user-friendly approach, it also offers the opportunity to produce solutions for the strategies created for the future.

2.4. *Determining the risk sources and risk management strategies that table olive farmers perceive*

Principal component analysis (PCA) was used to determine the risk sources and risk management strategies that farmers perceive and reduce them to a smaller number. During evaluation, risk sources and risk management strategies were considered separately using scores from data collected using Likert-type scales. PCA is a type of analysis that reduces many variables to a limited number of groups. Converting groups into new variables maximizes relationships between variables in the groups and minimizes relationships between groups, with the new variables called factors. Factor analysis enables finding new variables that are independent, fewer, more meaningful, and based briefly on many relationships (Lattin *et al.*, 2003; Field, 2009; Karagöz, 2016). During PCA and as part of the Kaiser Normalization transaction, varimax rotation was used to reduce the number of factors in the data (Lattin *et al.*, 2003; Field, 2009; Zhang *et al.*, 2019).

3. Results and discussion

3.1. *Socioeconomics of farmers and/or household members*

Responses that resulted in continuous data included farmers' socioeconomic characteristics (Table 1). Characteristics of farmers whose answers represented discrete data appear in Table 2. The average farmer's age was 54.03, which accords with extant studies (Giourga *et al.*, 2008). Duarte *et al.* (2008) explores what the traditional olive production system means and its definition in OLIVERA (i.e., Tras-os-Montes - Portugal, Cordoba and Granada / Jaen - Spain, Basilicata / Salerno - Italy, and West Crete - Greece). Twenty-four sloping and mountainous olive production systems (SMOPS) were defined during the OLIVERO project, which suggested that farmers of traditional SMOPS are older, about 50 years old. The average number of people living in a household was 3.38, and the average number of people engaged in agriculture in the household

Table 1 - Socioeconomic characteristics of farmers and/or households.

Variable	*Description*	*Mean*	*SD*	*Min*	*Max*
AGE	Year	54.03	11.69	27	80
HM	Household members	3.38	1.32	1	9
IHWA	People in household who work in agriculture	1.76	0.97	1	5
AE	Agricultural experience	33.12	14.99	1	70
OFE	Olive farming experience	36.07	49.11	3	55
SOFL	Size of olive-farming land	56.40	53.98	5	300

Table 2 - Socioeconomics of farmers indicative discrete data.

Variable	*Description*	*Frequency*	*Percent*
ED	Education		
	1: Literate	0	0.0
	2: Primary school graduate	67	55.3
	3: Middle school graduate	22	18.2
	4: Lycee graduate	25	20.7
	5: High school graduate	1	0.8
	6: Undergraduate and graduate	6	5.0
NAI	Non-agricultural income		
	0: No	72	59.5
	1: Yes	49	40.5
FRK	Farmers' recordkeeping		
	0: No	56	46.3
	1: Yes	65	53.7
MFC	Membership in a cooperative		
	0: No	31	25.6
	1: Yes	90	74.4

was 1.76. Agricultural production experience of farmers was 33.12 years, and experience with olive farming was 36.07 years. The average size of land on which olive farming was conducted was 56.40 decares (1 decare=1000 m^2), varying from 5 to 300 decares. Studying olive oil farmers in the western region of Turkey, Artukoglu (2002) reports similar results. Similar results were also found in Greece (Giourga *et al.*, 2008), and Berg *et al.* (2018) also reports similar findings.

Sixty-seven of the farmers (55.3%) were primary school graduates, 22 (18.2%) were secondary school graduates, and 25 (20.7%) were high school graduates. Six (5%) were undergraduate and graduate degree holders. The education of most of the farmers was thus low. These results accord with many studies conducted in Mediterranean countries (Artukoglu, 2002; Ligvani and Artukoğlu, 2015; Rodríguez Sousa *et al.*, 2020). Forty-nine (40.5%) of the olive farmers had non-farm income, and 72 (59.5%) explored non-farm income, similar to results from Giourga *et al.* (2008), EC (2012). Non-agricultural income earning status on farms was positive in terms of rising farm incomes but was negative in terms of decreasing concentration on olive production. During farm management, good recordkeeping provides optimal management, including for tax purposes. Using financial records and appropriate methodologies offers ideal assistive tools in achieving business profitability. Recordkeeping and optimal interpretation of data help identify the weakest links of a farm business's operation, and allows corrective actions (Arzeno, 2004). Sixty-five (53.7%) of the farmers kept records of their agricultural activities, and 56 (46.3%) did not have any agricultural registration system. Keeping records of agricultural production is important in terms of ensuring sustainability during agricultural production. Although not at a desired level, these figures are important and sufficient.

Recordkeeping in farm management is very important. Ninety (74.4%) olive farmers were members of a cooperative, and the remaining 31 (25.6%) were not. Most olive producers are members of a cooperative, making positive contributions to innovation, support mechanisms, and agricultural activities. Cooperative membership is high; in SMOPS CO1, it is 88% (Metzidakis, 2004), and in Granada/Jaen 90% (Duarte, 2005a; Fleskens, 2007). Of farmers surveyed in Basilicata/Salerno, nearly all were members of a cooperative, and the most important reason for membership was qualifying for CAP subsidies (Duarte, 2005b; Fleskens, 2007).

3.2. *Risk sources and risk management strategies perceived by table olive farmers*

3.2.1. *Sources of risk*

Twenty-seven risk sources were considered in olive farming, and expressions belonging to a risk source were created from items scored using a Likert-type scale. The arithmetic means, ranks, and standard deviations of the expressions appear in Table 3. During factor analysis, a high correlation between variables is ideal, calculated using the Barlett test and evaluated using the degree of significance ($p<0.01$). High correlations between variables were evident, and thus data came from multiple normal distributions. Results were adequate since the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and chi-square (χ^2) were 0.656 and 1495.103, respectively. Therefore, the sample size was sufficient to determine risk sources in the study. Common variance (i.e., communality) represents the variance a variable shares with other variables. Variables with factor loadings of 0.5 or greater were included during analysis, and the remainder were excluded. Since factor loadings for all items were greater than 0.5, all were included during analysis (Hair, 2006).

Explained total variance and eigenvalues before and after rotation were examined, identifying 8 factors from evaluation results. Cumulative variance explained by the eigenvalues was 68.74% of total variance. In a scree plot shown in Figure 1, the 8 factors were chosen because there were 8 factors with eigenvalues of one and

Table 3 - Identification of risk sources.

Item	*Mean*	*SD*	*Rank by mean*
Drought	4.55	0.82	5
Excessive rainfall	3.95	1.96	17
Hail	4.53	0.84	7
Storm	3.55	1.28	18
Frost	4.33	1.15	13
Earthquake	1.59	1.05	25
Theft	2.51	1.49	24
Bird and wildlife damage	1.50	0.90	26
Certified nursery supply	2.83	1.49	23
Pests (diseases and insects)	4.20	1.08	14
Unconscious use of inputs (chemical pesticides and fertilizer)	4.13	1.14	15
Unconscious use of water	3.97	1.23	16
Breakdown and malfunction of agricultural machines	3.09	1.40	22
Insufficient family workforce/young generation abandoning agriculture	4.71	0.65	1
Inability to use information technologies	4.27	1.00	13
Difficulties with finding foreign labor	3.54	1.41	19
Agricultural work accidents	3.22	1.33	21
Market uncertainty and instability	4.70	0.69	2
Low selling price	4.70	0.67	2
Increase in input prices	4.67	0.69	3
Logistics	3.35	1.47	20
Distrust between farmer and buyer	4.45	0.93	10
Economic crisis expectation	4.54	0.82	6
Borrowing	4.49	0.88	8
Failure to repay debts	4.48	0.86	9
Uncertainty of future interest rates	4.59	0.73	4
Volatility in exchange rates	4.40	0.86	11

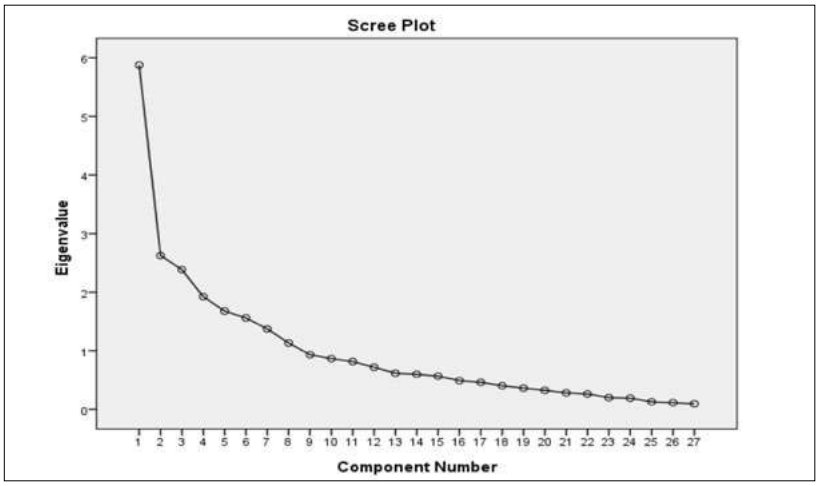

Figure 1 - Scree plot of risk source factors.

Table 4 - Varimax-rotated factor loadings of risk sources.

Item	*Factors*								
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*Commu-nality*
Uncertainty of future interest rates	0.814								0.709
Borrowing	0.806								0.691
Volatility in exchange rates	0.803								0.724
Economic crisis expectation	0.801								0.681
Failure to repay debts	0.796								0.738
Insufficient family workforce/young generation abandoning agriculture	0.488								0.633
Low selling price		0.860							0.765
Increase in input prices		0.814							0.734
Market uncertainty and instability		0.796							0.758
Unconscious use of inputs			0.873						0.830
Unconscious use of water			0.815						0.788
Pests			0.794						0.709
Excessive rainfall				0.776					0.792
Storm				0.709					0.634
Inability of the farmers to use IT				0.539					0.614
Breakdown and malfunction of agricultural machines				0.535					0.589
Drought				0.532					0.620
Hail					0.810				0.747
Earthquake					0.648				0.674
Frost					0.610				0.677
Logistics						0.780			0.721
Distrust between farmer and buyer						0.653			0.565
Agricultural work accidents						0.540			0.612
Theft							0.715		0.579
Certified nursery supply							0.614		0.538
Bird and wildlife damage							0.601		0.786
Difficulties with finding foreign labor								0.775	0.650

greater ($\lambda \geq 1$). The rotated component matrix and communalities appear in Table 4.

According to the factor loadings, general financial risk sources comprise the first group. In this group and unlike sources of financial risk, in the human-induced risk category there was only the insufficiency of the family workforce and abandonment of agriculture by the younger generation. The second group comprised general marketing risk sources, and the third comprised diseases and insects (pests) and unbalanced input and water use. Other risk sources included excessive rainfall, storms, a farmer's inability to use information technologies, and breakdown and malfunction of agricultural machines during work. Drought comprised a fourth group. Drought, hail, and frost comprised the fifth group, and logistics, distrust between farmers and buyers, and agricultural work accidents comprised the sixth. The seventh group included theft, certified nursery supplies, and bird and wildlife damage, and difficulties with finding foreign labor comprised the eighth group. These findings accord with extant studies from Patrick *et al.* (1985), Martin (1996), Flaten *et al.* (2005), and Aditto *et al.* (2012). Such studies suggest that fluctuations to product and input prices represent the most important risk sources that farmers perceive, especially when integrated with marketing risks.

Boggess *et al.* (1985) assess farmers' risk awareness regarding crop and livestock production systems in Northern Florida and Southern Alabama, finding that farmers define risk as the likelihood of an adverse outcome. Concerning plant production, precipitation variability, pests and diseases, and product price variability represent primary risk sources. Regarding animal husbandry, animal diseases are perceived to be the most important risk sources during animal production, in addition to animal and animal product prices, and weather variability. Patrick *et al.* (1985) assess risk perceptions and farmers' attitudes toward risk, conducted among farmers of mixed crops and livestock in the United States. Findings suggest that unexpected circumstances, such as weather conditions, output prices, and input costs, represent major sources of risk during both crop and livestock production.

Martin (1996) used a nationwide postal survey to examine the risk sources and risk management strategies of New Zealand farmers, assessing whether farmers perceive marketing risk (e.g., volatility in input and output prices) to be a major risk source. In contrast, production risks, such as precipitation and operating within the scope of agricultural control activities, were assessed from a variety of perspectives, depending on geographic region, type of farm activity, and crop. Pellegrino (1999) examines Argentinian rice farmers' perceptions of risk sources and risk management responses, finding that across small, medium, and large farms, farmers' awareness of risk sources varies. A farm's size thus determines such perceptions, with small farm owners having greater production risk awareness than those in the other two groups.

Meuwissen *et al.* (2001) found that price and production risks represent the most important risk sources in livestock farms that operate in the Netherlands, and agricultural insurance was reported as the most important risk management tool. Flaten *et al.* (2005) examine the risk perceptions and reactions of farmers in traditional and organic dairy farms that operate in Norway, finding that institutional and marketing risks, including government support policies, represent the most important risk sources in organic dairy farming. Hall *et al.* (2003) found that drought and meat price volatility represent major risk sources among cattle farmers in Texas and Nebraska. Nicol *et al.* (2007) found that large-scale South African sugar cane farmers perceive that land reform regulations, labor legislation, and crop price volatility are major risk factors. Çobanoğlu *et al.* (2015) defined major risk resources in earthen pond fish farming in Turkey, finding that the most important sources of risk are production and operational, market and price, financial, political and social, and personal risks.

Chand *et al.* (2018) conducted a survey to assess farmers' perceptions of risk sources in animal husbandry, finding that increasing feed costs, extreme weather conditions, and delays in veterinary services represent primary risk sources. Iqbal *et al.* (2018) examined farmers' perceptions of risk sources in cotton production in Pakistan, finding that frequent changes to agricultural policies, farm equipment prices, and inefficiencies in

farm cooperatives are primary constraints. Karadas and Birinci (2018) conducted a factor analysis to assess risk sources in bee farming that create financial risks, finding concern in the presence of biotic stressors and theft in Turkey. Thompson *et al.* (2019) used a best-worst choice experiment among farmers to assess the importance of types of risk in large commercial U.S. farms, finding that production, market, and financial risks are of greater concern than are personal or legal risks. Komarek *et al.* (2020) identified 3,283 peer-reviewed studies published between 1974 and 2019 that address one or more of the five types of risks in agriculture (i.e., production, market, corporate, personal, and financial), with results suggesting that 66% of the studies focus solely on production risks, and only 15% on more than one type. Only 18 studies considered all five types of risks, assessing either how farmers perceive the significance of each risk or focusing on conceptual issues, rather than assessing how exposure to all risks quantitatively affects farm indicators, such as yields and income.

3.2.2. *Risk management strategies*

Twenty-three risk management strategies are considered in this study, with statements related to such strategies assessed using scores obtained from Likert-type scale. Arithmetic means, ranks, and standard deviations of the statements appear in Table 5. Using factor analysis, high correlations between variables were examined, assessed using the Barlett test and its degree of significance ($p<0.01$). High correlations between variables were evident, and thus data came from multiple normal distributions, an adequate result since the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and chi-square (χ^2) were 0.678 and 1046.299, respectively. The sample size was thus sufficient to define the risk management strategies in the study. Common vari-

Table 5 - Defining risk management strategies.

