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# Assessing the Sustainability of Intensive Olive Farming in Arid Areas Through Multi-Criteria Analysis

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**Abstract**: Assessing farm sustainability is not only a scientific challenge, but also a necessity for sustainable development. It requires consideration of the three dimensions of sustainability: agro-ecological, socio-territorial and economic. Several assessment methods based on indicators and scoring have been proposed by researchers. Our work focuses on one of these methods: The Indicators of Farm Sustainability (IDEA). This method was applied to assess the sustainability of newly-created olive farms in the wilaya of Djelfa (Algeria) as a result of public policies implemented since the 2000s. The IDEA method assesses the sustainability of a farm using 42 indicators covering the three dimensions of agro-ecology, socio-territory and economy. Surveys of 57 olive farms in the study region were used to analyze the sustainability of these farms by highlighting the low level of sustainability at the socio-territorial level, with an average of 30/100. The results show that, overall, the farms are economically sustainable and less sustainable in agroecological terms, with averages of 67 and 53/100 respectively. Sustainability at farm level can be enhanced by intervening on one or more of the ten sustainability components proposed by the IDEA method, such as plant and animal diversity, spatial organization, product quality and production process efficiency. The findings highlight priority areas for improvement, including plant and animal diversity, spatial organization, product quality, and production process efficiency. These results provide guidance for targeted interventions to strengthen the overall sustainability of olive farms in arid regions.

**Keywords**: Assessment, agroecological sustainability, socio-territorial sustainability, economic sustainability, IDEA, indicators.

## Introduction

The question of sustainable development indicators has been raised ever since the definition of sustainable development was formalized: "*Meeting the needs of the present without compromising the ability of future generations to meet their own needs*". However, when defined in this comprehensive way, the notion of sustainable development struggles to become operational [1]. As a result, the question of assessment methods has gained importance, and demand for methods to assess the sustainability of agricultural systems has grown in recent years, to enable: i) farmers to identify the levers of action likely to improve the overall performance of their farms (level of sustainability), ii) agricultural development to broaden its technical advice in line with sustainability, and finally iii) public action to assess its systems in line with the agro-ecological transition [2]. The measurability of sustainability is crucial not only for identifying shortcomings and constraints that hinder sustainable practices, but also for proposing effective solutions. [3]

Recent reviews [4-7] show a significant diversity of indicator-based methods (some sixty listed). Indeed, sustainability assessment methods are extremely numerous, assessing different characteristics, using distinct indicators and meeting different objectives [8].

In terms of developing assessment methods, two main trends can be identified. The first emphasizes the environmental or ecological dimension in evaluating the performance of agricultural practices and the second acknowledges the legitimacy of economic and social development while reconciling it with the protection of natural resources and environments [9]. However, since sustainable development involves broader considerations than merely environmental aspects, research on assessment methods has gradually integrated other dimensions related to agricultural systems [10].

The literature presents several methods for assessing sustainability in agriculture, whether at the scale of the farm, the plot, or the territory. Over the past fifteen years, there has been a proliferation of studies addressing sustainability assessment at various spatial and temporal scales: the plot over a season, the cropping system, the entire farm, or even groups of farms within a shared territory. The indicators used take agricultural practices into account to varying degrees and can be applied to field crop systems, mixed crop-livestock systems, and more rarely, to perennial crops [11].

Some approaches remain focused solely on the environmental dimension, such as the Agricultural Sustainability Index or the Life Cycle Assessment applied to agriculture. Other

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methods adopt an integrated approach that includes the three dimensions of sustainability; environmental, social, and economic; such as the RISE tool or the IDEA method [12]).

In Algeria, few studies that have assessed sustainability at farm level, and most have focused on the evaluation of livestock farms using the farm sustainability indicator method [13-18]. The assessment of other farm types is less frequent and has involved only potatoes, arboriculture, cereals, palm dates and olive farms [19-24].

Since the 2000s, public policies in Algeria have encouraged the extension of olive cultivation into hitherto non-traditional areas, notably in the wilaya of Djelfa. This phenomenon represents a major challenge for sustainable development in arid and semi-arid environments [25]. Support measures aligned with overall economic reforms have ensured the promotion of intensive olive growing as an economic activity that generates wealth and employment [26].

However, intensive development under irrigation in semi-arid and arid zones most often leads to degradation of the quality of soil and water resources. The extent of degradation is strongly linked to the quality of irrigation water, to the lack of control over the Irrigation-Salinity-Drainage trilogy and to non-rational agricultural development practices [27] . Thus, the transition to intensive olive growing poses challenges in terms of sustainable management of natural resources and social integration of farms.

