Agroecological Sustainability Assessment of Olive Farms in Semi-Arid Algeria as a Decision-Support Tool for Guiding Farmers Towards Agroecological Transition

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Abstract

Climate change, soil degradation, groundwater depletion and the excessive use of pesticides and fertilizers are key stress factors for agricultural systems. In this context, farmers must adopt more sustainable farming models and manage natural resources more responsibly. Several tools have been developed to assess the sustainability of agricultural systems, based on predefined indicators. One of these is the Indicators of Farm Sustainability (IDEA) method, which evaluates sustainability through 42 indicators covering agroecological, socio-territorial, and economic dimensions. In this study, the IDEA method was used to assess the agroecological sustainability of 57 olive farms in the Djelfa region of Algeria. The results show an average agroecological score of 52.74 ± 10.29 out of 100. This reflects some good practices, such as limited pesticide and fertilizer use. However, improvements are needed in plot size and crop diversification. Farms integrating small ruminant livestock (sheep or goats) achieved better results (60.52/100) compared to those without (48.19/100), highlighting the value of diversification. This method can serve as a decision-support tool to help farmers identify areas for improvement and transition towards more sustainable agricultural practices.

Keywords: Sustainability; Olive farms; Agroecology; Indicators; Assessment; Method, Semi-arid

Introduction

In Algeria, the agricultural sector has been placed in tune with the State's policy in its overall development strategy for the country by wanting to take the national economy out of oil revenues and improve the level of food security in the country. Agricultural policies inclined to productivism with timidly displayed prowess with regard to sustainable agricultural development have allowed farmers to innovate adaptation strategies to deal with the erosion of their productive resources. Agroecological practices thus emerge as capacities that are essentially the result of private initiatives, which seem to be stifled in agricultural policy programs. (Ameur et al., 2017; Dugué et al., 2014).

In the context of global climate change, the key challenge is to protect scarce resources, ecological systems and natural heritage, which are the determinants of production growth and labour and soil productivity (Bessaoud et al., 2019). The objective of this study is to assess the state of agroecological sustainability of farms in Algeria, using olive farms in the wilaya of Djelfa as a case study. These farms were established mainly since the 2000s through public policies aimed at expanding agricultural areas and increasing production (Amrouni Sais and Benziouche, 2024). The assessment of agroecological sustainability is carried out using the IDEA method (Indicateurs de Durabilité des Exploitations Agricoles), which is one of the most widely applied frameworks for farm sustainability assessment in Algeria (Amrouni Sais and Benziouche, 2025a). This method is based on a set of structured indicators that evaluate farms' capacity to manage natural resources efficiently while limiting environmental impacts. The results of this study aim to identify the most vulnerable indicators in order to support public policies and guide decision-making towards improved agroecological management.

Materials and methods

Study area

The Djelfa region is located in central Algeria (Figure 1), in a transitional area between the Tellian Atlas and the Saharan regions. It is characterized by a semi-arid to arid climate, with low and irregular rainfall (200 to 350 mm/year in the north and less than 200 mm/year in the south). Olive growing, historically marginal, has recently expanded significantly due to agricultural development policies.

Figure 1 Map of the wilaya of Djelfa

Questionnaire development

To collect relevant and accurate data, a structured and functional questionnaire was designed. The latter was developed based on the IDEA grid allowing you to know the different agricultural practices.

Sampling and data collection

A sample of 57 farms spread throughout the wilaya was selected according to non-probability sampling methods, which are methods where the selection of entities is completely subjective and motivated by specific reasons. They are often useful and sometimes even the only methods available and applicable (Gumuchian and Marois, 2000). The difficulty of opting for probability sampling is justified, firstly, by the lack of precise information on the target population at the level of the Directorate of Agricultural Services and the Chamber of Agriculture of the wilaya of Djelfa (Number of olive farms, size, distribution, variability) (Saunders et al., 2020). The data were collected between November 2023 and May 2024 via a questionnaire based on the IDEA method (version 3), supplemented by direct observations.

Thus, different types of olive farms were identified in the study area: (i) capitalized olive farms, characterized by high capital and a predominance of olive cultivation; (ii) traditional agro-pastoral farms, combining various crops, livestock, and secondary olive production; and (iii) small diversified farms, with low area and capital, and diversified production including olives, other crops, and poultry (Amrouni Sais and Benziouche, 2026).