Item	*Mean*	*SD*	*Rank by mean*
Taking out agricultural insurance	3.97	1.28	12
Renting assets such as land, machinery, and equipment	2.71	1.32	19
Repair or renewal of agricultural machinery after a period	3.62	1.23	15
Using certified nurseries	3.16	1.46	16
Determining input use levels in appropriate amounts (chemical pesticides and fertilizers)	4.34	0.93	5
Efficient use of irrigation systems	4.40	0.89	4
State encouragement of young farmers to agricultural production, and agricultural training and demonstration studies	4.26	1.24	7
Accessing information using IT	4.40	0.89	4
Working with an educated workforce that is expert in its field, has appropriate skills and experience	4.41	0.97	3
Ensuring worker safety	3.92	1.07	13
Sales spread throughout the year	4.23	1.08	8
Personal storage (pool)	4.11	1.09	10
Licensed warehouse system	3.69	1.20	14
Cooperative and farmer organization	4.26	1.15	7
Direct selling (without brokerage firm)	4.40	0.99	4
Contractual agricultural production	3.62	1.38	15
Debt reduction	4.45	0.86	2
Insurance against financial losses	4.19	1.01	9
Planning expenses	4.54	0.68	1
Regulation of investments	4.33	0.91	6
Keeping financial records	4.07	1.13	11
Out-of-business investment	3.07	1.43	17
Work outside agriculture	2.88	1.44	18

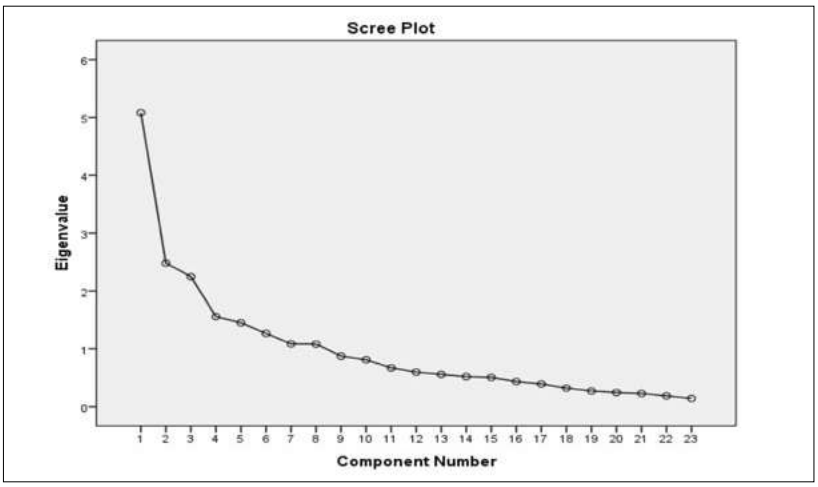

Figure 2 - Scree plot of risk management strategy factors.

ance (communality) represents the variance that a variable shares with other variables. Those with a factor loading of 0.5 or greater were retained, and those less than 0.5 were excluded. Since all factor loadings were greater than 0.5, they were all retained for analysis (Hair, 2006).

Explained total variance and eigenvalues before and after rotation suggested 8 factors from evaluation outcomes. Cumulative variance explained by the eigenvalues was 70.66% of the total variance. From a scree plot (Figure 2), the 8 factors were selected because there were 8 factors with eigenvalues of one and more ($\lambda \geq 1$). The rotated component matrix and communalities appear in Table 6.

Several inferences are warranted based on the factor loading results. Statements such as accessing information using information technology, state encouragement of young farmers to agricultural production and agricultural training and demonstration studies, working with an educated workforce that is expert in its field, has appropriate skills and experience, ensuring the safety of workers comprised the first factor, and efficient use of irrigation systems, determining the input use levels in appropriate amounts, repair or renewal of agricultural machinery after a certain period, and using certified nurseries comprised the second. The first factor includes strategies recommended for human-induced risks in general, and the second includes recommended strategies for risks related to production technology. The third factor included debt reduction, insurance against financial losses, and renting assets such as land, machinery, and equipment, and the fourth included keeping financial records, planning expenses, and regulation of investments. Among the third and fourth factors, there were risk management strategies related to production technology and strategies recommended for financial risks. The fifth factor included work outside agriculture and out-of-business investment expressions, and the sixth included sales spread throughout the year and personal storage (i.e., pools). These two groups comprised strategies for financial and marketing risks. The seventh factor group comprised licensed warehouse system, taking out agricultural insurance, and cooperative and farmer organization, and the eighth group comprised direct selling (i.e., without a brokerage firm) and contractual agricultural production. These last two groups comprised strategies for marketing risks.

Results from this study corroborate results from extant studies. Boggess *et al.* (1985) and Patrick *et al.* (1985) propose expressions such as improving investments, access to the most ideal and up-to-date market information, and entrepreneur differentiation as risk management strategies in the United States. Meuwissen *et al.* (2001) argue that management of production costs and improvement to insurance schedules are the most appropriate risk management strategies among livestock farmers. Flaten *et al.* (2005) recommend risk management strategies for farmers on organic and conventional cattle dairy farms in Norway, including improving farm cash flow,

Table 6 - Varimax-rotated factor loadings of risk management strategies.

Item	*Factors*								
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*Commu-nality*
Accessing information using IT	0.819								0.755
State encouragement of young farmers to agricultural production, and agricultural training and demonstration studies	0.697								0.667
Working with an educated workforce that is expert in its field, has appropriate skills and experience	0.696								0.602
Ensuring worker safety	0.574								0.631
Efficient use of irrigation systems		0.837							0.750
Determining input use levels in appropriate amounts (chemical pesticides and fertilizers)		0.828							0.777
Repair or renewal of agricultural machinery after a period		0.631							0.696
Using certified nurseries		0.561							0.608
Debt reduction			0.776						0.719
Insurance against financial losses			0.766						0.764
Renting assets such as land, machinery, and equipment			0.420						0.537
Keeping financial records				0.823					0.717
Planning expenses				0.725					0.736
Regulation of investments				0.685					0.774
Work outside agriculture					0.873				0.813
Out-of-business investment					0.855				0.764
Sales spread throughout the year						0.813			0.760
Personal storage (pool)						0.707			0.615
Licensed warehouse system							0.820		0.762
Taking out agricultural insurance							0.656		0.669
Cooperative and farmer organization							0.582		0.722
Direct selling (without brokerage firm)								0.726	0.747
Contractual agricultural production								0.725	0.767

preventing diseases, buying farm insurance, and improving production costs. Martin (1996) offers an ideal risk management strategy for farmers in New Zealand to reduce risk, arguing that it might vary significantly depending on the nature of the product, market structure and conditions, farmer characteristics, and dynamic risk regulation rules.

Kisaka-Lwayo and Obi (2012) introduce major traditional risk management strategies that are primarily at the first levels, including product diversification, precautionary savings, and participation in social networks. Using a comprehensive literature review, Duong *et al.* (2019) identify statements that represent what farmers perceive to be the most important risk management strategies, including diversification of plants and animals produced (i.e., differentiation in product patterns), monitoring and prevention of diseases and pests, development of off-farm business opportunities, farm insurance, debt reduction, adoption of new technologies, lowest cost production, improvement of extension services, working with other farmers, increasing cooperation opportunities, creating opportunities for good cooperation with the government, and increasing education and adaptation.

Lubben (2020) offers extension risk manage-

ment education (ERME) so that producers can develop various risk management strategies against excessively increasing prices of agricultural products and highly variable effects of Covid-19 in the United States. After a comprehensive survey conducted among producers, four topics emerged, including focusing on marketing (i.e., hedging), farm programs, crop insurance, and price levels. Most participants reported that price, profitability, and cost control will be the most important issues over the next 10 years. Important and dynamic recommendations should thus be created by focusing on the negative effects that Covid-19 created and/or might cause on agricultural production. In the United States and with Farm Income Protection (WFRP) as a new policy, a risk management safety net has been created for all goods under a single insurance tool, and the system is available in all territories across the country. The insurance scheme covers all insured income of up to $8.5 million, including farms with private or organic produce (e.g., both crop and livestock production) and local, regional, farm-protected, private, and direct farms capable of marketing their products (USDA, 2021c).

Boháčiková *et al.* (2021) report that in Slovakia, agricultural production is managed by commercial insurance, which does not cover all risks and losses adequately. In case of catastrophic damage and special events, private support from the state budget and insurance premium support for vineyards are available. Most farmers try to compensate for income losses with direct payments, and thus the study suggests that Slovak agriculture has much to learn about establishing risk management at the national and farm levels. Loriz-Hoffmann (2021) introduced the Common Agricultural Policy (CAP) principal framework and financial instrument, including risk management tools, in which the Paris Climate Agreement, the Sustainable Development Goals, and political priorities of the Commission are discussed. Economic, environmental, climatic, and social components included in specific purposes can be viewed as a kind of risk management strategy. As an economic factor, it ensures sustainable farm income and security within the Union, encourages market orientation and competitiveness, gives importance to research, technology, and digitalization, and improves the position of farmers in the value chain. Regarding environmental and climatic conditions, it contributes to climate change adaptation, accelerates sustainable development of soil, water, and air, manages natural resources, contributes to biodiversity protection, improves ecosystem services, and protects habitats. As a social principle, it makes rural areas attractive to young farmers, establishes jobs in rural areas, and develops rural areas, including bio-economies and sustainable forestry.

4. Conclusions

Manisa is the top producer of table olives across Turkey's Akhisar district, and its farmers variously perceive resources and risk management strategies. This study assesses factors that contribute to decisions regarding agricultural insurance, which represents an important risk management strategy tool. Findings suggest that farmers' recordkeeping, memberships in cooperatives, and the size of an olive farm affect the probability of buying agricultural insurance. According to factor loadings, financial risk sources represent the first factor group. Unlike sources of financial risk, in the human-induced risk category, only one factor exists—an insufficient family workforce and agricultural abandonment by the younger generation. The second group comprises sources of marketing risk, including risks related to production technology as risk management strategies.

The risk factors that farmers perceive and their risk management strategies overlap, but the rapid spread of Covid-19 worldwide during the first quarter of 2020 led to significant changes to producer behaviors and expectations. It is thus not difficult to predict that rapid and continuous increases to agricultural inputs and product prices will represent bottlenecks for both farmers and consumers soon. To allow farmers to continue to grow table olives and meet consumer expectations, especially worldwide, requires development of risk management strategies in Turkey.

The Akhisar region and the Mediterranean Basin have cultural and historical habits related to table olive farming. As with other types of agriculture, table olive farming has versatile dimensions such as multifunctionality, sustainability, and geographical indication, providing

farmers with sustainable income. Farmers use the most appropriate risk management strategies by prioritizing them against the risk sources that they perceive (e.g., risks related to production technology, human-induced risks, marketing risks, and financial risks). That process will likely become much more difficult and complex soon, and it would thus be beneficial for future research to analyze possible changes in-depth, especially regarding the effects of Covid-19.

The role of TARSİM (insurance of agriculture) should be increased in the production of table olives in the research region and throughout Turkey, the risk sources perceived by the producers and their risk management strategies. The full package includes many insurance products such as flood and flood, fire and landslide, storm, and the risk of frost is optional. Income protection insurance, which was used for the first time by TARSİM in 2021-2022, is very important. Although it is currently used as a pilot study in only one province and wheat, it is considered that the development of this insurance product to include table olives in the following processes will play an important role in the formation of agricultural policies and shaping agricultural supports.

In TARSİM, the government support for the premium generated in crop insurance is 50%, and in case of the occurrence of adverse risk sources such as drought and climate change, the government support provided to the premium can increase to 2/3. It can be stated that this solution tool also offers an important innovative approach.

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The last chance for intermodal strategies for redistribution of vegetables from Southeast Spain

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Abstract

European Administration has spent years trying to shift traffic from the road to the sea, using intermodality in order to achieve a modal rebalancing. This study analyses new approaches that strengthen the modal shift, rather than focusing simply on the reduction of externalities. A possible option is to redefine ports, conceptualising them as redistribution and coordination centres and not only as areas of cargo exchange. The present article analyses this problem by attempting to promote intermodality (truck and short sea shipping) for the transport of highly perishable products (vegetables) exported from Southeast Spain, which is the leading supplier to Europe. The location of coordination centres between customer-provider is analysed by applying a p-median multicriteria model, adapted to the transport of perishables. This scheme avoids bias in decision-making processes.

Keywords: *Agile response time, Digitalisation, Retailer, Transport, Supply chain.*

1. Introduction

Despite the efforts made to promote Short Sea Shipping (SSS) in merchandise transport, the demand for this service as an integral part of a logistics network is still well below that of road transport (European Commission, 2017). Several research works have shown that operators have a clear preference towards land transport (Raza *et al*., 2020). These studies point out several reasons for this preference: SSS has a bad image in the door-to-door transport chain; embarkation procedures require documentation which is not standardised among different ports or countries; port infrastructure often represents a limiting factor; there is a lack of information and monitoring of the cargo during transit; and the service provided tends to be slow and infrequent. Although intermodal transport using SSS is usually cheaper than by road, transit times are longer. This point is crucial when transporting perishable products, where product quality can be adversely affected. In any case, this variable is also influenced by the frequency and number of passages. It is possible that as the willingness to use intermodal shipping increases, the frequency of boats per week would increase as well, thereby reducing the time difference between intermodal and land transport. It is important to note that these problems do not occur only in intermodality for perishables with the use of SSS (Rossi *et al.*, 2021).

As a positive aspect, the literature finds that maritime transport is more sustainable than road

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transport (Gonzalez Aregall *et al*., 2018; Vallejo-Pinto *et al*., 2019. In this sense, it is clear that deep-sea shipping services are less polluting, but in the case of short see shipping (SSS) this comparative advantage is not so evident (see Hjelle, 2014). For example, considering Greenhouse Gas emissions per ton-km, SSS is not always preferable to road transport (Kotowska, 2016). Nonetheless, SSS is still considered an interesting alternative to be promoted as a step towards sustainable logistics chains (Pérez Mesa *et al.*, 2021).

Among the strategies of The European Commission to reduce greenhouse gas emissions by 2050 is to shift 30% of road freight transport over short distances to alternative modes (European Commission, 2011; European Commission, 2016). In this sense, SSS and motorways of the sea (MoS) are good tools. SSS and MoS, using Roll on-Roll off (Ro-Ro) short sea shipping services, are equivalent concepts. Both systems refer to the movement of cargo and passengers by sea between ports situated on a coastline of the seas in Europe or bordering Europe (European Commission, 2016). However, this definition does not clarify what type of goods must be transported. For Douet and Cappuccilli (2011), MoS may, or may not, be useful depending on the type of product, for example perishable or non-perishable. Therefore, it might make sense to use only MoS for goods where delivery time is not "vital".

In short, the European Commission believes shifting traffic from the road to the sea will be positive for the environment and society as a whole by mitigating negative externalities, such as congestion, pollution, or traffic accidents. Despite all efforts, however, shippers remain reluctant to shift traffic from the road to the sea (Paixão Casaca *et al*., 2010), and very little success has been achieved since the publication of the First White Paper on Transport (European Commission, 2001). Nevertheless, over time, the European Commission still expects to reconfigure maritime intermodal logistics by promoting a more sustainable transport model than roads can offer (European Commission, 2018). It is expected that improvement of frequency and quality to offer a door-to-door service at similar cost conditions to the truck alternative will be the key to MoS's success (Lupi *et al*., 2017; Paixão Casaca *et al*., 2010), more so in perishable goods (Pérez Mesa *et al*., 2012).

Within this framework, the aims of this paper are several. The most important is the identification and assessment of alternative transportation strategies, based in the intermodality, for F&V exported from Southern Spain to EU: the present study analyses whether SSS is applicable to the case of perishable goods. The empirical analysis will be applied to the exportation of fruit & vegetables (F&V) from Southeast Spain (Almeria, Murcia and Granada) to Europe. This region is the leading vegetable supplier to the European Union (EU), as well as the United Kingdom. Nearly 40% of vegetables consumed in the EU come from Southeast Spain. In 2020, this region exported more than 6 million tons of vegetables to the EU at a value of 5.7 billion euros (Eurostat, 2021). The key intermediary customers are large distribution chains (Aldi, Carrefour, Lidl, Edeka, Rewe, Tesco, etc.). These clients buy 70% of all shipments. The cost of transport represents, on average, 30% of the price received by the exporter in the destination markets (Pérez Mesa *et al*., 2019), meaning lowering its cost would be a key competitive strategy, more so considering large competitors outside the EU, such as Morocco, are already using SSS to transport large amounts of vegetables from Tangier to ports in the south of the United Kingdom and northern Europe.

