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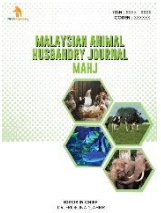

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RESEARCH ARTICLE

EVALUATION OF THE SUSTAINABILITY OF GOAT FARMS IN THE NORTH-WESTERN REGION OF TUNISIA

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ABSTRACT

Background: Sustainability issues are of particular importance for the goat sector in The North-southern of Tunisia, where many local populations are reared, ensuring livelihoods for vulnerable populations in rural areas, including those in marginal zones. Even though in recent decades there has been great progress in research aimed at increasing goat productivity, there is still great work to be done, namely in the sustainability of this sector Methods: The study aimed to assess the sustainability of goat farming in the North-West of Tunisia. Twenty farms practicing goat farming were involved. Sustainability was assessed using the IDEA method (Indicateurs de Durabilité des Exploitations Agricoles or Farm Sustainability Indicators). Results: The analysis of the three scales of sustainability (the agro-ecological scale, the socio-territorial scale, and the economic scale) permitted the identification of four classes of farmers in the agro-ecological scale, five classes on the socio-territorial scale, and five classes in the economic scale. The socio-territorial scale that had the lowest value (59.3 points/100) defined global sustainability. At this scale, the components, product territorial quality, ethics, and human development must be improved and optimized. While the highest performances are recorded by the economic scale (70.35), whose transmissibility indicator has the highest score (20 points). It was concluded that the most limiting factor of sustainability for all the farms is the socio-territorial scale, while the highest score of sustainability was found for the economic scale. Improvements should be implemented on all three scales.

KEYWORDS

Goat, IDEA, North-West, Sustainability, Tunisia.

1. INTRODUCTION

Within domestic animal species, and in several regions, goats represent an important source of animal protein, mainly meat. Despite its important role in the economy and agriculture, goat farming has suffered from a devalued perception. Indeed, the producing goat population in Tunisia has been progressively decreasing over the last ten years from 1,109,890 head in 2009 to 948,650 head in 2019, recording a decline of about 17% over the decade (OEP, 2020). However, the Tunisian goat herd was characterized by great diversification of breeds. Bello (2000) reported that the population was composed of a local indigenous population 'Arbi' raised in all bioclimatic areas of the country. This population also includes several imported pure breeds such as the Damascus, the Maltese, the Alpine, the Murciano-Granadina, and the Boer. However, 43% of the livestock is located in the Southern region, almost 30% occupies the Northern region and 27% were found in the center of the country. In the Northern regions, goats were raised in large mixed extensive farming systems with sheep and cattle (Ammar et al. 2011). In contrast, 70% of Tunisian goats located in the center and the south, were raised in the semi-intensive systems of oases, in small flocks. Although the extensive mixed systems were changing due to socio-economic development, the maintenance of this farming system was guaranteed by national projects for the development of the small ruminant sector (ODESYPANO, 2016).

In the North-west regions of Tunisia, goat livestock production was integrated into family farming and it was a main component of subsistence for rural populations with limited income. Indeed, it was based on grazing on maquis and existing plant cover or cultivated in small areas on clearings. Also, the breeders were not integrated into the local structures or organizations and are not given much technical support concerning animal husbandry and product valorization (ODESYPANO, 2020). Nevertheless, the development of this sector has been delayed, and consequently, few research works have been consecrated to this species (Rouissi et al. 2006; Boubaker, 2005). This study aimed to evaluate the sustainability of the current goat breeding system in the northwest of Tunisia.

2. MATERIALS AND METHODS

2.1 Study area and farm sampling

This study work was carried out in the North-Western region of Tunisia (governorates of Beja, Jendouba, Siliana, and Kef). This region belongs to the humid and sub-humid bioclimatic stages. The average annual precipitation was respectively from 1000 to 1500 mm/year for the humid stage and from 600 to 1000 mm/year for the sub-humid stage. The study was conducted on 20 small and medium goat farms. They were selected based on the breeders' adherence to the improvement program provided by the regional developing organism ODESYPANO.