Working method

The choice of method was the IDEA method, which is a method for quantifying sustainability. This method has contributed to numerous academic research works on the assessment of the sustainability of agricultural systems around the world (De Olde et al., 2016) but also in Algeria through the use of its different versions, mainly on livestock farms (Amrouni Sais et al., 2025b).

The IDEA method is a tool for establishing a multi-criteria assessment of the sustainability of production systems (Vilain et al., 2008). It

TABLE 1

Agroecological sustainability indicators by component (IDEA version 3)

Scale	Component	Indicator		Maximum values
Agro-ecological sustainability scale	DOMESTIC DIVERSITY	Diversity of annual or temporary crops: A1	14	Total capped at 33 units
		Diversity of perennial crops: A2	14	
		Animal diversity: A3	14	
		Valorisation and conservation of the genetic heritage: A4	6	
	ORGANISATION OF SPACE	Crop rotation: A5	8	Total capped at 33 units
		Plot size: A6	6	
		Organic Waste Management: A7	5	
		Ecological regulation zone: A8	12	
		Contribution to the environmental issues of the territory: A9	4	
		Valuation of space: A10	5	
		Forage Area Management: A11	3	
	AGRICULTURAL PRACTICES	Fertilisation : A12	8	Total capped at 34 units
		Liquid organic effluents: A13	3	
		Pesticides: A14	13	
		Veterinary treatments: A15	3	
		Protection of the soil resource: A16	5	
		Water resource management: A17	4	
		Energy dependence: A18	10	
Total: 100				

makes it possible to assess sustainability at the farm level, with the assumption that it is possible to quantify the various components of an agricultural system by assigning them a numerical score, and then to weight and aggregate the information obtained to obtain a farm score (Briquel et al., 2001).

The calculation method is based on a point system with a cap. The three durability scales are of the same weight and vary between 0 to 100 durability units. All the information is translated into basic sustainability units that determine the score assigned to each indicator. Maximum scores are defined for each indicator in order to cap the total number of sustainability units. Each indicator is made up of one or more elementary items, characterizing a practice (or characteristic) and contributing to the final value of the indicator. Negative values were set to zero (0), and values exceeding the maximum value were capped at that maximum (Vilain et al., 2008).

The higher the score, the more sustainable the farm is considered to be for the size in question. Moreover, there is no compensation between components within the same dimension. Therefore, the maximum score in each component is required to achieve the highest level of sustainability (100). This reflects the requirement for sustainability that covers all the themes of the components of the same dimension. (Zahm et al., 2023).

Data processing

The database was developed in Microsoft Excel, which allowed us to visualize the sustainability scores of the different farms surveyed. The data were then processed by IBM SPSS Statistics 27 software for descriptive statistics.

Results

Diversity of annual and temporary crops

This indicator, whose limits vary between 0 and 14, assesses the diversity of annual crops and takes into account the presence of annual species and/or varieties as well as legumes on the farm. The diversity of annual crops makes it possible to alleviate climatic, parasitic or economic hazards and also makes it possible to optimize crop rotation and soil fertility (Vilain et al., 2008).

At the level of the various farms visited, very little diversity in annual crops was observed, with the presence mainly of cereals (barley and durum wheat) and the virtual absence of market gardening, with the exception of a minority of farms. This low diversity resulted in low scores for this indicator with a minimum of 0, a maximum of 8 and an average value of 2.16±2.18. (Table 2).

Diversity of perennial crops

Like indicator A1 in Table 2, this indicator measures the diversity in terms of species and varieties of perennial crops and permanent grassland. A high score on this indicator suggests a diversity that will promote ecological stability and the proper functioning of the agroecosystem.

The presence of perennial crops, due to the stability of the space, which is not very intensive, gives the agrosystem many properties that strengthen agroecological sustainability, including soil fertility, protection against erosion, and the quality of water resources (Vilain et al., 2008). The scoring range for this indicator, according to the IDEA method, vary between 0 and 14.

The results obtained for this indicator, the minimum is 3, the maximum is 14 and the average is 7.31±4.38. (Table 2). Unlike annual crops, perennial crops have a certain diversity, marked by the presence of several species and fruit varieties such as olive, apple, pomegranate, plum and peach. This diversity is complemented by alfalfa, which is planted as a permanent fodder crop.

Animal diversity

For this indicator, it is a question of providing information on the existence or not of any breeding activity as well as its diversification in terms of the presence of several species and breeds. Indeed, sustainable agricultural systems are based on three pillars: animal production, perennial crops and annual crops. The absence of animal production reveals a dysfunction in the agricultural system because animal production contributes to the enhancement and maintenance of the fertility of the environment (Vilain et al., 2008).