The study also analyses the possibility of establishing redistribution centres in the centre of Europe for perishable products, in this case F&V from Southeast Spain that are exported to the rest of Europe. The fact that 95% of current F&V transport is conducted via refrigerated trucks could be the key reason for implementing the European strategy for SSS (Pérez Mesa *et al*., 2019). The present work also attempts to identify whether the inclusion of environmental costs can favour the modal shift from "only road" transport to an intermodal system. This is important because shippers prefer profitability to environmental performance of transport (Lupi *et al*., 2017). In any case, great care must be taken when comparing the suitability of SSS versus road transport because in some cases external costs are not correctly internalised (Suárez-Alemán *et al*., 2016), for example, by not considering the costs of infrastructure involved.

In general, the estimated total external costs for road transport per tonne and kilometre are higher compared to SSS (García Menéndez & Feo-Valero, 2009), but sometimes this depends on the chosen route (Vierth *et al*., 2019).

Methodologically, this paper seeks to contribute to the literature by proposing a different and complementary approach to establish a comparison between SSS and the "only road" alternative. For this purpose, the multicriteria decision is utilised in a p-median model (P-M) adapted to a means of shipping selection problem which must consider different variables: transit cost (including externalities), time and frequency (including agile response time). Some works have addressed intermodal selection based on modified p-median models. For example, Teye *et al*. (2017) proposed a probabilistic approach for locating competitive multi-user facilities in a maritime transportation system when complete information is not available for decision makers by using a bi-level model that incorporates the weighting of new variables (Abareshi & Zaferanieh, 2019). The multicriteria decision is another way to address this problem from a much simpler point of view.

2. Redistribution centres and its integration into a general perishable's transport strategy using SSS

Several works demonstrate that integrating redistribution or consolidation centres into perishable supply chains benefits suppliers and customers in several ways (Orjuela-Castro *et al.*, 2017; Caracciolo, 2018; Martins *et al.*, 2018; Pal & Kant, 2018). However, a few studies address the benefits related to the international distribution of this type of product (Pérez Mesa *et al.*, 2021). Some of the issues they analyse are detailed below.

1. Merchandise can be returned to the supplier for a variety of reasons. In such cases, the products would be disposed of due to the impossibility of returning them to origin. As an alternative, by utilising this new model, products could be repackaged and served again to customers. It is estimated that 10% of exports are returned by customers due to minor defects. In economic terms, for Southeast Spain, this represents more than 550 million euros in losses for exporters. In the case of the new strategy, response time to customers would be reduced, as a portion of the repackaged produce would be served from the redistribution centre rather than from origin. In other words, a product that would otherwise be wasted could be sold again.
2. It is important for suppliers to maintain a strategy of fast and agile (flexible) service. Suppliers could store produce in advance near the final demand and, based on their estimates, serve customers throughout Europe as they receive orders. As a result, response times to customers' orders (transit times) would be reduced by separating, albeit by a few days, transport to the logistics centre and the final shipment to the customer. Consequently, both service and customer loyalty would be improved. Also, this strategy could also have positive consequences on the reduction of waste, both in marketing companies at origin and at retail points of sale.
3. Large retailers (e.g., Aldi, Lidl, Rewe, Edeka, Carrefour or Tesco) with points of sale throughout Europe would want to have a distribution centre supplied by a priority origin (Southeast Spain in our case). This strategy would be framed within intensive supplier-customer collaboration in an ad hoc supply chain that is easier to implement. Although, in fact, there is a coordination system with buyer-driven supply chain dominance, especially in safety standards (Malorgio *et al.*, 2016).
4. This system constitutes a proactive strategy by suppliers, generating more stable relationships with customers. It must be noted that at present most shipping is organised by the customer. Additionally, this strategy can improve capacity to attract local/regional small retailers that require a more continuous service. What is more, vegetables from a long supply chain can be sold as "short chain" or "proximity".

In this context, the fundamental idea proposed is to integrate SSS and MoS into a global strate-

gy for the redistribution of perishables in Europe, which takes into account the reality of current supply chains that promote collaboration and logistical coordination between suppliers and customers (Cholez *et al.*, 2021). If properly managed, these redistribution centres could result in key advantages for all members in the supply chain: reduced delivery times, inverse logistics and improvement of flexibility and service quality and reliability. Digitalisation would become the key transversal focus at these centres, as it would serve to optimise all processes (Martins *et al.*, 2018). More specifically, the aim is to study the use of European ports on the Atlantic and Mediterranean coasts so they may serve as consolidation and redistribution centres of F&V that can generate an agile response to customer demands, integrating into the new trends towards short food supply chain (Enjolras & Aubert, 2018).

In practical terms, it is assumed that loads of F&V are to be transported from the port of Almería (Southern Spain) by means of an intermodal system making use of short sea shipping (SSS). The produce can be transported by ship from the port of Almería to various destination ports (along the Atlantic and Mediterranean); from there it is to be transported by road directly to the end customers. The opposite alternative consists exclusively of road transport from the origin port to the final customer. The present work will seek to determine the optimal routes in order to minimise transit cost (including external cost), time and frequency. Figure 1 illustrates the objective of this work and the integration of SSS into this strategy. The selected destination ports along the Atlantic coast are Southampton, Hamburg and Dunkirk; along the Mediterranean coast Marseille and Livorno. These destinations were agreed upon by logistics experts for having storage potential for perishable products. In fact, there have already been shipping trials from Southeast Spain to some of these ports, as in the case of Almeria to Dunkirk and Southampton. The final unloading destinations (specific cities) were obtained from interviews with logistics managers of horticultural commercialisation companies.[1] Unloading figures were calculated from the total exported volume of F&V from Almeria, Murcia, and Granada (Spanish Customs, 2020), distributed among the final destinations (unloading cities per country) identified by the experts, who also provided approximate % of unloading per city.

Note that the key elements in any intermodal transport system are the intermodal terminals (IMTs) and their geographical locations with respect to cargo origins and destinations (Salucci, 2006). The level of user benefits or attractiveness of the new means of transport critically also depends on where the IMT is located with respect to the cargo origins and destinations.

From a transversal perspective, this strategy would require a "refinement" of cross-docking procedures, e.g., the use of multifold transportation processes, temporary inventories or combining with other merchandise. In this sense,

Figure 1 - Intermodal transport strategy proposed for vegetable products from Southeast Spain. Metric tonnes transported.

Black = Origin of the merchandise; Grey = Unloading areas and transported volume (final customer); Arrows = Examples of intermodal routes; Crosses = Ports chosen as redistribution centres.

[1] Special thanks are given to the Organization of Fruit and Vegetable Producers of Andalusia (APROA, www.aproa.eu).

Table 1 - Logistics benefits of the digitalisation of the supply chain and its relationship with creating redistribution centres.

Tactical and operational improvements	*Strategic improvements*
• *Coordination of communication between supplier-customer*: real-time exchange of information that favours shipment planning and the selection of transport system. • *Capacity control*: Know the status of incoming cargo so it may be distributed to the means of transport without any delays. • *Route optimization*: Optimise the route and transport system in the most effective manner. • *Cargo control*: Be aware of any eventuality in real time, which favours communication with the customer to react with sufficient time to any setbacks. • *Traceability in real time*: Systems capable of following not only the vehicle or shipments, but also each item individually. • *Energy optimisation*: filtering of routes and intermodal systems according to effective energy consumption between origin and destination (optimisation of carbon footprint). • *Implementation of Business Intelligence systems* for the improvement of management (development of Data Cubes for each agent). • *Forecast improvements* related to supply (variable in agrifood sector) and demand. Such forecasts would lead to reductions in waste and losses.	• *Facilitate the creation of intelligent distribution centres at destination*: better coordination between supply and demand facilitate the exchange and consolidation of cargo at destination, making feasible the creation of redistribution centres at destination. The tactical and operational improvement can be more readily implemented. • *Development of stable logistics relationships between supplier and customer* based on intelligent information exchange strategies. Basis for differentiation in relation to the competition. • *Improvement of the logistics efficiency and sustainability* of the supply chain.

Source: Own elaboration.

the use of ports can be optimal. Nevertheless, supply chain digitalisation would have to be implemented. Digitalisation represents one of the key points for the development of redistribution centres due to the opportunities for coordination that it offers (Martins *et al.*, 2018).

More specifically, the digitalisation of logistics management implies the use of different methodologies, technologies and tools (Anke, 2017): i) the development of ad hoc software for tracking and product selection to bring production closer to the consumer, ii) the application of the Internet of Things (IoT) to facilitate multiple processes, for example, traceability, control and optimisation of transport, or access to real-time information so management can make decisions (Ben-Daya *et al.*, 2019); iii) the accumulation of disaggregated information with Big Data tools and its immediate availability to management (cloud computing) to be later interpreted by Business Intelligence applications; and, iv) the application of other technologies, such as Blockchain, to facilitate documentation exchange and expedite administrative procedures, or even recognise patterns (neuronal networks) with the objective of predicting supply (variable) and demand, common in the agrifood sector. As can be seen, these aspects could easily be taken advantage of at intermodal redistribution centres (Table 1).

3. Methodology

3.1. *Classic P-Median problem*

The distribution and location family of problems encompasses formulations varying in complexity from simple single commodity linear deterministic models to multi-commodity nonlinear stochastic versions (Farahani *et al.*, 2010). The techniques applied can be used for all types of facility location models including: single facility location, multiple facility location, quadratic assignment problems, location–allocation, covering problems, p-median problems, p-centre problems, hierarchical facility location problem, hub lo-cation problems, competitive facility location, warehouse location problems, dynamic facility location problems, location inventory,

location-routing, location reliability and, in recent times, location in supply chain using a mix of different approaches (Zheng *et al.*, 2019). The problem with p-medians (P-M) is locating p facilities in a network, minimising the sum of all costs or distances from a demand point to the nearest facility, while respecting its full capacity. This problem has been widely addressed in the literature, namely, the seminal works of Hakimi (1964). The general formulation implies:

$$Min \sum_i \sum_j h_i \, d_{ij} Y_{ij} \quad [1]$$

s.t.:

$$\sum_j Y_{ij} = 1 \quad \forall i \quad [2]$$

$$\sum_j X_j = p \quad [3]$$

$$Y_{ij} - X_j \leq 0 \;\; \forall i, j \quad [4]$$

$$X_j = 0, 1 \;\; \forall j \, ; Y_{ij} = 0, 1 \quad \forall i, j \quad [5]$$

Where Yij is 1 if customer i is served by facility j, 0 if not; hi is demand at location i; dij is cost/distance from location i to location j; p is the number of facilities to be located. The objective function [1] minimises the demand-weighted distance between each demand node and the nearest facility. Xj is 1 if a facility is located at candidate site j, 0 if not. The first constraint [2] ensures that each demand node will be allocated to one and only one facility. The second constraint [3] sets the number of facilities to open to exactly p. The next constraint [4] prevents demand from being allocated to candidate sites that do not have facilities. The last constraint ensures that Xi and Yij have Boolean values of 0 or 1.

All the models proposed in this paper were solved using PuLP, which is a modeler written in Python. PuLP has quite a few choices of solver algorithms (e.g., COIN_MP, Gurobi, CPLEX, etc.). For this problem, we do not specify any choice and let the program default to its own choice depending on the problem structure. Access to the software programmed for this paper is provided in the Google Collaboratory environment.

3.2. *Multi-criteria optimisation within the P-M problem*

The proposed models utilise land distance, travelled by truck, as a reference variable. However, it may be worthwhile to include other decision factors that introduce the possibility of a modal shift in the modelling. The two most important variables that condition the selection of a perishables transport system are time and cost (Pérez Mesa *et al.*, 2019), which is why they will be introduced in a multi-criteria optimisation approach within the P-M.

In short, this paper seeks to maximise a utility function as follows:

$$U = \sum_p^n w_p \;\; f_p(x),$$

where $f_s(x)$ is the mathematical expression of the p-th attribute and w_p is the weight or pondering that the decision maker gives to that attribute. More specifically, the present study utilises weighted goal programming, which is a widely-used multi-criteria solution method in the literature (Ching-Ter *et al.*, 2014; Antunes & Henriques, 2016). The function applied and adapted to the case of analysis can be found in Annex 1.

3.3. *Transportation cost function*

For intermodal costs, the calculations begin with a matrix c^l for unitary costs per lorry, derived from transporting the merchandise from each destination port to the customer's door and from the place of origin to the end customer (by truck). It is worth noting that introducing a type of non-linear cost function could be desirable considering the increase in cargoes that pass through a specific port could in turn increase the competitiveness of the logistics operators and reduce the unitary cost of maritime transport. However, from an environmental point of view, it is also shown that the higher the load factor of the ship, the wider the geographical scope for which the SSS is preferable (Vallejo-Pinto *et al.*, 2019). For these reasons, it is necessary to create a model for these effects. In order to solve this problem, a potential function of maritime costs was designed (see Annex 1).

3.4. *Transit time function*

In this paper, total intermodal transit time (t_{ij}^I), in contrast to "only road" transport time (t_{ij}^L), will include two variables that are relevant to selecting between land and intermodal systems. The first is shipping time plus the last stage by road

(t_{ij}^{Is}), which refers to the duration of the transport between the port (or area) of origin and the destination port and final customer. The second is a variable designated as maximum wait time (t_{ij}^{Ie}), whose purpose is to consider the frequency (f) of the mode of transport in the analysis. In this way, for example, if the operator chooses land rather than intermodal transport, and knowing that lorries depart 7 times a week, the maximum wait time is equal to the number of total hours in a week (168 h) divided by the weekly frequency of the mode of transport (departures/week) t_{ij}^{Ie} = (168h/week)/f, which is 24 h. This figure represents the maximum number of hours that, in the worst case, an operator would have to wait to send their merchandise to the customer due to not being able to find an available lorry. With this formulation it can be concluded that $t_{ij}^{I} = t_{ij}^{Is} + t_{ij}^{Ie}$. In the present case, the frequency corresponds to a route taken four times per week, that is, t_{ij}^{Ie}= 42 hours. Note that it is possible that as the willingness to use intermodal shipping increases, the frequency of boats per week would increase as well, thereby reducing the time difference between intermodal and land transport (Pérez Mesa *et al.*, 2019). The new objective function can be found in Annex 1.

3.4.1. *Randomness of transit time*

Intermodal transit time (t_{ij}^{I}) is one of the critical variables of model [10] due to its randomness, owing to the existence of uncontrollable factors, for example, weather conditions or the state of a ship, which can affect its speed. It must be noted that this variability can affect both shipping time (t_{ij}^{Is}) and maximum wait time (t_{ij}^{Ie}). For this reason, we analyse how this might affect the results if we consider that $t^{I}(\xi)_{ij} \sim N(\varepsilon, \sigma^2)$.

The resolution algorithms for this type of problem are complex and depend on the type of distributions involved, whether random variables only appear in the objective function, only in the restrictions set, or in both (Chen *et al.*, 2011). In certain cases, the problem is notably simplified if the distribution of the random variables assumes a specific probability distribution (normal is the most common), as in the present case. Many researchers have extensively studied random path problems, such as Zockaie *et al.*, 2014; Sheng and Gao, 2016. Many of these models can have significant biases if there are not enough observational data. Our model seeks a deterministic equivalent of this stochastic problem in order to facilitate practical implementation. Using this type of model makes it possible to test the robustness of deterministic models with conditions of variability. The new objective function can be found in Annex 1.