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2.2 Survey and Data Collection

The survey, containing 83 questions, covered all the sustainability indicators to characterize the performance of the farms. To collect and ensure the completeness of data, a questionnaire was prepared based on the IDEA tools to assess sustainability. The provided information allowed us to calculate the sustainability indicators for the different farms. This survey covered data on human capital, livestock, management, agricultural areas, environment, product quality, and economic aspects. It was carried out through direct interviews with farmers during March and April 2019.

2.3 Presentation of the used tool (IDEA)

The IDEA method (Indicateurs de Durabilité des Exploitations Agricoles or Farm SustainabilityIndicators) was an attempt to quantify sustainability. It was a scoring method that evaluates the sustainability of a farm, based on 42 indicators structured in three independent sustainability scales (agro-ecological, socio-territorial and economic scale) and offered practical content to the concept of sustainability at the farm level. The agro-ecological scale was composed of three components (diversity of production, organization of space, and farming practices) and 18 indicators (Zahm et al. 2008). Each component has the same weight of 33 or 34 points on a total score of 100 (Viaux, 1999). The socio-territorial scale also consists of three components (quality of products and land, employment and services, ethics, and human development) with the same weight of 33 or 34 points on a total score of 100, divided over 18 indicators. The economic scale was represented by four components (economic viability, independence, transferability, and efficiency) with weights of 20 to 30 points for a total of 100, and has six indicators (Zahm et al. 2008). The calculation method was based on two principles. The first one was the compensation between the indicators of the same component. Each indicator had a minimum value of zero and a maximum value. Indeed, the value of the score of each component is the cumulative number of basic sustainability units. Thus, within the same scale, the total sustainability value was the sum of the component scores and had an upper limit of 100 points. The final sustainability score was the lowest value of the three sustainability scales (Zahm et al. 2008).

2.4 Calculation and Statistical Analysis

The data collected from the survey was converted, via the IDEA calculator, into sustainability values, which were used to determine the score attributed to each indicator. Therefore, the final score of each scale was the sum of its indicators. Thereafter, statistical analyses were carried out using XLSTAT for multidimensional statistics on the data allowing a more refined interpretation of the results. A Principal Component Analysis (PCA) was applied on the three scales agro-ecological, socio-territorial and economic. Then, a hierarchical classification based on the individuals 'coordinates according to the predefined axes allowed the elaboration of farms' classification. The objective was to identify the farms that form homogeneous classes according to defined groups of variables.

3. Results and Discussion

3.1 Overall sustainability of the farms

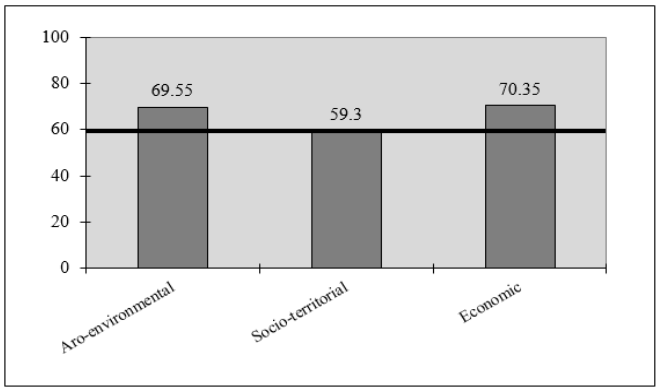

Figure 1: Numerical representation of the three scales of sustainability

The results obtained for each scale of sustainability were the averages relative to the studied farms. It should be noted that the overall sustainability score was the value of the lowest scale. Figure 1 showed that sustainability was limited by the socio-territorial scale with an average value of 59.3 points. This result was in line with those presented by M'Hamdi et al. (2009) in dairy farms in Tunisia, and Araba and Boughalmi (2016) for ovine farms in Morocco. These results were lower than ours respectively 52.5; 38.1 and 32.26. However, Srour et al. (2009) reported that the agro-ecological scale was the limiting factor when assessing the sustainability of small ruminants farms in Lebanon (in the order of 39). The objectives of the socio-territorial dimension are mainly: human development, citizenship, ethics, and local development. In this respect, the low score attributed to the social scale of sustainability was explained by the limited intellectual level (59.3%), low technicality (1.9), and the lack of interest of farmers in territorial management and collective work 0.75).