The scoring range for this indicator, according to Vilain et al. (2008), vary between 0 and 14. Sheep farming remains the predominant activity in the Djelfa region. However, poultry farming is increasing there, with the installation of many industrial buildings dedicated to the production of table eggs and broilers. New infrastructure is also being built. The most dominant sheep breed is the Ouled Djellal. It is a true steppe sheep and the most adapted to nomadism, with a proven aptitude for arid regions (Chekkal et al., 2015).

This A3 indicator has an average of 3.74±4.7 with a minimum score of 0 (which reflects the absence of livestock farming) and a maximum score of 14 (which reflects the presence of several animal species and races (Table 2).

Valorisation and conservation of genetic heritage

This indicator highlights efforts to preserve and enhance local and/or endangered breeds and varieties. It also highlights the fight against the generalization of varieties and breeds by using those standardized and selected to meet the needs of the market. Indeed, genetic erosion seriously compromises the world's agricultural and food resources (Vilain et al., 2008).

The limits granted to this indicator vary, according to the IDEA grid, between 0 and 6. The maximum score of 6 was obtained in only three farms, while the minimum score of 0 was obtained in 40 of the 57 farms, which reflects genetic erosion and the lack of interest in maintaining local or endangered breeds or varieties.

DOMESTIC DIVERSITY Component

This component represents the sum of indicators A1 to A4. It provides an overview of the plant and animal diversity on the farm. Economic, autonomous and non-polluting agriculture cannot, under any circumstances, be envisaged without a diversity of production that will allow a natural regulation of the agrosystem (Vilain et al., 2008). For this component, the results obtained, the minimum is 3, the maximum is 33 and the average is 14.18±8.76. The mode for this component is 5 and are obtained from eleven farms (Table 2).

TABLE 2

Results of the olive farms surveyed for the indicators of the DOMESTIC DIVERSITY component (Comp.1)

	A1	A2	A3	A4	Comp.1
Average	2,16	7,37	3,74	1,02	14,18
Median	2,00	6,00	0,00	0,00	14,00
Mode	2	3	0	0	5
Standard deviation	2,186	4,382	4,700	1,716	8,761
Minimum	0	3	0	0	3
Maximum	8	14	14	6	33

Crop rotation

The "crop rotation" indicator informs us about the level of simplicity or complexity of crop rotations that will make it possible to optimize rotations to avoid economic, ecological and parasitic risks. Indeed, simplified crop rotation leads to shorter rotations, which causes an alteration in the biological functioning of the soil and an overuse of chemicals (Vilain et al., 2008). The scoring range for this indicator by Vilain et al. (2008) vary between 0 and 8.

The agro-ecological conditions that characterize the Djelfa region have meant that the practice of crop rotation is very low, which justifies the score of 0 obtained in thirty-eight farms and the maximum score of 8 which is obtained in only two farms. The average obtained for this indicator is 1.37±2.28 (Table 3).

Parcel size

This indicator gives us an overview of the suitability of the size of plots which, if very large, can pose agronomic and environmental problems. Indeed, the management of modest-sized plots takes into account spatial heterogeneities, which allows for more detailed management of health risks and a strengthening of domestic biodiversity (Vilain et al., 2008). The IDEA Method assigns this indicator bounds that vary from 0 to 6.

This indicator obtained a score of 4±2.31, which is a good score, especially with twenty-eight farms that obtained the full score of 6 (Table 3). It is worth noting that the land structure and crops in the study area show considerable variability. Total farm area ranges from 6 to 210 ha, with an average of 34.5 ha and a mode of 10 ha observed in 23% of cases. Most farms (90%) operate less than 60 ha, and the average utilized agricultural area (UAA) is 30 ha.

Organic Waste Management

This indicator provides information on the levels of organic matter input, which remains a determining factor in soil fertility. Indicator A7 is largely related to the existence or absence of livestock farming (A3) because the latter is a permanent source of soil supply of organic matter, which allows the regular maintenance of soil fertility (Vilain et al., 2008).

The scoring range for this indicator, according to Vilain et al. (2008), vary between 0 and 5.

The score obtained for this indicator is 2.33±1.27 with a minimum score of 0 obtained by eleven farms and a maximum score of 5 obtained by three farms. As for the mode, it is 3 obtained by 35 farm (Table 3). This indicator obtains a good score with 65% of farms exceeding the score of 3, which reflects the regular use of organic matter by farmers, mainly consisting of sheep manure and or poultry droppings.