3.4.2. *Attractiveness of redistribution centres for the customer thanks to agile response time*

At this point, we must consider how to incorporate the attractiveness of each redistribution centre for the customer. With this aim, a term is defined which specifies the probability that a customer residing at demand point *i* (demand located at node i) is served by facility *j*:

$$A_{ij} = \frac{u_{ij}}{\sum_j u_{ij}}$$

where u_{ij} is the utility of a facility located at node *j* for a customer originating at node *i*. This gravity p-median model (Drezner and Drezner, 2007; Drezner, 2014) assumes that $u_{ij} = \partial_{ij} t_{ij}^{-\lambda}$ where t = t_{ij}^{I} for intermodal transport or t_{ij}^{L} for "only road" transport; and ∂_{ij} denotes the attractiveness of facility *j* for customer *i* and λ denotes the parameter of the exponential time decay function. In other words, the utility measure decreases with time and increases with the attractiveness of a facility. The larger the value of lambda, the more attached the customer is to the nearest facility. In our case, we utilise λ = 0.6 to prioritise facilities near the customer as we are dealing with highly perishable products. In practical terms, priority is given to the most centrally located points (Carling *et al.*, 2015). The new objective function can be found in Annex 1.

3.5. *Data*

This paper examines Ro-Ro type transport vessels (speed of 18 knots, 145 TEUs[2]), so the

[2] Twenty-foot Equivalent Unit = 21,600 tons.

Figure 2 - Cost (€/TEU) of maritime transport between the port of Almería (South of Spain) and the port of destination.

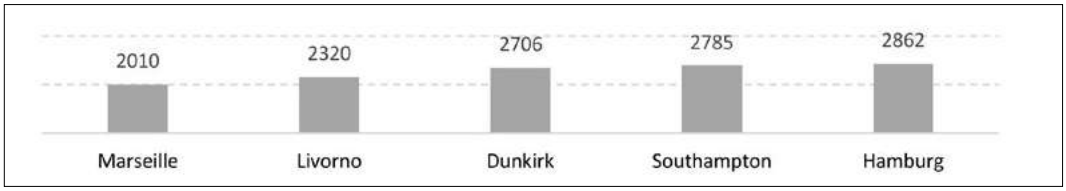


Figure 3 - Costs (€) for international transport refrigerated lorry.

maritime costs refer to the offer of a shipping company willing to provide the service plus the structural costs of leaving the platform of a trailer immobile for the duration of maritime transit. The port fees are the expenses derived from loading and unloading at the ports (origin and destination). In the present case, the offers proposed by the shipping companies are generic and include the port fees (offers received in December 2020). It is important to note that shipping lines do not exist. In order to obtain the price offers, a shipping broker located in the port of Almeria, was used. The researchers provided the destination ports, previously selected.

Figure 2 displays the transport costs of ad hoc lines with origin in Southern Spain and destination in Southampton, Hamburg, Dunkirk, Marseille and Livorno. These costs are roundtrip journeys. Upon return, it is considered that the containers are empty, which reflects current reality. In fact, maritime logistics have difficulties filling returning cargo, more so in the case of newly created lines.

The alternative is to transport the merchandise directly by road to the final customer. The data utilised are real. The cost (cL) corresponds to a refrigerated lorry for international transport and equal to 1.474 €/km (Spanish Ministry of Public Works and Transport, 2021), the distances (km) between ports and end customers were calculated using road guide software.[3] It is worth noting (Figure 3) that fuel costs only represent 29% of the total. It is also important to point out that tolls account for 8%.

In order to complete the analysis, it is necessary to include external costs derived from both maritime and ground transport: air pollution, costs derived from road congestion, noise, infrastructure wear and tear, costs from accidents and the emission of greenhouse gases. The present study followed the works of Denisis (2009), Álvarez Vivas (2012) and Vallejo-Pinto *et al.* (2019) in order to make the calculation. Said works establish costs per tonne and distance corresponding to land transport and Ro-Ro and Feeder (container) type maritime transport, similar to those used in this study. The summary of adapted data can be seen in Table 2. It must be noted that the inclusion of the externalities in road transport causes the former to increase by more than 35%. It is also important to ob-

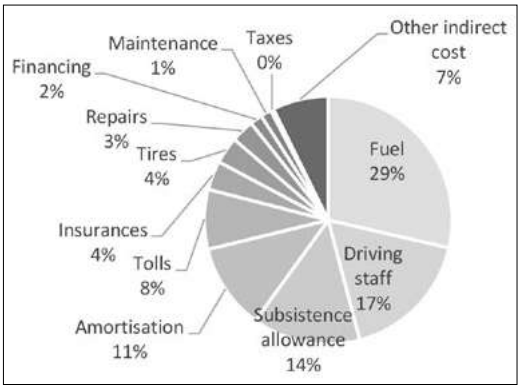
Table 2 - External costs of selected transport.

Concept	*Ro-Ro*	*Lorry*
Air pollution (1)	0.215	0.028
GHG (2)	0.001	0.002
Noise	0.000	0.290
Accidents	0.004	0.070
Congestion	0.007	0.046
Infrastructure	0.023	0.087
TOTAL (€/TEU/km)	0.249	0.522

(1) Emission of particulate matter, sulphur dioxide (SO_2), nitrogen oxide (NO_x), carbon monoxide (CO), volatic organic compounds.
(2) Emission of Greenhouses gases (CO_2). The calculations for (1) and (2) include all of the loading and unloading activities at the ports.
Source: Adaptation based on Denisis (2009), Álvarez Vivas (2012) and Vallejo-Pinto et al. (2019).

[3] To obtain the distance matrix more easily, software was programmed in Python, linking with Microsoft's Bing Maps API. Access in the Google Collaboratory environment.

Figure 3 - Costs (€) for international transport refrigerated lorry.



Source: Spanish Ministry of Public Works and Transport (2021).

serve that the concepts that favour SSS transport versus land are only those related to the maintenance of road and the indirect effects derived from road congestion. Emissions are higher in the case of Ro-Ro transport.

Annex 2 shows the costs (€/TEU) of transporting cargo from Southeast Spain to the three main exportation destinations via intermodal and only road, including externalities. The first feature that stands out is that even by including externalities there are routes, discarding the closest ones, where truck transport is cheaper and more sustainable, as in the cases of Stuttgart, Frankfurt, Lyon and Prague. The average savings cost of intermodal transport is 15%.

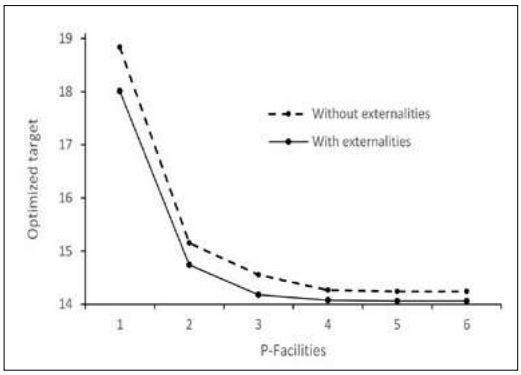
The time calculations utilised the average speed of 75 km/h and the legal driving times (only 9 hours per driver per day and obligatory breaks) and the matrix of distances obtained by the online land route manager (Microsoft Maps – Bing). The duration of the journeys by SSS between the port of Almeria (Southeast Spain) and Southampton, Hamburg, Dunkirk, Marseille and Livorno are 69, 76, 29, 41 and 94 hours, respectively. Sea transit times were provided by the logistics management (brokers) located in the port of Almeria, according to costs (and type of ship) also offered. Annex 3 displays the total times of both intermodal transport and "only road". The data show that the intermodal transport time is, on average, 2.3 times higher than "only road". Without question, this variable conditions the use of intermodality with perishable products.

4. Results and discussion

To begin, we must determine the number of facilities (p) that could be considered optimal. Figure 4 shows that with p>3 there is little improvement of the objective. The calculations are applied to the cost as it is the variable to which the externalities must be added. It can be deduced that p=3 can be considered the suitable number of distribution centres, more so if we consider the existence of destinations in remote areas of the European continent. Additionally, it can be observed that the introduction of environmental costs (externalities) improve the results 2.3%, on average. That is, this incorporation does not provide substantial improvements that can favour the modal change through the creation of redistribution centres at ports. Furthermore, it is shown that with p=3 the difference increases. Based on these results, it is determined that the suitable network which will continue to be studied herein will be defined by the existence of three ports or intermediate distribution centres.

Table 3 shows the results of all the proposed models ($p \leq 3$). If we consider a simple p-median model without cost correction, without including time as a decision variable, nor the externalities (O1), intermodality would represent 52% of transport. The inclusion of externalities

Figure 4 - Trade-off curve between target and P-facilities for w_c=1; α=0.2; θ=250,000t.



Source: Own elaboration.

Table 3 - Intermodal transport (truck+SSS) with and without externalities. Metric tonnes.

	O1	*O2*	*O3*	*O4*	*O5*	*O6*	*O7*	*O8*	*O7 agile*
Cases tested	w_c=1 $p \leq 3$	w_c=1 $\alpha = 0.5$ $\theta = 150{,}000t$ $p \leq 3$	w_c=1 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$	w_c=0.5 w_t=0.5 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\,h$	w_c=0.7 w_t=0.3 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\,h$	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\,h$	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 56\,h$	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42h$ $\sigma = 150\%$*	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42h$
A) % Intermodal without externalities	52%	65%	45%	13%	23%	33%	33%	28%	63%
B) % Intermodal with externalities	63%	68%	57%	23%	37%	57%	45%	51%	63%
Load Tons A (x 1000)	2799	3498	2422	700	1238	1776	1776	1507	3510
Load Tons B (x 1000)	3391	3660	3068	1238	1991	3068	2422	2745	3510

(*) ε = average shipments years 2018-2020; φ = 95%.

improves the results by 11 percentage points. The incorporation of economies of scale causes the results to vary for the most part, depending on the threshold (small thresholds (O2) would favour the modal shift, with respect to the base model, while the opposite would occur with higher thresholds (O3).

These results reveal the strong variability that can exist depending on the improvements in cargo groupage, the incorporation of better adapted ships or even the optimisation of coordination between customer and supplier, all of which with the aim of reducing unit costs. The decision to include the time variable in the models (O4 to O6) causes a "radical" drop in the expectations for intermodality. To return to the same results of model (O2), the weights must be wc=0.85 wt=0.15, in other terms, the decision maker must value the cost more than fivefold in relation to the transit time. For equal weights between cost and time (O4), intermodality would represent 23%. These results demonstrate that intermodality, despite the inclusion of time, can be an option, albeit to a small extent, for specific routes. It is also found that the simplification of the decision models can result in considerable bias in the results.

In parallel, we also test the increase in maximum wait times (O7), revealing a considerable reduction in intermodality. Undoubtedly, the existence of greater frequencies is a key variable to be considered if there is any desire for a modal change. The random times model (O8) demonstrates the robustness of the results of the deterministic model: such high variability as that incorporated (σ = 150%) barely changes the results.

In general, it is observed that the consideration of transit time annuls the advantages in costs that can generate externalities for the modal change. It must be highlighted that the incorporation of the capacity of a flexible service for the customer considerably improves intermodal use (up to 63%). Indirectly, the (O6) agile model supports the simple (O6) model, thereby justifying its validity.

Delving deeper into the composition of the network, including externalities (Table 4), it can be observed that in all the models where only cost is included as the decision variable (O1-O3), the key redistribution centres would be located in Hamburg and Dunkirk. In other words, the Atlantic coast would be the primary option. Important destinations located in the United Kingdom and the Netherlands and central Europe would be supplied through Dunkirk, while northern Germany and the most eastern areas of Europe would be supplied by Hamburg. It must be highlighted that, for the most part, the largest customers located in France would prefer the use of trucks.

When including time in the weighted models (O4 and O5), the option of the port of Marseille, on the Mediterranean coast, would be the preferred choice for supplying isolated destinations.

Table 4 - Intermodal transport routes (truck+SSS) and "only road" with externalities.

	Using port or only road:								
	O1	*O2*	*O3*	*O4*	*O5*	*O6*	*O7*	*O8*	*O6 agile*
Cases tested / Final destinations:	w_c=1 $p \leq 3$	w_c=1 $\alpha = 0.5$ $\theta = 150{,}000t$ $p \leq 3$	w_c=1 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$	w_c=0.5 w_f=0.5 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\,h$	w_c=0.7 w_f=0.3 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\,h$	w_c=0.85 w_f=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\,h$	w_c=0.85 w_f=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 56\,h$	w_c=0.85 w_f=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42h$ $\sigma = 150\%$*	w_c=0.85 w_f=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42h$
Hamburg	Hamburg	Hamburg	Hamburg	Road	Hamburg	Hamburg	Hamburg	Hamburg	Hamburg
Stuttgart	Road	Dunkirk	Dunkirk	Road	Marseilles	Dunkirk	Road	Marseilles	Dunkirk
Berlin	Hamburg	Hamburg	Hamburg	Road	Road	Hamburg	Hamburg	Hamburg	Hamburg
Cologne	Dunkirk	Dunkirk	Road	Road	Road	Road	Road	Road	Dunkirk
Frankfurt	Road	Road	Road	Road	Road	Road	Road	Road	Dunkirk
Perpignan	Road	Road	Road	Road	Road	Road	Road	Road	Road
Paris	Road	Dunkirk	Dunkirk	Road	Road	Dunkirk	Road	Marsella	Dunkirk
Lyon	Road	Road	Road	Road	Road	Road	Road	Road	Road
Barendrecht	Dunkirk	Dunkirk	Dunkirk	Marseilles	Marseilles	Dunkirk	Dunkirk	Marseilles	Dunkirk
London	Dunkirk	Dunkirk	Dunkirk	Marseilles	Marseilles	Dunkirk	Dunkirk	Marseilles	Dunkirk
Glasgow	Dunkirk	Dunkirk	Dunkirk	Road	Road	Dunkirk	Dunkirk	Road	Dunkirk
Dublin	Dunkirk	Dunkirk	Dunkirk	Road	Road	Dunkirk	Dunkirk	Road	Dunkirk
Milan	Road	Road	Road	Road	Road	Road	Road	Road	Road
Rome	Road	Road	Road	Road	Road	Road	Road	Road	Road
Brussels	Dunkirk	Dunkirk	Road	Road	Road	Road	Road	Road	Dunkirk
Warsaw	Hamburg	Hamburg	Hamburg	Road	Road	Hamburg	Hamburg	Hamburg	Hamburg
Prague	Road	Hamburg	Road	Road	Road	Road	Road	Road	Road
Vienna	Road	Hamburg	Road	Road	Road	Road	Road	Road	Road
Stockholm	Hamburg	Hamburg	Road	Road	Road	Road	Road	Road	Road
Copenhagen	Hamburg	Road	Road	Road	Road	Road	Road	Road	Road
Helsinki	Hamburg	Road	Road	Road	Road	Road	Road	Road	Road
Lisbon	Road	Road	Road	Road	Road	Road	Road	Road	Road
Athens	Road	Road	Road	Road	Road	Road	Road	Road	Road
% Intermodal	63%	68%	57%	23%	37%	57%	45%	51%	65%
% Only Road	37%	32%	43%	77%	63%	43%	55%	49%	35%
Interm. Road Kms (hours)**	426 (6.2)	514 (7.5)	509 (7.5)	1204 (17.7)	1115 (16.4)	534 (7.8)	543 (7.9)	896 (13.2)	474 (6.9)

(*) ε = average shipments years 2018-2020; φ = 95%.
(**) =Average of the last road section (kms / hours) in intermodality ("agile response time").