3.2 Sustainability Component Analysis

Figure 2: Radar Representing Component Values of Surveyed Farms

Figure 2 illustrated the scores for each sustainability component for all farmers compared to the maximum value. The components: viability, quality of products and territories, and organization of space had the lowest values (respectively 3.25; 13 and 14.8). Results of the components vary from one situation to another. Indeed, Benidir et al. (2009) reported that the components: Organization of space, employment and services, and Efficiency had the lowest scores (10.82; 12.56 and 7.98) in sheep systems in Algeria.

3.3 Analysis of Indicators

Tables 1, 2, and 3 illustrated the components of each scale compared to the terminals. The 'agricultural practices' component of the agro-ecological scale had a maximum score (32.8 points out of a total of 34 points) compared to spatial organization and domestic diversity with scores of 21.95/33 and 14.8/34, respectively. This reflects that permanent grasslands (>5 years) were very small or absent, due to the lack of technical and financial equipment for irrigation (M'Hamdi, 2009). Our results were higher than those of M'Hamdi et al. (2009) and Bekhouche-Guendouz (2011) in dairy cattle farming in Tunisia and Algeria, respectively.

3.4 Agro-Ecological Scale

The agro-ecological scale brings together indicators that reflect the capacity of farms to be self-sufficient (M'Hamdi et al. 2017). Indeed, it aimed to reduce the negative impact of different agricultural activities (use of energy or natural resources, pollution, etc.) on the environment. The analysis of this scale (Table 1) showed that the scores recorded for the indicators 'animal diversity' (11.6/14), 'size of plot' (5.5/6), 'pesticides' (10.95/13), 'veterinary treatments' (2.6/3), 'protection and management of water resources (4/4) and 'energy dependence' (8/10) have the highest scores compared to the maximum value. The observed results could be explained by the management breeding ways of goats (dominance of the extensive agro-pastoral system (Ammar et al. 2011). Araba and Boughalmi (2016) stated that in three sheep farming systems, the score of the diversity component was reinforced by high animal diversity, which was reflected by the presence of more than two species in the same flock, as well as the breeding of local breeds in their region of origin.

Moreover, this component provides information on the autonomy and hardiness of the goat species. On the other hand, the 'domestic diversity' component obtained a lower score, which explains the low diversity of annual and perennial crops. It should be noted that the value of the diversity of perennial crops was also low (3.75/14). Similarly, the score of the indicator valorization and conservation of genetic heritage was very low (0.6/6). The organic matter management indicator had a score equal to zero, due to the non-valorization of manure in goat breeding, which explains the difference between these results and those presented by M'Hamdi et al. (2009) in cattle breeding. Likewise, a null score attributed to the indicator contribution to the environmental stakes of the territory was noted. It could be explained by a lack of organization in this sector. Concerning the indicator size of the plots, the scores obtained were high

with an average of 5.5/6, which indicates that the plots are of average size.

Table 1: Agro-ecological sustainability indicators.

Components	Indicators	Score	Borne
Diversity	A1-Diversity of annual or temporary crops	6	0 to 14
	A2-Diversity of perennial crops	3.75	0 to 14
	A3-Animal diversity	11 .6	0 to 14
	A4-Conservation of local genetic resources	0.6	0 to 6
Organization of space	A5-Cropping pattern	3.25	0 to 8
	A6-Size of plots	5.5	0 to 6
	A7-Organic matter management	0	0 to 5
	A8-Ecological regulation zone	2.4	0 to 12
	A9-Contribution to environmental issues	0	0 to 4
	A10-Space management	2.5	0 to 5
	A11-Fodder area management	1.15	0 to 3
Farming practices	A12-Fertilization	4.95	0 to 8
	A13-Liquid effluent management	1.5	0 to 3
	A14-Pesticides	10.95	0 to 13
	A15-Veterinary treatment	2.6	0 to 3
	A16-Soils protection	0.8	0 to 5
	A17-Water resources management	4	0 to 4
	A18-Energy dependence	8	0 to 10
	Total	69.55	0 to 100

3.5 Socio-Territorial Scale

Table 2: Socio-territorial sustainability indicators.