Ecological Regulation Zone

This factor, whose limits vary between 0 and 12, accounts for areas with little or no anthropization that can contribute to the balance of the agroecosystem. These spaces,

TABLE 3
Results of the olive farms surveyed for the indicators of the ORGANIZATION OF SPACE COMPONENT (Comp.2)

	A5	A6	A7	A8	A9	A10	A11	Comp.2
Average	1,37	4,00	2,33	6,39	0,00	0,82	0,53	15,44
Median	0,00	5,00	3,00	7,00	0,00	0,00	0,00	15,00
Mode	0	6	3	9	0	0	0	18
Standard deviation	2,288	2,315	1,272	2,505	0,000	1,548	0,710	5,110
Minimum	0	0	0	2	0	0	0	7
Maximum	8	6	5	11	0	5	3	26

such as forest edges, hedges, ponds, etc. are of great interest to the ecosystem and the most important is the biological regulatory power provided by these areas and their ability to buffer and cushion the risks of a population explosion of harmful species (Vilain et al., 2008).

In the Djelfa region, the frequency of sand winds forces farmers to set up windbreaks mainly made of casuarina. The size of the farms means that farmers plan fences and plant boundaries made of prickly pears, reeds or olive trees or fences made of stones from the removal of stones from their land.

Also, the majority of farmers, for irrigation purposes, have hard or geomembrane basins. These three factors mean that this indicator also obtains a good score with 6.39±2.50 and a mode of 9 obtained by 13 farms. All farms scored points on this indicator (Table 3).

Contribution to the territory's environmental issues

This indicator, with limits ranging from 0 to 4, provides information on the operator's level of commitment in compliance with territorialized specifications. This commitment contributes to maintaining and preserving the existing natural biodiversity on his farm, in particular through the change of certain agricultural practices and interventions (Vilain et al., 2008).

This indicator was given a score of 0 in the 57 farms surveyed, due to its unsuitability for the Algerian context, marked by the absence of a regulatory framework defining specifications for the preservation of the territory, which would commit the farmer to public services (Table 3).

Valuation of space

The A10 indicator with terminals from 0 to 5 makes it possible to evaluate the animal load according to the areas intended for animal feeding. This tells us the level of fodder autonomy, including cereals and protein crops, which remains one of the principles of sustainable agriculture. Animal loading tells us about excess effluents that cause water pollution (Vilain et al., 2008).

The score of 0 is obtained when the grazing load is greater than 2 LSU (Livestock Standard Unit) /hectare of area intended for animals or when there is no breeding on the farm.

Thus, 42 farms, i.e. 74% of the sample, obtained a minimum score of 0, reflecting the high fodder dependence of these farms on external resources. The indicator shows an average of 0.82 ± 1.55 on a scale of 0 to 5, reflecting low fodder autonomy and highlighting the need to encourage practices aimed at strengthening self-production of fodder (Table 3).

Forage management

This indicator, whose bounds vary between 0 and 3, evaluates certain forage management practices, such as alternating between mowing and grazing or the presence of permanent grassland. The latter play a key role in strengthening the sustainability of farms, thanks to their ability to limit the use of chemical inputs, while contributing to the preservation of biodiversity (Vilain et al., 2008).

However, the results show that these practices are still not widely adopted by the farms surveyed. The score obtained for this indicator is 0.53±0.71 with a mode of 0 observed in 58% of the farms (33 farms), which reflects the low value of fodder areas in the farms studied (Table 3).

ORGANIZATION OF SPACE Component

This component, which represents the sum of indicators A5 to A11, provides us with information on the development of the farm's spaces, which makes it possible to make the most of natural assets and to contribute to the environmental challenges of the territories.

Indeed, certain developments in territories generate agronomic added value and can contribute to the protection of water resources and the collective preservation of biodiversity (Vilain et al., 2008).

As for the DIVERSITY component, the SPATIAL ORGANIZATION component is also capped at 33 points. The results obtained for this component show a minimum of 7, a maximum of 26 (obtained by a single operation) and an average of 15.44±5.11. The mode for this component being 18 obtained by 12% of the farms (Table 3). These results show variability between the farms surveyed.