As the cost variable becomes more relevant (models O6 and O7), Dunkirk is again preferred over Mediterranean ports. It should be noted that intermodality in the use of perishables requires the decision maker to value cost nearly six times more than transit time. It is also observed that intermodality is suitable for areas with certain proximity to redistribution centres (coastal areas) on the Atlantic coast and which generate loading capacities that can create economies of scale. A paradigmatic case is that of Brussels, which, despite its proximity to Dunkirk, would be better to supply by road. Of course, its location is on the borderline between intermodality and road and could surely be absorbed by the Durkirk hub with slight improvements to the intermodal logistics management, which is similar to the case of Cologne (in Germany). It is worth noting that models O1 and O2 provide for these changes, as does agile model O6. By introducing variability in transit time (O8), Marseille would be the key centre on the Mediterranean coast as this port combines the advantage of cost and customer response time in situations of uncer-

Figure 5 - Possible intermodal strategy (O6 agile). Metric tonnes transported.

Light Grey = Transport by road; Medium Grey = Intermodal centre using Hamburg; Dark Grey = Intermodal centre using Dunkirk.

tainty regarding sea transit time; this port boasts the shortest shipping time, which compensates for a longer road transit.

Agile model O6 incorporates Cologne, Frankfurt and Brussels into the Dunkirk hub, and as expected, improves response time. It is important to highlight that the redistribution centreoptions (excluding Marseille) have a response time of around six hours in the final stage by road. This detail is fundamental for providing the customer with optimum service, a key element for implementing redistribution centres. This system would also make it easier for returned products to be repackaged and resold.

Figure 5 shows the agile O6 strategy, which is a feasible extension of the O3 and O6 strategies and, thus, is one of the options with the highest prospects of success. Undoubtedly, the collaboration of merchandise suppliers, logistics services companies and customers (large European retailers), aided by the possibilities of coordination generated by the digitalisation of the supply chain, could produce synergies that would facilitate the modal shift, thereby further expanding the action radius of the selected redistribution centres. It is important to highlight that model (O8), even with longer response times, is a robust system that would minimise the risks derived from the longest SSS transit times, meaning it should not be discarded either.

5. Conclusions

The European Commission has not been successful in its efforts to shift traffic from the road to the sea using intermodality. The shippers still remain reluctant. It is time to seek new approaches. Objectively speaking, traditional transport logistics suffer from very significant deficiencies. A reason for this is the lack of cooperation and coordination among logistics companies, but also among marketing companies regarding groupage of shipments. Another factor is the complexity of ensuring empty trucks (in the upon turn), which is further complicated by perishability. Raising the efficiency of perishable transport and distribution is a very complex issue that becomes even more difficult when dealing with mixed commodity types (Pal & Kant, 2018).

Recent trends towards preferences for regionally grown food place further stress on regional, low volume distribution (local logistics) and complicate its integration with long-distance logistics, which is traditionally high volume and uses refrigerated transport. In fact, it is tempting to forego expensive refrigerated transportation for local logistics. In contrast, this article argues that international transport using intermodality can be a good option if it is integrated into specific business strategies, such as the creation of real distribution centres at ports or nearby locations. Moreover, the development of logistics networks is a fundamental point for the commercial maintenance of peripheral areas in the Mediterranean (Kendi *et al.*, 2020).

The main benefits of SSS compared to road transport are: i) cost savings (around 15%); and ii) reduction of externalities (around 35%). Undoubtedly, the critical point is the increase in transit times: 2.3 times higher than “only road”. However, utilising the multicriteria decision

within an adapted p-median model (P-M) for intermodality to be an ideal option, the cost variable (including externalities) must be valued by the exporter six times higher than transit time – a factor which affects quality, increases returns due to damage, etc. In a recent survey conducted among horticultural exporters (Pérez Mesa *et al.*, 2021), the most important decision variable, in nearly 37% of all cases, was that "the shipment is made in the shortest possible time". It is clear that perishability is the fundamental factor preventing modal shift. The difficulty of implementing intermodality leads us to consider whether to grant priority to road transit for the transport of perishable products and the use of SSS for other less delicate ones.

In general, the results reveal that, in the case of perishables and under normal circumstances, intermodality would be a secondary and viable option only for very specific destinations, for example, Hamburg and nearby locations, the area of influence of London, Paris and the Netherlands. In this regard, the Netherlands represents a special case, as it is an area of reexportation of similar products from, for example, north Africa. Thus, this last option should be avoided as it would not favour the differentiation of European products. Nonetheless, there are additional drawbacks.

As discussed above, the influence of externalities as a driver of modal shift "vanishes" when transit time is introduced as a decision variable. These results confirm that general strategies, e.g. those used by the European Commission, based on the benefits of intermodality to reduce transport externalities, lose their enforceability when applied to complex circumstances. We therefore considered whether the European strategy of applying SSS indiscriminately is the right approach. Subsequently, we proceeded to introduce several scenarios for transit time, including its randomness, as it is the key variable for modal shift. Note that we also reveal the robustness of deterministic models. This contribution is therefore a novelty in the sense that this paper infers that simplifying decision models, avoiding models or eliminating transport determinants can lead to considerable bias in the results.

The study also shows that by introducing the concept of agile response time (i.e., the time needed to deliver an urgent order from the redistribution centre to the customer), the intermodal option improves. In this sense, this article argues that international transport using intermodality can be a good option if it is integrated into specific business strategies, such as the creation of real distribution centres in ports or nearby locations, close to final consumers. Through these redistribution centres, F&V exports would be integrated into the new trends towards short food supply chain. These redistribution centres would offer important advantages: reduction of delivery times, inverse logistics, cost optimisation, flexibility and service quality and reliability, and improvements, when applicable, to order preparation and shipment. Moreover, the development of logistics networks is a key point for the commercial sustainability of peripheral areas of the Mediterranean (Kendi *et al.*, 2020).

In summary, perhaps the government should promote specific business strategies based on new trends in the supply chain (not only on the reduction of externalities) and find new approaches that strengthen the modal shift. A possible option is to redefine ports, conceptualising them as digitalised redistribution and coordination centres and not only as areas of cargo exchange. This entire strategy would not be viable without close coordination between the horticultural exporter, the customer (large European retailers) and the logistics service provider. In this regard, the digitalisation of logistics management should be a priority (Anke, 2017) as it would facilitate and "fine tune" the coordination of all the actors involved. As a further limitation, other operational aspects related to the management of redistribution centres are not addressed in this work. Without question, these issues deserve more in-depth research in future studies, specifically for the case of perishables.

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Annex 1 - Methodological annex

1. *Multi-criteria optimisation within the P-M problem*

The problem that arises from a practical point of view is:

$$Max \sum_p^n \frac{w_p}{K_p} f_p(x) \quad \text{Subject to F} \in \text{x; x} \geq 0 \qquad [a1]$$

Where F is the set of restrictions utilised and K_p is a factor of standardisation. To provide a sense of fairness between each objective function, it is necessary to normalise using root mean square, so $K_p = \sqrt{E\left[f_p(x)\right]^2}$. In the standardisation method, the minimising function is marked negative, while the maximising function is marked positive.

Applying formulation [a1], the new equation [1] would take the following form:

$$Min \ \sum_p \sum_i \sum_j \frac{w_p}{K_p} h_i \, d_{pij} Y_{ij} \qquad [a2]$$

Where, in our case, $d_{p=1}$ is the intermodal transport cost (c^I) or land transport cost (c^L) and $d_{p=2}$ is the intermodal transport time (t^I) or land transport time (t^L). Organising [a2] for this specific analysis, we have:

$$Min \ \sum_i \sum_j \frac{w_c}{K_c} (c_{ij}^I + c_{ij}^L) h_i Y_{ij} + \sum_i \sum_j \frac{w_t}{K_t} (t_{ij}^I + t_{ij}^L) h_i Y_{ij} \qquad [a3]$$

s.t.: [2] to [5]

Where $\frac{w_c}{K_c}$ and $\frac{w_t}{K_{ct}}$ will be the standardised weights for transit cost and time, respectively.

2. *Transport cost*

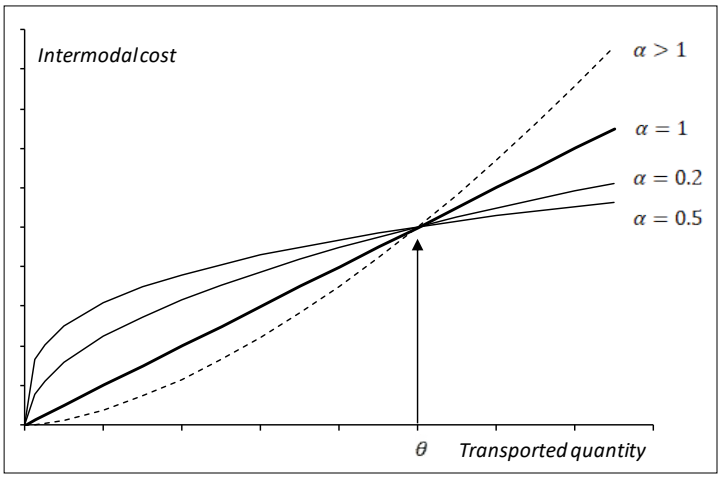
To simulated the effect that the existence of decreasing scale costs has on the distribution of routes, a function is incorporated which provides for the drop in costs according to the volume transported: $\theta_i^{(1-\alpha)} h_i^{\alpha}$. It must be noted that it is assumed the greater the volume transported, the greater the average size of the ships will also be. The formulation of the p-median problem [a3] will now be:

$$Min \sum_i \sum_j \frac{w_c}{K_c} [c_{ij}^I \theta_i^{(1-\alpha)} h_i^{\alpha} Y_{ij} + c_{ij}^L h_i Y_{ij}] + \sum_i \sum_j \frac{w_t}{K_t} [(t_{ij}^I + t_{ij}^L) h_i Y_{ij}] \qquad [a4]$$

s.t.: [2] to [5]

Where θ will be the tonnage at which economies of scale begin to appear that affect both internal and external (environmental) costs. This value, therefore, can be understood as the cargo threshold (Figure a1). Specification [a4] was thus designed to facilitate the comparison between the differences produced in the distribution of merchandise as a consequence of cost fluctuation resulting from increases in cargoes. Taking the existence of economies of scale as a starting point, the value of α must be inferior to the unit, since it determines the elasticity of the maritime costs in relation to the increase in production. We take $\alpha > 1$ and θ = average volume transported for all destinations. Also tested were $\alpha = 0.5$ and $\theta = 150{,}000$ t.

Figure a1 - Potential costs function for Intermodal transport.



3. *Transit time*

The new objective function which will need to be minimised is now:

$$T(c,t) = \sum_i \sum_j \frac{w_c}{K_c} [c_{ij}^I \theta_i^{(1-\alpha)} h_i^{\alpha} Y_{ij} + c_{ij}^L h_i Y_{ij}] + \sum_i \sum_j \frac{w_t}{K_t} [(t_{ij}^{Is} + t_{ij}^{Ie}) h_i Y_{ij} + t_{ij}^L h_i Y_{ij}] \qquad [a5]$$

3.1. *Randomness of transit time*

We now encounter a new function: $T[c, t^I(\xi)]$ To build a new model with non-precision variables, Charnes & Cooper (1959) propose a chance-constrained model. So, the new p-median model will be:

$$Min\, T(c,t) \qquad [a6]$$

s. t.

$prob\{T[c, t^I(\xi)] \leq T\ (c, t)\} \geq \varphi$

[2] to [5]

The following can be done to convert an uncertain chance-constrained programming model [a5] into a deterministic model (Huiru *et al*., 2015): first, $T[c, t^{Is}(\xi)]$ is an uncertain regular variable, so its distribution function and inverse distribution functions are ψ, ψ^{-1}, respectively. In terms of a given confidence level (φ), we can find a number $T(\varphi)$ that satisfies

$$prob\{T[c, t^{Is}(\xi)] \leq T(\varphi)\} = \varphi.$$

Also, we can deduce that $T(\varphi) = \psi^{-1}(\varphi)$, where:

$$\psi^{-1}(\varphi) = \sum_i \sum_j \frac{w_c}{K_c} [c_{ij}^I \theta_i^{(1-\alpha)} h_i^\alpha Y_{ij} + c_{ij}^L h_i Y_{ij}] + \sum_i \sum_j \frac{w_t}{K_t} [\phi_{ij}^{-1}(\varphi)] h_i Y_{ij} + t_{ij}^L h_i Y_{ij}]$$

being $\phi_{ij}^{-1}(\varphi) = \varepsilon + \frac{\sigma\sqrt{3}}{\pi} ln\ (\frac{\varphi}{1-\varphi})$; that is, the inverse of the normal distribution of $t^I(\xi)_{ij}$.

The p-median model [a5] is now redefined in a deterministic form as:

$$Min\ T(c, t) \qquad \text{[a7]}$$

s. t.

$\psi^{-1}(\varphi) \leq T\ (c, t)$

[2] to [5]

In our model, we solve model [12] for σ = 150 % over the value of the median (a high value to test at the limit) and taking ε = average shipments for years 2018-2020, also φ = 95%.

3.2. *Attractiveness of redistribution centres for the customer using agile response time*

The new objective function based on [a4] would become:

$$T(c, t) = \sum_i \sum_j \frac{w_c}{K_c} [c_{ij}^I \theta_i^{(1-\alpha)} h_i^\alpha Y_{ij} + c_{ij}^L h_i Y_{ij}] + \sum_i \sum_j \frac{w_t}{K_t} A_{ij} h_i Y_{ij} \qquad \text{[a8]}$$

To build ∂_{ij} included in A_{ij}, an index is calculated according to the agile response time (t_{ij}^r), that is, the minimum hours needed to supply an express order from the redistribution centre to the customer:

$$\partial_{ij} = \frac{t_{ij}^r - min\ (t_{ij}^r)}{max(t_{ij}^r) - min\ (t_{ij}^r)}$$

In the intermodal case, t_{ij}^r will be the time of the final stage by road. In other words, it is supposed that the product is already present at the redistribution centre. In the case of road transport, the total transit from the origin is considered, diminishing the attractiveness of this option. It should be noted that the decision is made by the supplier and customer jointly, which means the weight system remains valid.

Annex 2 - Transport cost (€/TEU) from Southern Spain using intermodal transport and "only road" with externalities

Using port:						
Cases tested / Final destinations:	*Southampton*	*Dunkirk*	*Marseille*	*Livorno*	*Hamburg*	*Truck*
Hamburg	5599	4868	5256	5747	3753	5194
Stuttgart	5597	4866	4160	4544	5058	4096
Berlin	5936	5205	5352	5516	4314	5289
Cologne	4934	4203	4358	5182	4599	4295
Frankfurt	5287	4558	4288	4859	4735	4224
Perpignan	5964	5724	2923	4626	6996	1958
Paris	4325	4049	3835	5111	5555	3645
Lyon	5239	4977	2913	4222	6106	2850
Barendrecht	4682	3952	4623	5604	4765	4499
London	3774	3874	4759	6001	5595	4549
Glasgow	4888	5131	6017	7258	6853	5477
Dublin	4758	5049	5935	7177	6771	5347
Milan	6134	5574	3320	3530	5966	3531
Rome	7287	6730	4081	3298	7074	4293
Bruxelles	4485	3754	4324	5350	4931	4247
Warsaw	7012	6281	6330	6067	5454	6265
Prague	6305	5574	5073	5131	5034	5010
Vienna	6696	5965	4997	4745	5689	5210
Stockholm	7537	6806	7194	7602	5705	7132
Copenhagen	6247	5516	5905	6312	4416	5842
Helsinki	8491	7762	8150	8248	6661	8086
Lisbon	7491	7498	5599	7302	9004	1745
Athens	10018	9287	6633	5803	8992	6844

Annex 3 - Transport time (hours) from Southern Spain using intermodal transport and "only road"

Using port:						
Cases tested / Final destinations:	*Southampton*	*Dunkerque*	*Marsella*	*Livorno*	*Hamburgo*	*Truck*
Hamburg	129	131	97	110	136	46
Stuttgart	129	131	88	99	148	36
Berlin	132	134	98	108	141	47
Cologne	124	125	89	105	144	38
Frankfurt	127	128	89	102	145	38
Perpignan	133	138	77	100	165	17
Paris	118	123	85	104	152	32
Lyon	126	132	77	97	157	25
Barendrecht	121	123	92	109	145	40
London	113	122	93	112	152	40
Glasgow	123	133	104	123	164	49
Dublin	122	132	103	123	163	48
Milan	134	137	80	90	156	31
Rome	144	147	87	88	166	38
Bruxelles	120	121	89	107	146	38
Warsaw	142	143	107	113	151	56
Prague	136	137	96	105	147	45
Vienna	139	140	95	101	153	46
Stockholm	147	148	115	127	153	63
Copenhagen	135	136	103	115	142	52
Helsinki	155	156	123	132	162	72
Lisbon	146	154	100	124	183	15
Athens	169	170	110	111	183	61

Analyse du processus d'émergence de la filière figue de Barbarie et de ses coproduits en Algérie : Potentiel, contraintes et perspectives

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Abstract

This article analyses several possibilities to valorize prickly pear farming in Algeria, a context dominated by semi-arid ecosystems. It uses sociotechnical and evolutionary approaches in order to understand the new dynamics happening within this sector. Based on field surveys and literature review, this study shows that the production and processing of prickly pear by-products present a high potential, but remains largely under-exploited. Production is mostly artisanal, collection uses traditional practices and marketing is dominated by unstructured and informal channels. The development of processing activities is fairly recent and its dynamic reflects the high interest for this emerging sector by adopting certain practices already observed elsewhere. Finally, an important constraint is foreign market entry. Due to the partial failure of producer's commercial export strategies', local outlets remain dominant.