Components	Indicators	Score	Borne
Quality of products and territories	B1- Quality approach	0	0 to 10
	B2- Enhancement of built heritage and landscapes	4.55	0 to 8
	B3- Management of non-organic waste	2.4	0 to 5
	B4- Accessibility of space	4.65	0 to 5
	B5- Social implication	1.4	0 to 6
Employment and services	B6- Short trade	7	0 to 7
	B7- Autonomy and valorization of local resources	5.5	10
	B8- Services multi-activities	0.2	0 to 5
	B9- Employment contribution	4.1	0 to 6
	B10- Collective work	0.75	0 to 5
	B11- Probable sustainability	2.75	0 to 3
Ethics and human development	B12- Contribution to the world food balance	10	0 to 10
	B13- Animal welfare	2.25	0 to 3
	B14- Training	1.9	0 to 6
	B15- Labor intensity	4	0 to 7
	B16- Quality of life	4.65	0 to 6
	B17- Isolation	1.2	0 to 3
	B18- Reception. hygiene and safety	2	0 to 4
	Total	52.2	100

Table 2 showed that at the socio-territorial level, the 'ethics and human development component had the highest score (26 points out of a total of 34 points), in second place the 'employment and services' component with a score of 20.3 points / 33 and the 'quality of products and territories' component with a score of 13 points/33. The socio-territorial scale examines the farmer's relationship with his territory and society, regarding the principles of ethics and human development (Vilain, 2003). The 'quality of products and territories' component, had a zero score,

which reflects the lack of valorization of the sector. The indicators service and multi-activities and collective work of the component 'employment and services', obtained the lowest scores 0.2/5 and 0.75/5, respectively. This result could be explained by the dominance of family labor and consequently, the need for supervision of farmers. However, the indicator of the valorization by short value chains received a better score (7/7). The indicator contribution to world food balance holds a maximum score of 10/10, which explained the autonomy of the goat breed and its power to produce with the minimum of inputs.

3.6 Economic Scale

Table 3: Economic sustainability indicators.

Components	Indicators	Score	Borne
Viability	C1 —Economic viability	3.25	0 à 20
	C2- Economic specialization rate	4.6	0 à 10
Independence	C3- Financial autonomy	15	0 à 15
	C4- Sensitivity for Governmental aid	10	0 à 10
Transferability	C5- Economic transferability	20	à 20
Efficiency	C6- Efficiency of the production process	17.5	0 à 25
	Total	70.35	0 à 100

The economic scale analysis (Table 3) had low values for the economic viability component (7.85/30). The economic viability of the farm depends largely on the economic indicators. It can be seen that the indicators of financial autonomy, sensitivity to aid, and transferability obtained full scores of 15/15, 10/10, and 20/20, respectively. The value of the efficiency indicator was also high (17.5/25). These values were better than those reported by M'Hamdi et al. (2009) and Yakhlef et al. (2008), 11.95 and 7.73, respectively. Indeed, the scores obtained for the two components 'independence' and 'transferability' provide information on the degree of financial autonomy and economic dependence of the farms. However, in reality, these obtained values may be due to the total absence of financial aid and the difficulty of obtaining bank loans. On the other hand, the indicators 'economic viability and 'economic specialization rate' had low scores (3.25/20 and 4.6/10).