The main objective of this research is to evaluate the sustainability of newly established olive farms in recently planted areas. To this end, the IDEA method was selected for its comprehensive, multidimensional framework, which allows for the assessment of environmental, economic, and social performance of farming systems. Drawing on the definition of a sustainable farm as "*a viable, liveable, transferable and reproducible farm"* [28], this study seeks to answer a central question: Do these newly established farms align with the principles of sustainable development? Specifically, are they agroecologically sound (environmental scale), socially equitable and livable (socio-territorial scale), and economically viable and transferable (economic scale)?

## Materials and Methods

### Characterization of the study area

The wilaya of Djelfa is located in central Algeria, some 300 km south of Algiers. Traditionally pastoral, this region has seen its olive-growing area increase from 100 ha in 2000 to almost 12,000 ha in 2023 [29].

The climate of Djelfa, located at 1,190 m altitude, is semi-arid to arid, with an average annual rainfall of about 290 mm, mostly occurring from September to May. There are 36 rainy days per year. The mean annual temperature is 15 °C, ranging from 1 °C in winter to 35 °C in summer. The climate is continental, with strong seasonal contrasts. Frequent winds blow across the region, including the sirocco, which can last 20 to 30 days per year [30] .


**Figure (1):** Location of the Study Area.

### Data collection

The study covered 57 intensive olive farms. Data were collected through semi-structured interviews and direct field observation during the period November 2023–May 2024. The surveys were conducted by one of the authors (H.A.S) in the local Arabic dialect with farm owners or family members directly involved in farm management. Simplified explanations of technical terms from the IDEA method were provided to ensure clarity. Verbal informed consent was obtained after explaining the study's objectives and ensuring data confidentiality.

The questionnaire was developed based on the IDEA grid and followed a three-step process: (i) a preparatory phase to identify relevant questions derived from sustainability indicators; (ii) a testing phase on a small sample of farms to assess the clarity of questions, relevance of responses, and estimated interview duration; (iii) a final validation phase incorporating necessary adjustments.

The questionnaire is divided into two main parts: the first focuses on the characterization of the farm and the farmer's profile, while the second gathers the information required for indicator assessment. It includes both open-ended questions, for detailed qualitative insights, and closed-ended questions, to facilitate scoring. The final version spans 10 pages.

The sample was selected using non-probability sampling techniques, in which selection is based on subjective judgment and specific criteria. Such methods are often appropriate, and sometimes the only feasible option, when precise data on the population are lacking [31] . In this case, the use of probability sampling was not possible due to the absence of detailed and reliable information from the Directorate of Agricultural Services and the Chamber of Agriculture of Djelfa regarding the number, size, distribution, and diversity of olive farms.

### Method used

The IDEA method (Indicateurs de Durabilité des Exploitations Agricoles) was chosen to quantify the sustainability of farming systems. Developed in France, this method has made a major contribution to academic research on sustainability assessment and is used by various agricultural structures to support change through a global approach to the farm [2]. The IDEA method is based on a multi-criteria assessment of the sustainability of agricultural systems, integrating three main dimensions: economic, ecological and social (Table 1). The calculation is based on a system of capped points, with equivalent weighting between the three dimensions, each varying from 0 to 100 sustainability units. The IDEA grid contains 42 indicators. Each indicator, made up of elementary items representing practices or characteristics, is capped to limit the total number of units assigned [32].

A higher score reflects greater sustainability for a given dimension. However, components do not offset each other within the same dimension: maximum sustainability (100) requires a high level in each component, reflecting a comprehensive approach to sustainability [33].

All components are capped (Table 1). For instance, the "diversity" component is limited to a maximum of 33 points, even though its theoretical maximum is 48. This capping mechanism prevents a farm with very high diversity from fully offsetting poor performance in other agroecological dimensions. It ensures a more balanced assessment across all components of agroecological sustainability. The same rationale applies to the components of the other sustainability scales (socio-territorial and economic), thus maintaining coherence and comparability in the overall sustainability evaluation. [32]

Agro-ecological sustainability is based on the calculation of 18 indicators (A1-A18). Agroecological sustainability provides information on the autonomy of farming systems in terms of energy use and non-renewable resources, as well as their capacity to protect water, soil and natural environments. [32]. This scale, which is the sum of the three components of agroecological sustainability, is capped at 100.