Fertilization

This indicator, with a range from 0 to 8, is based on the apparent balance sheet to provide information on the level of use of chemical fertilizers by farmers. If the apparent balance is less than 30 kg of N/ha, the farm receives the maximum score assigned to this indicator, showing a very good balance between nitrogen imports and exports in the system. When the nitrogen balance, which represents the difference between nitrogen imports and exports, is in surplus, it causes the contamination of the water by nitrates and even by pesticides because there is a close correlation between nitrogen levels and pesticide levels in the water. This is because nitrogen over-fertilization weakens plants, which requires enhanced phytosanitary protection (Vilain et al., 2008).

The maximum limit of 8 was obtained by 33 farms, i.e. 58% of the farms surveyed, which indicates a very balanced apparent nitrogen balance that protects the soil, the groundwater and the atmosphere from the risks of pollution. However, 30% of farms have a surplus of more than 40 kg/ha, indicating excessive fertilization likely to have environmental impacts. The average of the indicator is 5.95 ± 3.19, reflecting an overall satisfactory situation, despite heterogeneity between farms. (Table 4). It should be noted that nitrogen imports, in addition to organic matter, are mainly through the addition of urea-46 in the case of field crops and fodder and NPK (15.15.15) in the case of fruit growing.

Liquid Organic Effluents

This indicator, with scores ranging from 0 to 3, penalizes farms that generate organic effluents and do not treat them. Some production systems, such as arboriculture, do not generate any organic effluent, which is a positive point for the preservation of water resources. It must be considered that producing without polluting is a fundamental condition for sustainability (Vilain et al., 2008). Out of a maximum score of 3 for this indicator, the score obtained is 2.26±1.22 with a mode of 3 obtained by 68% of farms. This good score can be explained by the vocation of the farms (arboriculture) which generally does not generate effluents. Farms associated with livestock farming have been penalized when no manure management is envisaged (Table 4).

Pesticides

Indicator A14 is based on the calculation of the pollutant pressure, which corresponds to the developed (treated) area in relation to the total agricultural area.

A farm that does not use pesticides gets the full score for this indicator. Indeed, ecologically sound agriculture must limit the use of pesticides that constitute a danger to wildlife, the environment and the user. The limits given to this indicator vary between 0 and 13 (Vilain et al., 2008).

In our study, this indicator obtained a score of 8.63±3.11 and a score above 9 by 74% of farms (Table 4). This result reflects the limited use of

TABLE 4
Results of the indicators of the AGRICULTURAL PRACTICES component (Comp.3)

	A12	A13	A14	A15	A16	A17	A18	Comp.3
Average	5,95	2,26	8,63	1,25	1,53	1,61	2,00	23,12
Median	8,00	3,00	9,00	1,00	1,00	2,00	1,00	23,00
Mode	8	3	9	0	0	2	0	22
Standard deviation	3,193	1,218	3,109	1,392	1,537	0,861	2,478	6,617
Minimum	0	0	0	0	0	0	0	10
Maximum	8	3	13	3	5	4	8	34

pesticides. However, it should not be forgotten that this is olive growing, where the use of pesticides is usually limited or even absent (Amrouni Sais et al., 2023; Amrouni Sais et al., 2021). The olive fruit fly (Bactrocera oleae) is the pest most frequently reported by farmers. However, they generally do not treat the trees, as extreme climatic conditions particularly low winter temperatures (below 0 °C) and high summer temperatures (30–35 °C) naturally limit the survival and fecundity of the insect. During heatwaves, with temperatures reaching 40 °C or higher, larval and adult mortality is high, substantially reducing the risk of damage (AFIDOL,2018). This natural climatic regulation largely explains the absence of chemical treatments by farmers.
No farm obtained the maximum score of 13 because of certain non-compliant phytosanitary practices, in particular the absence of a record book of phytosanitary treatments at the farm level.

Veterinary treatments
This indicator, with limits between 0 and 3, is based on the calculation of veterinary treatments (VT). A farm with a VT of less than 0.5 obtains the maximum score for this indicator. It should be noted that dependence on veterinary inputs signals inadequate husbandry practices (Vilain et al., 2008).
This indicator, which only concerns farms with livestock, obtained a score of 1.25±1.4 and a mode of 0 in 49% of farms (Table 4). This indicates that half of the farms, for fear of losing their herd, resort to a lot of veterinary treatments, which can be detrimental to the animal's well-being and the quality of production.