***Keywords**: Prickly pear sector, By-product valorization, Sociotechnical system, Algeria.*

1. Introduction

En Algérie les activités agricoles évoluent dans un contexte naturel difficile dans une large partie du pays, compte-tenu des conditions géographiques et climatiques à dominance aride et semi-aride. Le figuier de Barbarie, une culture adaptée à des conditions d'aridité, fut introduit en Algérie par les espagnoles au XVIème siècle comme le retracent les écrits de De Oviedo (1880). Au début de la colonisation française, cette culture est décrite comme endémique et parmi les plus précieuses des productions agricoles algériennes de l'*époque* (Moll, 1843 ; Rosny, 1857). Attirée par la réussite des expériences de cette culture dans plusieurs pays, la figue de Barbarie connait en Algérie depuis une dizaine d'années, un regain d'intérêt pour l'augmentation de sa production et la diversification de ses utilisations.

Aujourd'hui, selon les statistiques de la direction des services agricoles (DSA), le pays

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compte une superficie de plus de 150 000 ha dont 60% dans la zone de Sidi-Fradj, située dans la wilaya de Souk Ahras au Nord-Est de l'Algérie. Cette importante plantation a été réalisée dans le cadre du programme de lutte contre la désertification, mené par le Haut-Commissariat pour le Développement de la Steppe (HCDS) et la Direction des Services Agricoles au début des années 1990 (Nefzaoui et Ben Salem, 2006 ; Inglese *et al.*, 2018). Les plantations se répartissent en majorité dans les hauts plateaux mais aussi dans les zones montagneuses telliennes.

Les produits de cette culture sont principalement utilisés en alimentation humaine pour ses fruits frais et en alimentation animale pour ses parties végétatives (cladodes). Ce dernier usage est en progression dans le sud du pays comme aliment des petits ruminants ou encore du dromadaire (Inglese *et al.*, 2018). Malgré son fort potentiel marqué par les progrès technologiques et scientifiques ayant permis d'explorer ses autres modes de valorisation notamment l'extraction de l'huile des graines (Saenz et Berger, 2006), malgré l'ancrage historique de cette culture en Algérie et les dynamiques récentes de son développement (Madani *et al*., 2016), la filière reste peu structurée et confrontée à de nombreuses contraintes.

En adoptant une approche sociotechnique et évolutionniste, cet article a pour objectif de présenter les potentialités réelles de valorisation de cette culture en dressant le portrait des gisements potentiels et des contraintes de l'amont de cette filière dans le contexte algérien. Les résultats de cette étude reposent, d'une part, sur un ensemble de données primaires issues des enquêtes auprès des principaux acteurs de la filière et, d'autre part, sur des données secondaires extraites de la littérature scientifique afin d'évaluer les gisements potentiels de différents produits, coproduits et sous-produits.

Cet article est organisé en trois sections. Nous présentons dans la section 2 d'une part l'approche sociotechnique et l'évolutionnisme économique qui nous servira de cadre d'analyse de la filière et, d'autre part, le potentiel et les perspectives de valorisation de la figue de Barbarie et de ses coproduits par une synthèse bibliographique internationale sur ces différentes voies. Notre démarche méthodologique et empirique est explicitée dans la section 3. Les différents usages de la figue de Barbarie, le positionnement stratégique de ses acteurs, et plus globalement les freins et les leviers de l'émergence de cette filière feront l'objet de la section 4.

2. Cadre conceptuelde la valorisation des coproduits de figuier de Barbarie

2.1. *Approche sociotechnique et évolutionnisme économique*

L'approche par système sociotechnique (SST) se concentre sur le processus de développement et l'appropriation par les acteurs de l'innovation technologique avec une prise en compte des interactions entre les acteurs dans l'analyse des dynamiques de son émergence, de sa diffusion et de son utilisation (Coutant, 2015). Le SST étudie les modes de coordination, les règles de fonctionnement, de régulation et de négociation entre les acteurs organisés autour d'une nouvelle technologie (Flichy, 2008). Puisqu'elle suppose que les acteurs économiques sont guidés par un SST, elle vise à analyser le réseau qui les rassemble selon un flux d'amont en aval, une filière ou une « chaîne de marché ». L'objectif est de comprendre la place et le rôle de chaque acteur dans l'exercice libre de son activité mais aussi ses interactions et ses relations de dépendance au fonctionnement de ce réseau (Belmin, 2016). Les SST sont aussi définis par les flux de connaissances ou de compétences en plus des biens et services ordinaires (Geels, 2004).

De plus, le SST permet d'analyser les transformations des pratiques où l'innovation technologique donne lieu à de nouveaux systèmes de production et à de nouveaux modes de gestion économique capables d'assurer le fonctionnement des nouveaux sous-secteurs créés autour d'elle (Chia et Deffontaines, 1999). Il cherche donc à trouver un moyen de rendre l'organisation des agents économiques autour d'une nouvelle technologie efficace et cela nécessite de considérer les aspects organisationnels et techniques interdépendants. En raison des changements apportés par l'introduction de l'innovation, les dispositions optimales qui existent déjà pour une

technologie existante ne sont pas toujours optimales pour la nouvelle.

Des compromis doivent être trouvés dans la conception organisationnelle d'un nouveau SST afin qu'il puisse être efficace (Fox, 1995). Les changements d'un élément du système déclenchent des changements dans d'autres éléments qui, à leur tour, entraînent d'autres changements. C'est ce qu'on appelle la dynamique en cascade dans le SST. Ces processus de reconfiguration s'appliquent à tous les éléments du système (marchés, utilisateurs et pratiques, technologies, réseaux de production, politiques, etc.) (Geels, 2002). Un SST consiste à décrypter les nouvelles potentialités qui émergent et à les développer grâce à certaines forces motrices qui accompagnent l'émergence des nouvelles technologies. Il s'agit également d'identifier comment la création de produits et de valeurs par l'innovation permet de réunir un ensemble d'éléments technologiques complémentaires à l'émergence d'un nouveau SST organisé autour de nouvelles façons de faire et permettant de satisfaire un certain nombre de demandes ou de besoins (De Bandt, 2002).

Sur le plan de la théorie économique, la dynamique des SST se rapproche des approches évolutionnistes appliquées aux innovations. La théorie évolutionniste a été principalement mobilisée pour l'étude des innovations et des changements techniques existants ou à mettre en œuvre pour coordonner et favoriser une stratégie d'ensemble. Dans le domaine social, ces modèles comportent des processus imparfaits d'apprentissage et de découverte par essais et erreurs, d'une part et, de l'autre, des mécanismes de sélection. Ces modèles précisent les déterminants de l'adaptation (*fitness*), ce qui suppose à la fois la détermination de l'unité de sélection et les principaux mécanismes par lesquels la sélection opère (Montaigne, 1996).

Ces approches permettent donc d'appréhender la dynamique des SST à la fois par l'analyse des interactions entre les acteurs et leurs propres trajectoires d'apprentissage. L'application de telles approches semble donc particulièrement adaptée afin d'analyser l'émergence et la construction d'une filière à partir des résultats de recherches scientifiques. Notre recherche sur la valorisation de la figue de Barbarie, a débuté, en effet, par l'étude des résultats du laboratoire de zootechnie de l'Université de Ghardaïa, qui a évalué l'efficacité d'une ration alimentaire à base de tourteaux issus de l'extraction de l'huile des grains et des enveloppes de la figue de Barbarie par comparaison avec la ration de référence classique composée de tourteau de soja et de maïs importés (Cherif *et al.*, 2021). Cette question scientifique est qualifiée de paradigme technologique dans l'approche de l'économie évolutionniste (Dosi, 1982 ; Nelson et Winter, 1982). C'est pourquoi les chercheurs en sciences sociales se sont demandés quelles étaient les conditions nécessaires à la mise en place d'une nouvelle chaîne de valeur pour ces nouveaux coproduits, autrement dit, les conditions de développement d'une filière d'innovation. Toutefois, le lien entre ces coproduits et d'autres produits issus de la transformation du figuier de Barbarie (ex. huile, mélasse) est complexe et leur coévolution requière une étude sur l'ensemble des dérivés de cette culture par rapport à ses usages traditionnels (cladodes et fruits frais). Il s'agit, donc, d'une étude des effets techniques et socioéconomiques d'une innovation particulière sur un SST.

2.2. *Valorisation des coproduits de la figue de Barbarie*

Avant d'aborder plus particulièrement le contexte algérien, il nous faut décrire et comprendre les différentes valorisations possibles des coproduits de la figue de Barbarie et passer en revue certaines expériences « réussies » de construction de ces filières dans le monde. Le figuier de Barbarie est une plante à usages multiples tant par ses produits que ses coproduits, pour une utilisation directe et pour sa transformation (Saenz et Berger, 2006). Nous présentons dans Tableau 1 récapitulatif non exhaustif de ces coproduits et leurs usages relevés dans la littérature scientifique, alors que le Tableau 2 récapitule les relations entre les produits et les sous-produits selon leurs usages.

Il est à noter qu'un coproduit est une matière, intentionnelle et inévitable, créée au cours du même processus de fabrication et en même temps que le produit principal. Le produit fini principal et le coproduit doivent tous les deux

Tableau 1 - Produits et coproduits du figuier de Barbarie.

Produits ou coproduits	*Usages*	*Formes*	*Références*
Cladodes	Aliment du bétail	Fourrage vert	Tegegne, 2000 ; Nefzaoui et Ben Salem, 2006
		Fourrage sec	Dos Santos *et al*., 2018
		Ensilage	Gusha *et al*., 2015
	Consommation utilisation humaine et animale	Vert cuit et cru	Ramírez-Moreno *et al.*, 2011
		Séché	Gallegos-Infante *et al.*, 2009
Fruits		Frais	Livrea et Tesoriere, 2006
		Séché/déshydraté	Sepúlveda *et al.*, 2000
Huile des graines		Industries cosmétiques et parapharmaceutiques	Kumar et Sharma, 2020
Tourteaux des graines et enveloppes déshydratées	Consommation animale	Industrie d'aliment du bétail	Ennouri *et al.*, 2006 ; Cherif *et al.*, 2021
Pulpes du fruit	Consommation humaine	Pur ou mélangé avec d'autres extraits	Saenz et Berger, 2006
Jus du fruit et sirop			Saenz et Sepúlveda, 2001
Confiture et confiserie			Atef *et al*., 2013
Vinaigre			Prieto *et al.*, 2009
Extraits pharmacologiques	Industrie pharmaceutique et cosmétique	Différents composants : anti-inflammatoires ; antioxydants …	Tilahun et Welegerima, 2018
Biogaz et biocarburant	Industrie énergétique	Gaz et liquides	Comparettia *et al.*, 2017

Tableau 2 - Différences et liens entre les produits, sous-produits et coproduits de la figue de Barbarie.

	Produits et coproduits	*Sous-produits*	*Autre coproduits*
Usages traditionnels sans conditionnement ni transformation	Cladodes	Déchets dispersés à l'échelle des ménages non-valorisables	Si les sous-produits sont valorisés, ils deviennent coproduits
	Fruits		
Unité de conditionnement	Fruits de la figue de Barbarie en l'état		
	Fruits de la figue de Barbarie épluchés	Enveloppes du fruits	
Unité de transformation	Vinaigre	Enveloppes + graines + Mélasse	
	Jus +sirop		
	Confiture et confiserie		
	Biogaz et biocarburant		
	Huile des graines	Tourteaux des graines	
	Poudre du cactus	/	

répondre à des spécifications de caractéristiques, et chacun est apte à être utilisé directement pour un usage particulier. Les coproduits sont aussi caractérisés par leur valorisation économique : marché spécifique du coproduit en question, cotation, etc. Il ne faut pas confondre coproduit et sous-produit, puisque le sous-produit est non-intentionnel et généralement non valorisable. Il peut néanmoins être parfois utilisé directement ou constituer l'ingrédient d'un autre processus de production. Il devient alors coproduit. C'est le cas aussi du sous-produit intentionnellement récolté pour être valorisé, mais qui ne contribue que de manière secondaire aux bénéfices.

2.3. Expériences à l'international

Plusieurs exemples peuvent illustrer le succès des expériences internationales de valorisation des coproduits de la figue de Barbarie. Sans être exhaustif, nous pouvons citer les exemples du Mexique, de l'Italie et du Maroc. Berceau historique, le Mexique est de loin le pays qui abrite la plus grande diversité génétique mais aussi le plus grand niveau de consommation et de valorisation des coproduits de la figue de Barbarie (Reyes-Agüero *et al.*, 2005). L'intérêt public pour le développement de cette culture a été marqué dès les années 1950 via des programmes nationaux. Durant les années 1970-1980, l'objectif de ces programmes de subvention, couplés à une vaste compagne de vulgarisation technique et d'expérimentation, était de promouvoir cette culture comme alternative à des cultures comme le maïs et les haricots secs, gourmandes en termes de ressources hydriques.

La croissance de la production au milieu des années 1980 a réorienté les priorités de l'intervention publiques vers l'organisation de la filière, notamment en favorisant l'organisation horizontale de ses acteurs (organisations des producteurs, des grossistes et des industriels). Grâce au soutien continu de cette culture par les pouvoirs publics mexicains, la figue de Barbarie représente aujourd'hui la cinquième culture avec une production annuelle d'environ 428 763 tonnes (Inglese *et al.*, 2018). La filière a connu un progrès technique important avec l'introduction de l'irrigation en goutte-à-goutte, la sélection variétale adaptée aux différentes zones bioclimatiques, la mécanisation de l'opération du nettoyage des fruits, le développement de la logistique et du marketing pour le marché local et international (Corrales-García, 2009). Simultanément, l'accent sur les vertus nutritionnelles de la consommation régulière de ses coproduits a été mis en avant (fruits, cladodes, graines, pulpes) (González-Stuart et Rivera, 2019).