3.7 Principal Component Analysis (PCA) on the Agro-Ecological Scale

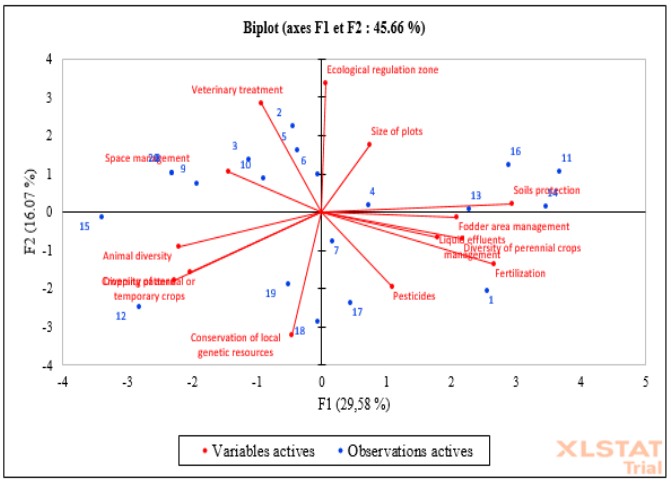

Figure 3: PCA on the agro-ecological scale

Figure 3 illustrates the distribution of the indicators of the agro-ecological scale. The indicators 'soil resource protection', 'fertilization' and 'diversity of annual and temporary crops' were strongly represented on axis 1 with percentages of 87.3; 78.8, and 64.4%, respectively. While, ecological control zones and veterinary treatments were well defined on axis 2, with percentages of 73.4 and 62.3%, respectively. The Ascending Hierarchical Classification (AHC) on the agro-ecological scale allowed the identification of 4 classes (Figure 4). Class 1 characterized 25% of the farms. These farms had high values for the 4 indicators (6 points/6), fertilization (7.5 points/8), pesticides (12.4 points/13), and protection of the soil resources (1.5 points/5). Moreover, they were characterized by a relatively healthy production with a low nitrogen balance (<30 kg N/ha) and very limited or absent use of pesticides. Furthermore, these farms were also characterized by a low crop diversity with a score of 2.85 points/14, due to the absence of permanent grassland and arboriculture. Equally, animal diversity was very limited with a score lower than 8 points/14. Class 2 included 35% of the farm with a high animal diversity (14 points/14), nearby ecological regulation (water points, and permanent grassland). Class 3 represented 35% of the farms characterized by considerable diversity of crops and livestock. The scores attributed to these two indicators were respectively 8.8 and 14 points out of 14. It should be noted that the farms belonging to this class were characterized by forage autonomy. Class 4 was presented by only one farm representing 5% of the sample. Undeniably, it was characterized by good plant diversity (6.8/14 for annual crops and 6.6/14 for perennial crops) and animal diversity (13.2/14). Also, this farm had the highest score of the genetic heritage valorization and conservation indicator (1.2 points/6) which was explained by the presence of the local goat.