Socio-territorial sustainability is assessed through 18 indicators (B1 to B18), which promote a range of objectives including human development, quality of life and ethics. Socio-territorial sustainability seeks to assess the farmer's quality of life and the weight of the market and non-market services he provides to society and the territory [32]. This scale, which is the sum of the three components of socio-territorial sustainability, is capped at 100.

Economic sustainability is a basic requirement for sustainable development. It is the result of calculating six economic indicators (C1-C6). Unlike the two previous scales, each comprising 18 indicators, the economic scale is made up of just 6 indicators, as the economic sustainability of an agricultural enterprise is simpler to define and characterize. However, this scale, like the agro-ecological and socio-territorial scales, is also capped at 100, reflecting the equal importance of the three dimensions [32].

For each sustainability scale, the closer the score is to 100, the more sustainable the system is considered to be, and conversely, the further it is from 100, the less sustainable it is [32,33].

**Data analysis**

The database was created in Excel, which provided us with the initial results of our work and enabled us to visualize the sustainability scores obtained by the different farms. The data were then processed using IBM SPSS Statistics 27 software [34], enabling us to carry out the various statistical analyses including descriptive statistics such as frequencies, means, standard deviations, and cross-tabulations.

**Table (1):** Sustainability Indicators by Component and Scale (IDEA version 3)

| Scale | Component | Indicator | Maximum values | |
|---|---|---|---|---|
| **Agro-ecological sustainability scale**<br><br>**Total: 100** | Diversity | Diversity of annual or temporary crops A1 | 14 | Total capped at 33 units |
| | | Diversity of perennial crops A2 | 14 | |
| | | Animal diversity A3 | 14 | |
| | | Enhancement and conservation of the genetic heritage A4 | 6 | |
| | Organization of the 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 challenges of the territory A9 | 4 | |
| | | Enhancing space A10 | 5 | |
| | | Forage area management A11 | 3 | |
| | Agricultural Practices | Fertilization 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 | |
| **Socio-territorial sustainability scale** | Quality of products and territories | Quality approach B1 | 10 | Total capped at 33 units |
| | | Enhancement of the built heritage and landscape B2 | 8 | |
| | | Non-organic waste management B3 | 5 | |
| | | Accessibility of the space B4 | 5 | |
| | | Social involvement B5 | 6 | |
| | | Valorization by short supply chains B6 | 7 | |

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|---|---|---|---|---|
| **Total: 100** | Employment and services | Autonomy and development of local resources B7 | 10 | Total capped at 33 units |
| | | Services, multi-activity B8 | 5 | |
| | | Contribution to employment B9 | 6 | |
| | | Collective work B10 | 5 | |
| | | Probable sustainability B11 | 3 | |
| | Ethics and Human Development | Contribution to the global diet balance B12 | 10 | Total capped at 34 units |
| | | Animal welfare B13 | 3 | |
| | | Formation B14 | 6 | |
| | | Work intensity B15 | 7 | |
| | | Quality of life B16 | 6 | |
| | | Isolation B17 | 3 | |
| | | Reception, hygiene and safety B18 | 4 | |
| **Economic Sustainability Scale** | Viability | Economic viability C1 | 20 | Total capped at 100 units |
| | | Specialization rate C2 | 10 | |
| | Independence | Financial autonomy C3 | 15 | |
| | | Sensitivity to aids C4 | 10 | |
| | Transmissibility | Transmissibility of capital C5 | 20 | |
| **Total: 100** | Efficiency | Efficiency of the production process C6 | 25 | |

## Results and Discussion

### Agro-ecological sustainability

Agroecological sustainability obtained an average of 52.74±10.29, indicating a partial adoption of environmentally-friendly practices, with a minimum score of 31/100 and a maximum score of 76/100. 54% of farms, i.e. 31 farms, obtained a score above 50/100. (Table 2)

Benidir [16] in the same study region and on livestock farms obtained much lower results, with an average of 43 and a score range from a minimum of 25 to a maximum of 57. Ouali [17], on the other hand, obtained a higher score of 63/100 on sheep farming systems.

**Table (2):** Distribution **o**f agroecological sustainability scores

| Score | Frequency | Percentage | Cumulative percentage |
|---|---|---|---|
| From 30 to 39 | 6 | 10.53 | 10.53 |
| From 40 to 49 | 20 | 35.09 | 45.61 |
| From 50 to 59 | 15 | 26.32 | 71.93 |
| From 60 to 69 | 12 | 21.05 | 92.98 |
| From 70 to 79 | 4 | 7.02 | 100.00 |

Several indicators significantly lowered the agroecological sustainability score, notably A1 (Diversity of annual and temporary crops) with 15/100, A4 (Enhancement and conservation of the genetic heritage) and A5 (Crop rotation) with 17/100, A9 (Contribution to the environmental challenges of the territory) with 0/100, and A10 (Valorization of space) with 16/100. In contrast, better scores were observed for A12 (Fertilization) with 74/100 and A13 (Liquid Organic Effluents) with 75/100. These disparities are illustrated in Figure 2, where the blue line shows obtained scores and the orange line represents maximum scores.