Sur la rive nord de la Méditerranée, la culture de la figue de Barbarie a pris de l'importance en Italie dès le XVIIIème siècle pour ses multiples usages, en plus de ses fruits, comme fourrage et escrime[1] pour la délimitation des parcelles dans les exploitations agricoles (Barbera *et al.*, 1992). Malgré la diversité variétale de cette culture (18 variétés recensées), deux variétés commerciales *Gialla* et *Rossa* sélectionnées pour leur rendement et la qualité de leurs fruits représentent à elles seules 90% de la production (Inglese *et al.*, 2002). La Sicile demeure la principale zone de production de la figue de Barbarie pour la commercialisation de ses fruits, avec notamment plus de 4 000 ha de culture intensive sur les 15 000 ha produisant annuellement 60 000 tonnes (Inglese *et al.*, 2018).

Le développement de cette culture s'est établi sur la base d'une stratégie commerciale de production en automne (90 % de récolte) plutôt qu'en fin d'été (*scozzolatura*)[2] pour échapper à la concurrence. De par le succès de ce modèle économique, cette technique a été copiée ailleurs dans le monde notamment en Argentine, en Afrique du Sud ou encore en Tunisie et au Maroc et même au Mexique, le leader du marché mondial en la matière. De plus la filière figue de Barbarie italienne bénéficie de bonnes stratégies de marketing tant sur le marché local qu'international pour en faire le deuxième producteur mondial de cette culture (Inglese *et al.*, 2002 ; 2018).

Sur la rive sud de la Méditerranée, le Maroc a procédé à des plantations massives dès les années 1970 (Barthes *et al.*, 2016), à l'origine d'une nette augmentation des surfaces cultivées (140%) surtout durant les deux dernières décennies, celles-ci passant de 50 000 ha à plus de 120 000 ha. Les différents programmes nationaux de lutte contre la sécheresse, soutenus par l'implication de la population rurale sont à l'origine de cette expansion. Alors que son usage a été longtemps réservé à la délimitation des es-

[1] Le terme « escrime » est issu de l'ancien français 'escremie' lui-même dérivé du francique 'skirmjan' signifiant « défendre, protéger ». Formation naturelle de haies défensives (Wikipedia : usage agricole).

[2] La « scozzolatura » est une technique qui permet de décaler la période de floraison des plants de cactus et la maturité de leurs fruits au-delà de leur période habituelle en supprimant tous les bourgeons floraux et les jeunes cladodes émis au printemps. https://pampat.ma/wp-content/uploads/2015/09/Scozzolatura-web.pdf.

paces ruraux et à la production du fourrage avec l'équivalent de 10 à 30 tonnes de matière sèche par hectare, la stratégie de valorisation de cette culture de lutte contre la sécheresse a évolué durant la dernière décennie et s'est orientée vers la diversification des produits transformés.

Au Maroc, c'est grâce à la multiplication des initiatives entrepreneuriales privées et de coopératives de femmes rurales que les nouveaux coproduits (vinaigre, huile, farine, confiture, jus…) ont pu émerger sur le marché local et international, en particulier pour l'huile des graines de la figue de Barbarie vendue à 1 000€ le litre (Boutakiout, 2015 ; Barthes *et al.*, 2016 ; Inglese *et al.*, 2018). Le développement de la transformation du fruit au détriment de sa commercialisation en frais s'explique par la recherche d'une plus grande valeur ajoutée. En effet les intermédiaires (grossistes) dominent le marché marocain du frais et ne proposent que des prix faibles à la récolte. Pour tirer profit de la dynamique économique créée par les activités de transformation du figuier, les autorités marocaines prévoient dans le cadre du Plan Maroc Vert, l'extension de sa culture sur 120 000 ha supplémentaires, doublant la surface consacrée à cette culture.

Ce bref panorama des différentes expériences internationales de valorisation des coproduits de la figue de Barbarie rend compte du potentiel important d'une telle démarche en Algérie. Ici, l'intérêt de cette culture pour la lutte contre la désertification, pour les usages traditionnels de ses fruits frais en alimentation humaine et l'utilisation les cladodes en aliment d'appoint pour les animaux d'élevage, ont conduit les pouvoirs publics, depuis 2013, à mener une campagne de réflexion et d'expérimentation sur de nouvelles voies de valorisation des coproduits du figuier de Barbarie. L'extraction de l'huile des graines semble la voie la plus prometteuse de par sa valeur ajoutée et, en particulier, l'activité créée pour son extraction et sa vente à l'industrie cosmétique européenne. Cette dernière activité génère la production de sous-produits comme le vinaigre de figue de Barbarie recherché en milieu pharmaceutique, auxquels s'ajoutent les tourteaux des graines, les enveloppes déshydratées et la mélasse, intrants potentiels pour l'industrie de l'aliment du bétail.

3. Démarches et méthodes empiriques

3.1. *Démarche empirique et recueil des données*

Les résultats empiriques de ce travail s'appuient sur des données documentaires (revues de presse, recherches empiriques antérieures, monographies d'entreprises, Sites internet, observations sur le terrain…), sur 24 entretiens semi-directifs avec les principaux acteurs intervenants (Tableau 3) dans le développement et la valorisation de la figue de Barbarie, mais aussi sur des entretiens auprès des experts (4 interviews) pour identifier le potentiel technique de production et de valorisation. La combinaison des données récoltées par les enquêtes empiriques et des informations issues des sources secondaires, s'inscrit dans une démarche de triangulation des sources et permet de renforcer la pertinence de notre analyse (Yin, 2017).

Les entretiens semi directifs ont été menés de 2018 à 2020, avec une durée moyenne de deux heures. Ils ont concerné des acteurs de la production, de la transformation et de la commercialisation, des agents des institutions (Ministère, Chambre d'Agriculture, conseil technique) ainsi que des organisations professionnelles (association de producteurs, coopérative). Cette enquête a été complétée par une étude de cas basée sur la collecte des données qualitatives et quantitatives (Yin, 2017) relatives au fonctionnement technique de la transformation de la figue de Barbarie par la coopérative Nopaltec située dans localité de Sidi Fradj à Souk Ahras, région qui abrite la plus grande surface de cette culture en Algérie.

3.2. *Traitement des données*

Le traitement des données a été fait en suivant une démarche qualitative qui avait pour objectif d'évaluer le gisement réel, ou technique, de valorisation des différents usages de la figue de Barbarie en Algérie. Ainsi, il s'agit d'abord d'évaluer les gisements potentiels de production des différents produits et coproduits du figuier de Barbarie à la lumière des résultats techniques obtenus par les différentes études

Tableau 3 - Les sources de données et acteurs enquêtés.

Fonction dans la filière	*Acteurs enquêtés*	*Principaux thèmes de l'entretien*
Transformateurs	- 11 unités fonctionnelles dont la coopérative Nopaltec - 2 unités en cours de réalisation - 2 unités en cessation d'activité	- Historique de création de l'unité - Raison sociale et forme juridique - Capacité de transformation technique - Production (gamme et quantité) - Stratégies commerciales - Atouts perçus de l'entreprise - Contraintes perçues de l'entreprise
Soutien technique	- Chambre d'Agriculture (Souk Ahras) - Haut-Commissariat du Développement des Steppes (Djelfa) - Institut Technique d'Élevage (Annaba)	- Contexte passé et actuel de la filière - Rôle de la structure dans la filière - Identification et description des moteurs et des obstacles spécifiques à la filière - Perspectives du développement de la filière
Établissements publics	- Ministère d'Agriculture et du Développement Rural (Alger) - Direction des Services Agricoles (Souk Ahras) - Direction de l'Environnement (Souk Ahras)	
Autres	- Associations Nationale de cactus « Cactus DZ » (Tebessa) - GIZ (Gesellschaft für Internationale Zusammenarbeit) (délégation de Souk Ahras)	
Experts de la filière	- 2 professeurs d'universités (Ghardaïa et Bejaïa) - 2 haut-responsables professionnels du secteur (Alger)	- Contexte passé et actuel de la filière - Identification et description des leviers et des freins techniques de la filière - Perspectives du développement de la filière

menées en Algérie. Selon Spezzani (2014), l'évaluation des gisements en coproduits agricoles doit distinguer deux types de gisement à savoir :

- *le gisement théorique* qui représente les quantités de coproduits disponibles sur un territoire donné sans faire référence à un usage spécifique. Ici, il englobe les quantités à la fois des cladodes et des fruits en faisant référence aux surfaces cultivées et aux rendements respectifs par hectare ; il s'agit d'une vision brute globale.
- *le gisement technique* qui peut être inférieur ou égal au gisement théorique du fait qu'il fait l'abstraction des usages non spécifiques envisagés par les stratégies de valorisation du potentiel théorique. Il identifie donc les usages spécifiques des coproduits selon le profil de ses usagers actifs sur un territoire. Ici nous estimons les quantités des cladodes exploitables en alimentation animale, puis les quantités de fruits transformables en coproduits en tenant compte des technologies et des stratégies effectives mises en place par les différents opérateurs économiques en Algérie. Il s'agit ici des volumes potentiellement et raisonnablement « récupérables ».

En lien avec cette dernière évaluation, nous analysons par la suite le positionnement stratégique des unités de transformation de la figue de Barbarie pour en tirer des informations sur l'état du développement des activités de transformation et les obstacles qui se dressent face à l'émergence de sa filière. A la lumière de cette deuxième partie des résultats, nous analyserons les freins et leviers du développement de la filière. De cette façon, des éléments de discussion du contexte structurel et politique ont été formulés à l'image des recherches antérieures et des expériences internationales.

4. Résultats et discussions

4.1. *Gisements potentiels des différents usages de la figue de Barbarie en Algérie*

Les gisements théorique et technique de valorisation des produits, coproduits et sous-produits ont été évalués à la fois sur la base des entretiens auprès des acteurs et des experts et des recherches antérieures menées en Algérie. Ces évaluations se basent sur les caractéristiques agronomiques des surfaces potentielles ou exploitées et sur les données recueillies en termes de rendement et de transformation.

Dans l'évaluation théorique des gisements de produits à l'échelle nationale, nous considérons à la fois la surface cultivée (150 000 ha) en figues de Barbarie rapportée dans la littérature en Algérie, puis son rendement en matière première (fraiche ou séchée) pour les cladodes à usage alimentaire pour le bétail, mais aussi le rendement en fruits pour l'alimentation humaine et l'industrie de transformation agroalimentaire. Le Tableau 4 nous fournit un aperçu du gisement théorique de production en cladodes et en fruits.

Le premier constat que nous pouvons dresser de l'évaluation des gisements, concerne le grand écart entre les gisements théoriques et techniques. Si l'on considère le seul facteur de prélèvement du fourrage vert qui ne s'exerce quasiment que sur une seule variété sans épines appelée « cactus inerme » dont la surface est d'environ 15% de la surface cultivée totale (l'équivalent de 22 500 ha), seul un gisement de 96 750 tonnes de matière sèche est réellement exploité annuellement par les animaux d'élevage. Cette situation engendre pour la variété inerme une surexploitation (surpâturage) et une dégradation des cultures de figue de Barbarie surtout dans certaines régions du centre du pays. Il faut donc reconsidérer la finalité de cette culture et surtout les possibilités d'exploitation des autres variétés (pour une production équivalant à 548 250 tonnes de matière sèche) par des voies alternatives afin d'utiliser pleinement leur potentiel fourrager. Des solutions techniques efficaces ont été développées notamment au Mexique (machines d'enlèvement des épines au laser pulsé) pour exploiter les cladodes épineux et augmenter leur valeur sur le marché (Cabrera *et al.*, 2016).

Le constat n'en est pas moins nuancé pour l'exploitation des fruits du figuier de Barbarie. Le potentiel de production de 4,5 millions de tonnes de ce fruit représente presque l'équivalent du total de toute la production arboricole en Algérie, évaluée 5 millions de tonnes en 2017[3]. En raison de la cueillette manuelle exercée exclusivement par une main d'œuvre familiale, mais aussi de la concentration de la saison de maturation en fin d'été et en l'absence de circuits de commercialisation structurés, le taux de collecte ne dépasse guère les 10%. Ces fruits sont essentiellement destinés à l'autoconsommation et la vente à la sauvette. Ceci peut s'expliquer par sa faible valorisation (200 DA/kg pour le prix de vente au consommateur, soit l'équivalent de 1 € contre 3 € en moyenne en Europe[4]). Cela montre qu'il y a de la marge pour le développement de ce segment de la filière au regard de la place de la consommation du fruit dans les traditions culinaires en Algérie et aux opportunités d'exportation sur le marché international, notamment en Europe.

L'usage industriel des fruits, sous réserve de son développement à grande échelle, est directement en concurrence avec la consommation humaine en frais car il peut offrir des prix plus attractifs (au regard des intérêts industriels cités plus haut) et épargne aux producteurs de pratiquer la vente au détail à la sauvette. D'après nos enquêtes les deux usages sont actuellement complémentaires du fait des contraintes techniques de la cueillette et de la collecte qui ne permettent d'exploiter que 10% de la production dans la transformation. Avec ce taux de transformation, l'extraction de l'huile pourrait atteindre 450 000

[3] Statistiques du Ministère de l'Agriculture et du Développement Rural disponibles en ligne sur le lien : http://madrp.gov.dz/agriculture/statistiques-agricoles/.

[4] https://rnm.franceagrimer.fr/prix?FIGUE. MIN de Strasbourg : fruits et légumes marché du 26/11/20 (cours Grossistes) unité : € HT le kg*. Figue de Barbarie fraîche U.E. : moyenne 3.06 € HT le kg ; min. 2.60 € HT le kg ; max. 3.75€ HT le kg.

Tableau 4 - Gisements des produits et coproduits du figuier de Barbarie en Algérie.

Produits ou coproduits	*Usages*	*Formes*		*Gisement théorique*		*Gisement technique*			
				Coef. [a,b]	Quantité	Contraintes techniques	Coef. [a,b]		Quantité
Cladodes	Aliment du bétail	Fourrage vert (Matière Brute)		100%	7 500 000 t	- Taux de prélèvement/ ha (80-100% pour la variété inerme et marginale pour les autres variétés - Qualité des cladodes (âge) - Espèce animale concernée - Saison du pâturage	15%		1 125 000 t
		Matière Sèche (MS)		8,6%	645 000 t		8,6%		96 750 t
		Matière Organique (g/kg de MS)		643	482 250 t		6,43%		72 337 t
		Matière Minérale (g/kg de MS)		357	211 500 t		2,82%		31 725 t
		Matière Azotée Totale (g/kg de MS)		67	50 250 t		0,67%		7 537 t
		Sucres Totaux (g/kg de MS)		30,2	226 500 t		3,02%		33 975 t
		Matière Grasse (g/kg de MS)		9,16	12 000 t		0,16%		1800 t
Fruits	Consommation humaine	Frais		100%	4 500 000 t	- Taux de récole - Variabilités interannuelle et variétale des rendements	10 %		300 000 t
	Usages industriels	Transformés	Huile	1 l/t	4 500 000 l	- Taux de récole - Variabilités interannuelle et variétale des rendements - Techniques utilisées - Capacité industrielle	10 %	1 l/t	450 000 l
			Vinaigre	12,3 l/t	55 350 000 l			12,3 l/t	5 535 000 l
			Mélasse	3,07 l/t	13 815 000 l			3,07 l/t	1 381 500 l
			Tourteaux	2,02 kg/t	9 090 t			2,02 kg/t	909 t

(a) Calculs basés sur la composition chimique des cladodes en Algérie (Chentli et al., 2013).
(b) Calculs basés sur nos enquêtes techniques auprès de la coopérative Nopaltec et des experts de la filière.

litres. Cette faiblesse du taux de cueillette pour la transformation est la conséquence des difficultés à recruter de la main d'œuvre liées à la pénibilité de cette activité manuelle. L'atomicité de l'offre renforce davantage cette difficulté.