Protection of the soil resource
Agricultural practices that have a positive or negative influence on the soil are evaluated using this indicator, the limits of which vary between 0 and 5 (Vilain et al., 2008).
Soil is the basis of agricultural production, which is why its management and conservation must be addressed in a holistic manner. We must consider the aspects that reduce its productivity as well as the aspects that make it more sustainable (Deoleo, 2018).
Responsible technical management (plant cover, anti-erosion device, etc.) contributes to the preservation of soils, which are a practically non-renewable resource (Vilain et al., 2008).
This indicator obtained a score of 1.53±1.54 with a mode of 0 obtained on 22 farms surveyed and only three farms in our sample obtained the maximum limit of 5 (Table 4).
This low score indicates poor soil protection due to frequent ploughing with turning of the soil which causes biological upheaval of the soil and exposure to the risk of erosion.
In the calculation of protection of the soil resource, if the farmer burns straw and olive prunings, he will be penalized with a negative score (-3) which will be subtracted from the score of this indicator. However, this practice was unfortunately observed in the majority of the farms visited.

Water resource management
Effective water management, including monitoring of consumption, is one of the key points of environmental sustainability and a fundamental component of farm management.

This indicator evaluates eco-responsible practices related to crop irrigation. Of course, water remains essential for agriculture and drip irrigation can contribute to the preservation of the resource.

The use of irrigation leads to agrochemical and energy intensification. Irrigation accelerates the mineralization of organic matter which leads to a decrease in soil fertility (Vilain et al., 2008).

This indicator is assessed on a scale of 0 to 4, where 0 corresponds to non-existent or very inadequate management of water resources, and 4 represents optimal management (Vilain et al., 2008).

Indicator A17 obtains an average of 1.61±0,861, with a mode of 2, which means that the majority of farms (65% of the units visited) have an intermediate management of water resources, neither totally inefficient nor optimal. However, field observations reveal unsound irrigation practices. In many cases, irrigation has become routine, with farmers watering their fields nearly every day. Water is often applied without considering climatic conditions or the nature of the soil, which can lead to significant waste, inefficient irrigation, and negative effects on soil and crop health. In addition, technical failures are frequently noted, including a defective and damaged drip network that are responsible for the loss of significant quantities of water (Table 4).

Energy dependence

This indicator reports on the level of use of different energy sources at the farm level. It underlines the dependence of the farm in terms of energy. This indicator does not replace a real energy balance. However, it does give a trend towards the energy recovery of local renewable resources (Vilain et al., 2008).

The energy dependence indicator is evaluated on a scale of 0 to 10 (Vilain et al., 2008). For this indicator, 86% of the farms surveyed did not even achieve a score of 5, while the maximum score is 10. The minimum limit of 0 is the mode of our sample and was obtained by 20 farms (35%). No farm scored the maximum limit of 10. The average obtained for our sample is 2±2.48 (Table 4). This shows that farms are very dependent on electricity in terms of energy, which is still very much in demand for irrigating crops.

AGRICULTURAL PRACTICES Component

It is the last component of the agroecological scale that represents the sum of indicators A12 to A18 and which informs us of agricultural practices that are favourable or unfavourable to sustainability. The search for efficiency in terms of agricultural practices strengthens the autonomy and sustainability of farms (Vilain et al., 2008). The "AGRICULTURAL PRACTICES" component is capped at 34 units, so the three components: DIVERSITY, ORGANIZATION OF SPACE and AGRICULTURAL PRACTICES, total 100 units are allocated at the agroecological scale.

The results obtained for this component show that the minimum is 10, the maximum is 34 (obtained on three farms) and the average is 23.12±6.62. The mode for this component is 22 and was obtained on 10% of the farms (Table 4).

While components 1 and 2 show very similar averages, with 14.18 and 15.44 respectively, the AGRICULTURAL PRACTICES component stands out by obtaining the best average of 23.12.

Agroecological Sustainability

It is based on the calculation of the 18 indicators mentioned above. Agroecological sustainability tells us about the autonomy of agricultural systems in relation to the use of energy and non-renewable resources as well as the ability of these systems to protect water, soil and natural environments (Vilain et al., 2008).

Agroecological sustainability obtains, for our sample, an average of 52.74±10.29 with a minimum score of 31/100 and a maximum score of 76/100. 54% of the farms, i.e. 31 farms, obtained a score above 50/100 (Table 5).

These scores reflect a moderate sustainability and heterogeneity of the agroecological practices adopted by the different farms.