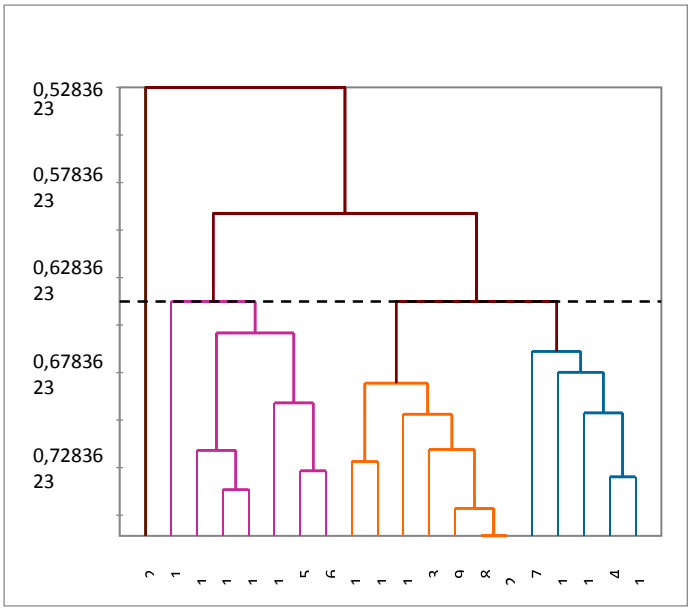

Figure 4: CAH on the agro-ecological scale

3.8 Principal Component Analysis (PCA) on the socio-territorial scale

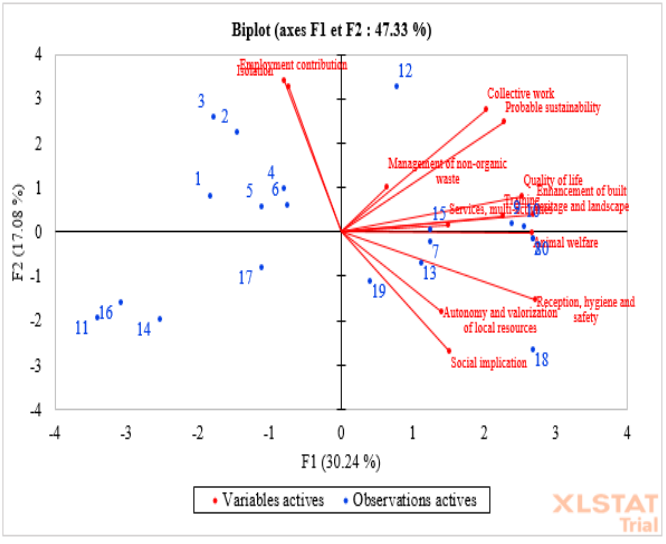

Figure 5: PCA at the Socio-Territorial Scale

Figure 5 illustrates the distribution of the socio-territorial scale indicators. The three indicators 'health and safety, 'enhancement of the built heritage, and 'landscape and animal welfare' were highly represented on axis 1 with respectively (76.6, 73.4, and 72.5%). Thus, the indicator 'contribution to employment was strongly represented on axis 2 (73.1%), and the indicator 'isolation' was (71.4%).

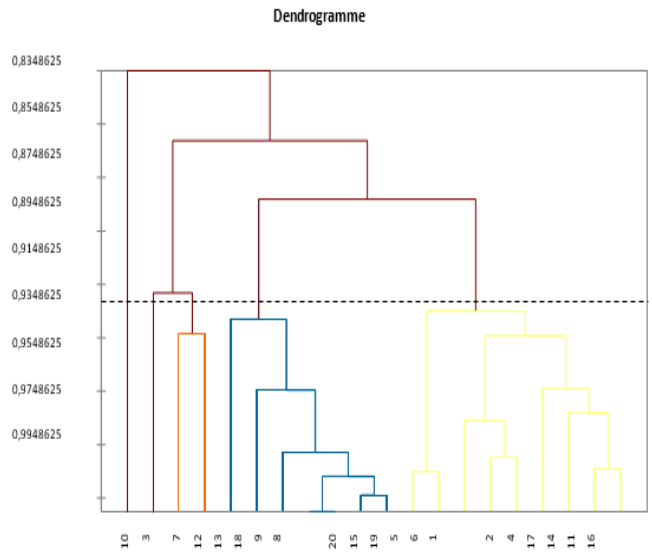

Figure 6: CAH at the socio-territorial scale

Figure 6 illustrates the five classes obtained according to the Ascending Hierarchical Classification (AHC) at the socio-territorial scale. Class 1 contains the majority of the farms (45%). These farms were accessible (4.7 points/5) and characterized by a high value for the indicator contribution to employment (4.22 points/6). However, they had a low social involvement in agricultural associations and cooperatives with scores that did not exceed 1 point/6. Class 2 was represented by one farm. It was characterized by good management of non-organic waste (3 points/5). Nevertheless, it had a low autonomy and valorization of local resources and a total absence of hygienic practices. Class 3 includes farms that contribute to maintaining employment on its territory (5 points/6) and livestock farmers with a good quality of life (5.5 points/6). Also, this class characterizes farms that respect animal welfare (3 points/3). However, these farms were not autonomous (2.5 points/10). Class 4 includes 7 farms having an excellent quality of life (5.7 points/6), the social involvement of the farmer – 6.5 points/8 for the indicator 'valorization of the built heritage and landscape' – .

Class 5 characterizes a single farm that was easily accessible and has better autonomy (7 points/10). Likewise, it contributed strongly to employment, since it presented a high percentage for the components 'employment and services' and 'ethics and human development.