Si nous nous basons sur le seul cas de la coopérative Nopaltec de Souk Ahras, région qui abrite 60% de la surface totale cultivée en figuiers de Barbarie et qui n'a produit que 440 litres d'huile de graines en 2017, nous constatons que le taux de collecte est surestimé ainsi que le taux d'extraction (440 litres d'huile pour 960 tonnes transformées ce qui fait un taux d'extraction de 0,45 l/t au lieu de 1l/t généralement retenu). La maîtrise des paramètres techniques de l'extraction semble nécessaire pour atteindre au moins le rendement prévu, c'est-à-dire le potentiel technique. Le même constat est à faire pour les autres produits issus de la transformation de la figue de Barbarie. Par exemple, la coopérative Nopaltec n'a produit que 1 000 litres de vinaigre et 875 quintaux d'aliment du bétail à partir des tourteaux issus de l'extraction de l'huile et de la mélasse, mélangés à d'autres matières premières énergétiques (son du blé et maïs). Le potentiel technique de l'usage industriel peut être atteint grâce notamment à l'augmentation de la capacité de transformation des fruits par la mobilisation des infrastructures agroindustrielles existantes. Les experts estiment que les unités de transformation des jus, de confitures, d'extraction d'huile peuvent être mobilisées pour la transformation de la figue de Barbarie en introduisant quelques aménagements des équipements.

A ce stade, nous constatons donc que le potentiel de production et de transformation des coproduits de la figue de Barbarie est important, mais demeure très largement sous-exploité. La production reste en majorité artisanale et relève d'une pratique de collecte traditionnelle. De plus, la commercialisation en aval de la filière est dominée par des circuits peu structurés et informels. Les débouchés sont centrés sur le fruit frais, peu valorisé, même si des tentatives de transformation et de valorisation sont initiées par des acteurs mieux organisés et de plus grande taille comme Nopaltec.

4.2. *Positionnement stratégique des transformateurs de la filière de figue de Barbarie*

D'après nos enquêtes, exhaustives auprès des unités de transformation, nous pouvons constater que le développement de cette activité est assez récent (dernière décennie, avec une accélération depuis 2016), et reflète un engouement pour cette filière émergente. Il faut retenir que l'extraction de l'huile est considérée à l'unanimité comme la principale activité de transformation et toutes les unités en font le pivot de leur stratégie commerciale. Onze unités sur quinze sont réellement fonctionnelles sur le terrain ; deux unités sont totalement à l'arrêt et ont abandonné l'activité de transformation faute des moyens techniques et financiers appropriés. Signalons enfin, les projets de création de deux unités de transformation qui restent pour le moment à un stade embryonnaire (pas d'installations techniques en vue).

Les onze unités en activité fonctionnent généralement avec une capacité de transformation en moyenne quatre fois supérieure à la quantité réellement transformée ce qui confirme l'explication des experts sur le taux de collecte qui reste un obstacle à la valorisation de la figue de Barbarie par sa transformation (Tableau 5). A l'exception de la coopérative Nopaltec dont la capacité de transformation (4 160 litres/an) peut être justifiée par sa localisation dans la région la plus productive du pays, toutes les autres unités sont de taille familiale et leur capacité technique d'extraction ne dépasse pas 1 000 litres/an (Tableau 5).

Seules trois unités de petite capacité (moins de 300 litres d'huile par an) atteignent des taux d'utilisation importants de leur capacité de transformation, mais ne souhaitent pas étendre leur activité afin de se concentrer sur la diversification de leur gamme et la fabrication d'autres coproduits comme le vinaigre, la poudre de cactus et le tourteau de graines. A travers notre enquête, nous avons recensé six produits de la transformation de la figue de Barbarie effectivement fabriqués par les unités actives en Algérie ; l'huile de la graine de figue de Barbarie, le vinaigre, le tourteau de graines pour l'alimentation animale, la poudre du cactus, la mélasse, la poudre des tourteaux de graines. Des perspectives de fabrication d'autres produits tels les colorants comme pigments naturels, le jus de fruit, la confiture et les arômes ont aussi été identifiés avec un fort potentiel de valorisation lors des entretiens.

Actuellement, le marché local reste le débouché le plus important. Les quantités d'huile exportées par les unités enquêtées ne représente que 27% de leur production et reflète l'échec relatif de la conquête du marché international, notamment européen. Nos enquêtes pointent du doigt deux obstacles majeurs à cette stratégie ; (i) la gestion inefficace de la qualité, amplifiée par le manque de certification et ; (ii) la lenteur et la complexité des démarches administratives liées à l'exporta-

Tableau 5 - Caractérisation des unités de transformation en huile de la figue de Barbarie.

	Moyenne	*Min*	*Max*	*Total*
Année de création de l'unité	2016,4	2008	2019	/
Capacité de transformation (litre/an)	638,6	25	4160	7025
Quantités transformées (litre)	157,2	0,00	420	1730
Nombre de coproduits issus de la transformation	1,90	1	4	6
Quantité de l'huile exportée (litre)	42,3	0	400	466

tion, du fait de l'atomicité des quantités. Seules trois unités sur onze ont réussi à franchir ces barrières pour exporter vers le marché européen.

4.3. *Examen des freins et des leviers à l'émergence de cette filière*

En Algérie, la culture du figuier de Barbarie bénéficie d'une situation géo-climatique qui lui est favorable et permet d'en planter sur des terres arides auparavant très peu exploitées. Les possibilités de son extension sont immenses si l'on tient compte des surfaces steppiques dans les hauts plateaux (7,5 millions d'hectares). Mise à part la contribution du gouvernement par l'augmentation des surfaces dédiées à la culture du figuier de Barbarie, à travers les nouvelles lois de concessions agricoles et les subventions de valorisation des terres dans les régions du sud et des hauts plateaux, les pouvoirs publics algériens misent sur le renforcement des capacités humaines (formation des professionnels de la filière dans le cadre du programme PRCHAT : Renforcement des Capacités Humaines et d'Appui Technique) pour accompagner le développement de la filière figue de Barbarie et de ses coproduits.

Les pouvoirs publics jouent un rôle central dans la mise en place de ce nouveau SST qui implique non seulement les utilisateurs et les marchés, mais aussi les organisations de soutien technique financés par les politiques publiques (Geels, 2005, p. 6). Dans le même sens, les acteurs de la filière peuvent capitaliser les connaissances techniques issues des résultats des recherches engagés dans plusieurs établissements universitaires et de recherche & développement algériens pour identifier les voies de valorisation des produits et des coproduits du figuier de Barbarie. Cette dynamique de capitalisation des connaissances est une étape nécessaire pour préparer l'expansion future de ce SST et ainsi avoir une meilleure adaptabilité malgré des circonstances variables (Flichy, 2008, p. 87).

Le développement de cette filière, qui pour l'heure dépend d'initiatives individuelles, peut s'appuyer sur une gouvernance participative concrétisée par un partenariat entre les pouvoirs publics et des acteurs privés, au niveau local (Chambres d'Agriculture, coopératives agricoles, associations de producteurs, Direction des Services Agricoles et de l'Environnement), au niveau national (association nationale du cactus, groupement d'intérêt commun pour la figue de Barbarie, Institut d'Élevage ITELV, HCDS) et au niveau international (GIZ, ambassade du Mexique). La participation permanente des différents acteurs de cette filière ne se limite pas au seul développement de la culture de la figue de Barbarie pour ses usages traditionnels mais également à l'encouragement de l'utilisation de ses coproduits issus de la transformation dans des marchés de niches très florissants (huile, vinaigre, tourteaux).

L'association nationale du cactus, en particulier, joue un rôle majeur dans cette gouvernance participative par son rôle d'accompagnement des producteurs, des transformateurs et même de ceux qui en font la commercialisation. Cette association anime actuellement le groupe d'intérêt commun pour la figue de Barbarie et elle était à l'origine de sa création. Elle organise également des évènements pour promouvoir la filière comme la fête du figuier de Barbarie qui est une occasion de partager des expériences par ses différents acteurs et de faciliter le transfert de technologies pour la valorisation de ses coproduits. L'association participe également au côté des pouvoirs publics à l'étude des stratégies possibles pour l'organisation et le développement de la filière et en proposer un plan d'action national qui encourage les acteurs économiques notamment les coopératives, à l'industrialisation de la filière.

Toutefois, le potentiel de développement de cette filière fait face à de multiples freins techniques, organisationnels et institutionnels. L'objectif de valorisation du figuier de Barbarie va de pair avec la mise en place d'une culture capable de fournir des produits. Or, dans leur état actuel, les surfaces couvertes par le figuier de Barbarie en Algérie ne sont pas toutes aptes, ni prédisposées à cette finalité. Mises à part les cultures mises en place par les agriculteurs en accompagnement du HCDS, la majorité des surfaces a été soit le fruit de poussées spontanées par « envahissement naturel » de cette plante, soit des cultures anarchiques peu contrôlées et par conséquent très peu exploitables même pour le pâturage des animaux d'élevage. La dimension variétale reste essentielle.

Cela explique en grande partie la surexploitation exercée sur la variété cactus inerme et la sous-exploitation des autres variétés à épines. Toutefois, comme le souligne Geels (2002), les configurations traditionnelles de production qui fonctionnent (actuellement en vigueur) ne peuvent pas être facilement changées indépendamment du système dans son ensemble. Les technologies et les compétences font partie des routines organisationnelles (Dosi, 1982), des modèles de comportement, des organisations qui ne fonctionnent que parce qu'elles sont intégrées dans un SST commun.

La nécessité de maîtriser les techniques de valorisation ne concerne pas que l'amont de la filière, le constat fait lors de cette enquête montre que la chaine de transformation des coproduits du figuier est aussi concernée par le progrès technique. Les transformateurs peinent à maîtriser les paramètres techniques. La qualité de coproduits de la figue notamment l'huile et le vinaigre, restent en dessous des normes pour franchir le pas vers l'exportation. Une collaboration avec des établissements de recherche scientifique semble plus que nécessaire pour surmonter ces difficultés techniques (Geels, 2004).

En outre, la dispersion de la production mise sur le marché, induite notamment par les difficultés d'exploitation des champs de figuier de Barbarie, n'incite pas les industriels à investir dans sa valorisation. A cela s'ajoute l'absence d'une stratégie commune d'organisation d'une chaine d'acteurs capables de structurer la filière et de garantir la fluidité des flux de produits. De ce fait, les usages traditionnels restent majoritaires car portés par l'autoconsommation (cladodes pour les animaux et fruits pour les ménages) et la vente informelle de proximité sur les marchés (fruits). Comme il a été noté plus haut, la progression des activités de transformation industrielle de la figue de Barbarie doit s'appuyer principalement sur l'organisation de la chaine d'acteurs pour échapper aux circuits de commercialisation traditionnels peu rémunérateurs.

Enfin, et en plus des contraintes identifiées au niveau de l'amont (cueillette et collecte) et de la transformation, d'autres difficultés portent sur le stade de la commercialisation. En Algérie, la faiblesse de la production valorisée à l'échelle industrielle sur le marché international, notamment l'huile et le vinaigre de figue de Barbarie, est due à l'absence de certification. Le pays ne dispose pas à ce jour d'un organisme certificateur spécialisé pour garantir la qualité, élément essentiel pour réussir la mise en marché des coproduits du figuier. Il n'existe par ailleurs, aucune entreprise qui propose un packaging approprié aux produits et aux coproduits du figuier, d'où également des difficultés d'accès au marché international.

L'ensemble de ces problèmes techniques, logistiques et commerciaux limitent la valorisation des produits de cette filière. Par exemple, la coopérative Nopaltec n'a pu vendre son huile qu'à 550 €/litre au lieu de 1 000 € et ce malgré le certificat « Agriculture biologique » dont elle dispose. Ceci souligne l'importance de la place de la gestion de la qualité dans les filières émergentes comme celle de la figue de Barbarie en Algérie. Selon Akrich (1991), les acteurs de cette filière innovante doivent repenser leur *business model* traditionnel pour s'adapter aux exigences du marché pour en créer de nouveaux allant de pair avec les changements techniques liées aux différentes voies de valorisations des coproduits du figuier de Barbarie.

5. Conclusion : implications en termes de structuration de la filière

Dans le contexte du changement climatique et ses conséquences sur la vulnérabilité des ressources naturelles, l'agriculture algérienne cherche un nouveau souffle lui permettant une meilleure résilience à travers le développement des cultures résistantes à la sècheresse comme le figuier de Barbarie. En plus de sa propre expérience et de l'ancrage historique de cette culture, l'Algérie voulait reproduire le succès qu'a eu la figue de Barbarie ailleurs dans le monde en exploitant les progrès scientifiques sur les techniques de valorisation. Cet article a présenté les potentialités de valorisation de cette culture dans le contexte Algérien, en adoptant une approche SST et évolutionniste afin d'appréhender la nouvelle dynamique de la filière.

Les résultats de cette étude, montrent que le potentiel de production et de transformation des coproduits de la figue de Barbarie est impor-

tant, mais reste très largement sous exploité. La phase industrielle est confrontée aux contraintes de l'amont et de l'aval de la filière, ainsi qu'à une faiblesse de structuration sociotechnique et des interactions entre les acteurs (recherche, accompagnement, institutions, etc.). La production demeure en majorité artisanale et relève d'une pratique de collecte traditionnelle (cueillette manuelle et familiale). La commercialisation est dominée par des circuits peu structurés et informels (vente à la sauvette des fruits frais). Les débouchés sont centrés sur le fruit frais, peu valorisé, même si des tentatives de transformation et de valorisation sont initiées par des acteurs mieux organisés et de plus grandes tailles comme la coopérative Nopaltec.

Cette étude montre également que le développement de ces activités de transformation est assez récent et reflète l'engouement pour cette filière émergente surtout pour l'activité de l'extraction de l'huile des graines. Il est le résultat du développement de recherches techniques sur les coproduits de la filière et de la volonté de certains acteurs de répliquer des modèles déjà observés ailleurs. Cet engouement part donc d'une innovation technique et institutionnelle et l'interrogation porte sur sa diffusion et son utilisation par les acteurs dans le contexte algérien et l'appropriation des pratiques déjà développées dans d'autres pays méditerranéens (Ben Hassen et El Bilali, 2021). L'approche par SST et l'analyse de l'évolution de la filière semblent ainsi pertinentes afin de comprendre le potentiel de valorisation, les contraintes de la filière et les interactions entre les différents acteurs.

Au-delà de l'analyse du potentiel des coproduits de la figue de Barbarie, nos résultats montrent que la capacité de transformation reste également handicapée par ses difficultés d'approvisionnement. En aval et malgré la diversité de la gamme produite, les débouchés locaux restent dominants du fait d'un échec relatif de l'exportation. Notre recherche met en lumière deux obstacles majeurs à cette stratégie ; (i) la gestion inefficace de la qualité, amplifiée par le manque de certification et ; (ii) la lenteur et la complexité des démarches administratives liées à l'exportation du fait de l'atomicité des quantités. Ces constats appellent les opérateurs économiques à repenser leur *business model* et les pouvoirs publics à mieux orienter leur action de soutien sur les maillons défaillants de cette filière.

De plus, et dans une optique d'apprentissage organisationnel et institutionnel, l'accompagnement à l'acquisition des nouvelles compétences serait indispensable pour réussir la transition de ce SST portée principalement par des initiatives privées *via* l'investissement dans les technologies de transformation de la figue de Barbarie. Outre le renforcement des capacités humaines des opérateurs économiques de la filière, les pouvoirs publics pourraient contribuer à lever les freins à cette dynamique par une orientation du système de recherche & développement sur l'amélioration des plantations et les conditions de cueillette en amont. S'appuyer sur les expériences passées dans des contextes similaires (organisation des différents maillons de la filière) et le transfert technique (plantation, cueillette, gestion de la qualité) peut être un levier efficace pour structurer la filière mais ne doit pas se faire sans tenir compte de l'évolution du contexte économique et social spécifique de l'Algérie.

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