TABLE 5

Results of the frequencies of agroecological sustainability of the farms surveyed

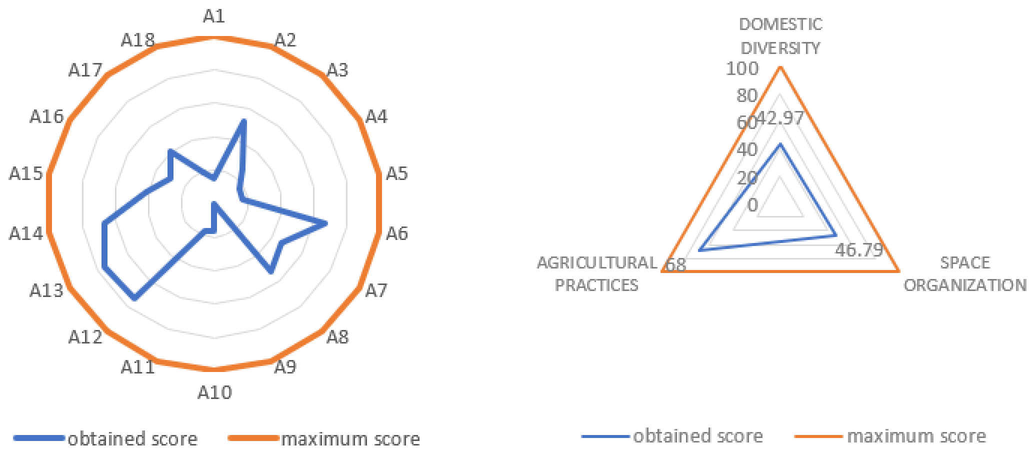
Scores	Frequency	Percentage	Cumulative percentage
< to 29	0	0	0
30 to 39	6	10,53	10,53
40 to 49	20	35,09	45,61
50 to 59	15	26,32	71,93
60 to 69	12	21,05	92,98
70 to 79	4	7,02	100,00
> to 80	0	0,00	100,00

TABLE 6

Results of the indicators and agroecological components of the farms surveyed

Indicators and components		Average score	Score maximum	Score reduced to maximum 100
A1	Diversity of annual and temporary crops	2,16	14	15,43
A2	Diversity of perennial crops	7,37	14	52,64
A3	Animal diversity	3,74	14	26,71
A4	Enhancement and conservation of the genetic heritage	1,02	6	17,00
Comp.1	DOMESTIC DIVERSITY	**14,18**	**33**	**42,97**
A5	Crop rotation	1,37	8	17,13
A6	Plot size	4,00	6	66,67
A7	Organic Waste Management	2,33	5	46,60
A8	Ecological regulation zones	6,39	12	53,25
A9	Contribution to the environmental challenges of the territory	0,00	4	0,00
A10	Valuation of space	0,82	5	16,40
A11	Forage area management	0,53	3	17,67
Comp.2	SPACE ORGANIZATION	**15,44**	**33**	**46,79**
A12	Fertilisation	5,95	8	74,38
A13	Liquid Organic Effluents	2,26	3	75,33
A14	Pesticides	8,63	13	66,38
A15	Veterinary treatments	1,25	3	41,67
A16	Protection of soil resources	1,53	5	30,60
A17	Water resource management	1,61	4	40,25
A18	Energy dependence	2,00	10	20,00
Comp.3	AGRICULTURAL PRACTICES	**23,12**	**34**	**68,00**
Total		**52.74**	**100**	

If we reduce all the indicators of the agroecological dimension to the same maximum score of 100 to allow a comparison between the different indicators, Table 6 shows that the indicators related to agricultural practices obtain the highest scores, especially those related to fertilization and organic effluents. Other indicators also score well (Figure 2a), contributing significantly to improving agroecological sustainability, such as the diversity of perennial crops and the size of plots. However, some indicators represent a limitation to agroecological sustainability (A1, A5, A9…) which still need improvement. Consequently, components exhibiting high indicator levels contribute significantly to



2a 2b

Figure 2 Relative contribution of indicators (2a) and components (2b) to the agroecological sustainability score

agroecological sustainability, particularly the component related to agricultural practices (Figure 2b).

Discussion

Agroecological sustainability scores an average of 52.74±10.29 with a minimum score of 31/100 and a maximum score of 76/100. Only 54% of the farms (31 farms), obtained a score above 50/100. Comparison of the results with those of the only two studies conducted in the same region reveals lower agroecological sustainability in the Benidir (2015) study, with a mean of 43 and scores ranging from a minimum of 25 to a maximum of 57. On the other hand, Ouali (2021) scores higher, amounting to 63/100.