As far as crop diversity is concerned, the weaknesses are mainly linked to the diversity of temporary and annual crops, with the lowest values [35]. Laajimi and Ben Nasr [36] point out that for conventional olive farms in Tunisia, the weakness of the agroecological scale is also linked to crop diversity. They add that, on the one hand, the monoculture of the olive tree strongly penalizes the level of sustainability of these farms and, on the other, the absence of livestock farming and, therefore, of organic fertilization in the production system.

According to Bouzaida and Doukali [27], the organization of farm space was the main constraint affecting agroecological sustainability, but this did not prevent the high score of 70/100 reflecting good agroecological practices on olive farms. This can be further improved by the adoption of organic olive growing [36].

Indeed, Elfkih et al. [35] obtained an average score of 87/100 for agro-ecological sustainability in organic olive growing for farms in the Sfax region and 75/100 for those in the Mahdia region.

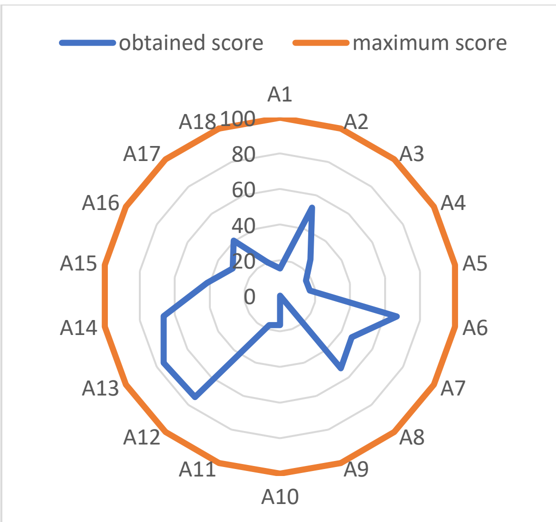


**Figure (2):** Results of agro-ecological scale indicators.

### Socio-territorial sustainability

Socio-territorial sustainability obtained an average of 30.28±9.77, indicating weak integration into the local socio-economic fabric, with a minimum score of 10/100 and a maximum score of 51/100. Only three farms, i.e. 5% of farms, obtained a score higher than 50/100. (Table 3)

Ouali [17] in the same study region obtains an average score of 33/100 on sheep farming systems, which is very close to the result we obtained. However, Benidir [16], also working **on** livestock farms**,** obtains much higher results, with an average of 45 and a score range from a minimum of 27 to a maximum of 62. As for conventional olive farms in Tunisia, they obtain the very low score of 12/100 for the socio-territorial scale [36]. This is explained by a lack of social involvement, such as training, participation in social events and access to information [37].

**Table (3)**: Distribution of socio-territorial sustainability scores

| Score | Frequency | Percentage | Cumulative percentage |
|---|---|---|---|
| < 19 | 8 | 14.04 | 14.04 |
| From 20 to 29 | 18 | 31.58 | 45.61 |
| From 30 to 39 | 22 | 38.60 | 84.21 |
| From 40 to 49 | 6 | 10.53 | 94.74 |
| > 50 | 3 | 5.26 | 100 |

In our study, with the exception of five indicators: B9 (Contribution to employment) with a score of 90/100, B11 (Probable sustainability) with a score of 82/100, B16 (Quality of life) with a score of 68/100, B17 (Isolation) with a score of 70/100 and B18 (Reception, hygiene and safety) with a score of 51/100, the thirteen other indicators proposed by the IDEA method are all deficient (Figure 3).

Finally, the various studies carried out in Algeria on different types of farms highlight that socio-territorial sustainability is the weak point of the farms surveyed. This situation is influenced by the low scores obtained for indicators related to product and territorial quality, ethics and human development [13-18,20-24].