3.9 Principal Component Analysis (PCA) at the economic scale

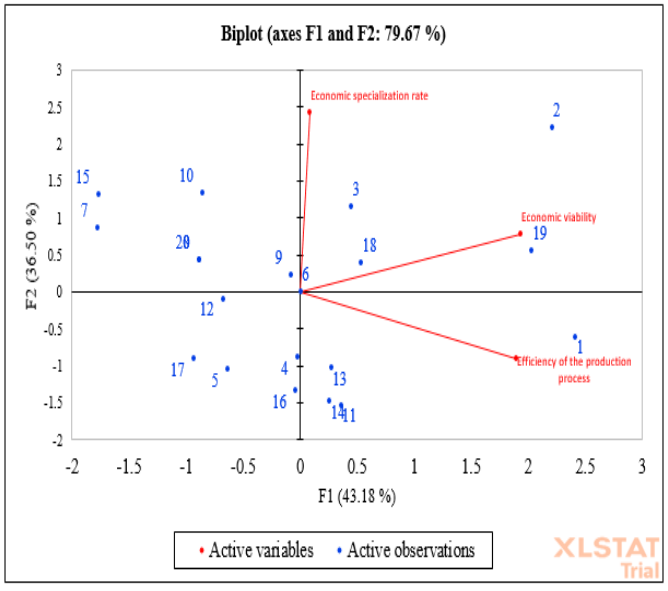

Figure 7: PCA on the economic scale

Figure 7 illustrates the distribution of economic scale indicators. For axis 1, the economic viability and efficiency indicators were strongly represented (81.3 and 79.6%). On-axis 2, the specialization rate indicator was well presented (90%).

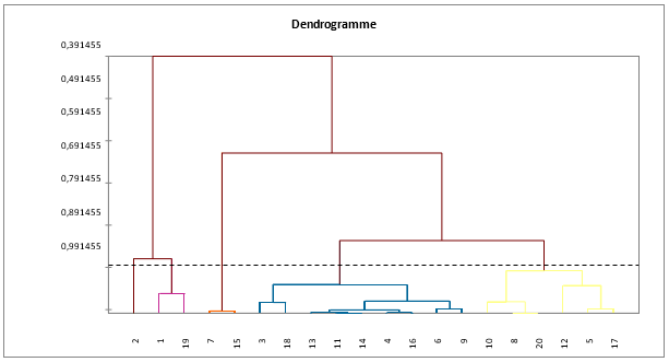

Figure 8: CAH on the Economic Scale

Figure 8 identified 5 classes based on the economic scale. Class 1 included farms having good economic viability with a score of 18 points/20 and high efficiency (24 points/25), which reflects the autonomy and economy of resources at the level of these farms. While the specialization rate was low (3 points/10). Although, the specialization rate was low in the order of 3 points/10. Class 2 was represented by one farm with high economic viability and specialization rate (20/20 and 10 points/10). This explains the diversification of products sold. Class 3 covered 45% of the sample. In these farms, the economic viability was very low (0.4/20) as was the specialization rate (4/10). However, the indicator efficiency of the production processes was high (22.5/25). Class 4 contains farms with low economic viability, speciation rates, and efficiency (0.83/20; 4/10, and 12/25, respectively). Class 5 contained farms where economic viability was equal to zero and low efficiency (3/10). However, the specialization rate was relatively high (7 points/10).

4. Conclusions

It was concluded that the limiting value is attributed to the socio-territorial scale, while the best performances of sustainability were attributed to the economic scale. The advanced analysis showed the important role of animal and crop diversity in achieving better performances on the scale of agro-ecological sustainability. The score of farmers' practice was acceptable, but that relative to the organization of the space was very low and improperly controlled. The weaknesses in performances at the socio-territorial level are due to the insufficient product quality component, the lack of social involvement of collective work and services, and multi-activities among farmers in the region. Finally, despite the high performance obtained by the economic scale, further efforts were to be deployed to improve the efficiency of the production process, which is represented by a low score due to the importance of financial expenses.

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