Some indicators have contributed to the lowering of the score of agroecological sustainability. These are mainly, indicators A1 (Diversity of annual and temporary crops) with a score of 15.43/100, A4 (Enhancement and conservation of the genetic heritage) and A5 (Crop rotation) with scores of 17.00 and 17.13/100 respectively, A9 (Contribution to the environmental challenges of the territory) with a score of 0.00/100 and A10 (Valuation of space) with a score of 16.40/100.

In the absence of studies on the sustainability of olive farms in Algeria, the results were compared with those obtained in some regions of Tunisia where agroecological conditions are substantially similar.

As far as crop diversity is concerned, the weaknesses are mainly related to the diversity of temporary and annual crops with the lowest values (Elfkih et al., 2012). Laajimi and Ben Nasr (2009) point out that for farms managed in conventional mode in Tunisia, the weak point of the agroecological scale is also linked to the diversity of crops. The authors add that on the one hand, the monoculture of the olive tree strongly penalizes the level of sustainability of the farms and on the other hand, the absence of livestock farming and therefore, of organic fertilization in the production system. The organization of space at the farm level was the main constraint affecting agroecological sustainability according to Bouzaida and Doukali (2019) which did not prevent the high score of 70/100 reflecting good agroecological practices at the level of olive farms.

These practices could be further optimized by the adoption of organic olive growing (Laajimi and Ben Nasr, 2009, Amrouni Sais et al., 2025; Amrouni Sais and Benziouche, 2025b). Indeed, Elfkih et al. (2012) report average agroecological sustainability scores of 87/100 for organic farms in the Sfax region and 75/100 for those in the Mahdia region of

Tunisia.

For farms in the Mitidja plain in Algeria characterized by a Mediterranean climate, Yakhlef (2015) explains the low agroecological sustainability score by several factors, such as the low diversity of perennial crops (A2), the practice of monoculture and the absence of crop rotation (A5), a large animal load (A10), insufficient management of fodder areas (A11), the lack of soil protection, mainly due to the practice of ploughing (A16), and a high energy dependence (A18). These same indicators are also problematic in our study, with the exception of indicator A2, which scored better than in the Yakhlef study, unlike A1, which scored lower in our analysis. This difference can probably be attributed to the agroecological particularities of each region.

In the Cheliff Valley, another region of Algeria, Ouakali (2015) reports that the best scores are for the domestic diversity component (63%), while the organization of space scores low (43%) and agricultural practices a medium score (57%). For our study, the scores are 43%, 47% and 68% respectively for domestic diversity, spatial organization and agricultural practices. It is noteworthy that the spatial organization component shows similar results in the two studies.

In the highlands, Bir (2015) scores 51% for domestic diversity, 61% for spatial organization, and 56% for agricultural practices. These results vary considerably from ours. These differences can be explained by the distinct agroecological contexts, including crop diversity and weather conditions, suggesting that these components are closely linked to the specific characteristics of each region.

Finally, in terms of agroecological sustainability, Merrouchi and Amrouni Sais (2025) in oasis farms in the Oued Righ valley in southern Algeria obtain results that show that farms are generally efficient on this dimension. Sixteen out of nineteen farms obtained a score of more than 50 points, reflecting a certain level of agroecological sustainability. The average score recorded is 60.95±11.11, which reflects a relative mastery of environmentally friendly practices (rational fertilization, effluent management, organization of space). On the other hand, farms with a below-average score are characterized by low crop diversity, particularly in perennial crops and fodder crops. This weakness has a negative impact on complementarity with livestock farming and limits the ability of these systems to make sustainable use of available resources.

These results confirm that, although farms have a certain agroecological balance, significant efforts are still needed in terms of diversification of production, integration of livestock practices (Amrouni Sais and al., 2025) and territorial integration to improve their resilience (Amrouni Sais and Fethallah, 2025).

Conclusion

Our study shows that the agroecological sustainability of farms in the study area (Djelfa) remains modest, mainly due to a lack of diversification, weak spatial organization, and unsustainable practices. However, integrating livestock enhances resilience by optimizing resource use. Transitioning towards sustainability requires adopting agroecological practices, improving resource management, diversifying production, and using renewable energy.

This transition must be supported by tailored technical assistance, sector structuring, and the promotion of quality products. Finally, strong and coherent policies are essential to encourage change through incentives, financial support, and regulatory frameworks recognizing agroecological approaches.

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