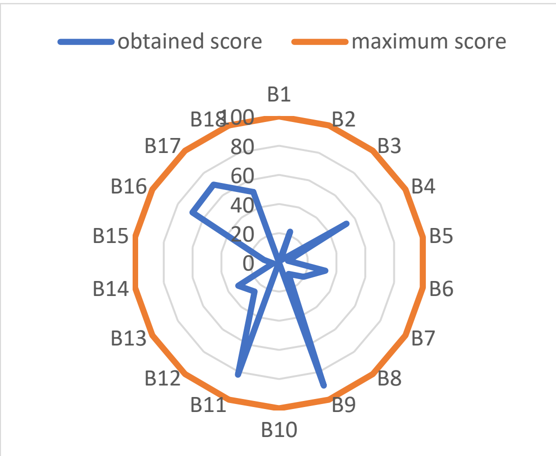


**Figure (3):** Results of the indicators of the socio-territorial scale

### Economic sustainability

Economic sustainability obtained a satisfactory score of 66.98±10.72, reflecting generally good economic viability, but disparities remain between farms, with a minimum score of 39/100 and a maximum score of 90/100. With the exception of two farms, all scored above 50/100, reflecting the economic sustainability of these farms. (Table 4). In the same study region, Benidir [16] and Ouali [17] obtained very similar results, with 63/100 and 69/100 respectively.

**Table 4**: Distribution of economic Sustainability scores

| Score | Frequency | Percentage | Cumulative percentage |
|---|---|---|---|
| < 50 | 2 | 3.51 | 3.51 |
| From 50 to 59 | 10 | 17.54 | 21.05 |
| From 60 to 69 | 24 | 42.11 | 63.16 |
| From 70 to 79 | 15 | 26.32 | 89.47 |
| From 80 to 89 | 5 | 8.77 | 98.25 |
| > 90 | 1 | 1.75 | 100 |

In Tunisia and in the Kairouan region, olive farms show high economic scores. This shows that farmers in irrigated olive-growing areas attach more importance to productivity and economic gain than to social and environmental issues [37]. Olive farms in the Sfax region of Tunisia also score well on economic sustainability, with a score of 59/100 for conventional and 65/100 for organic farming [36], and 64/100 for farming in the Zarzis region [27].

The economic sustainability scale shows generally good results. Indicators C3 (98.6/100) and C4 (100/100) reflect excellent economic viability and transferability. C1, C5, and C6 also show satisfactory scores (between 56 and 60). The only relatively weak point is C2 (43.16/100), indicating a moderate level of economic specialization. These results are summarized in Figure 4.

This was also found by Elfkih et al. [37] with a low score obtained for this indicator, leading to less economic stability. This is an important indicator essentially in the case of olive growing for the alternating nature of production so diversification can bring greater stability to farmers' incomes.

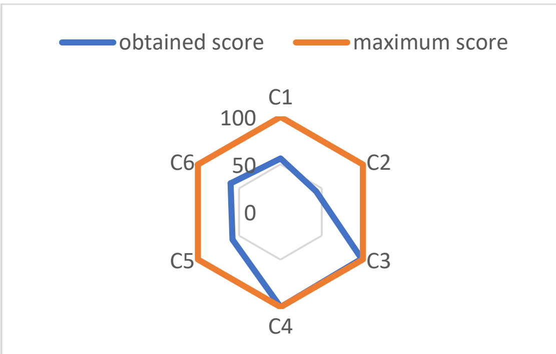


**Figure (4):** Results of the Economic Scale Indicators.

## Conclusion

This study, focusing on the sustainability of new olive farms in the wilaya of Djelfa, highlighted both the challenges and opportunities inherent in adopting sustainable farming practices in a region characterized by arid and semi-arid conditions. Using the IDEA evaluation method, we found that, while these farms display relatively satisfactory economic sustainability, they nevertheless show notable shortcomings in the agroecological and socio-territorial dimensions.

The analysis revealed specific challenges faced by newly-established farms, particularly with regard to irrigation water management. This challenge is all the more crucial in a context marked by limited availability of water resources and progressive depletion of groundwater, making the sustainability of production systems even more delicate.

Moreover, the results obtained vary significantly among farms, highlighting the need for an individualized approach. We therefore propose the introduction of a voluntary self-assessment approach to sustainability. This would enable farmers themselves to identify the weak points of their farms in terms of the three dimensions of sustainability, and to make the necessary adjustments in the case of failing indicators.

To make this initiative operational, it would be essential to develop a simplified assessment tool, specifically adapted to the local conditions of the region studied. Although the IDEA method has demonstrated its usefulness in assessing farm sustainability, it remains complex for farmers to apply, particularly for certain technical indicators such as A12 (fertilization) and A18 (energy dependency).

This situation calls for a strong institutional response, in the form of technical guidance and ongoing support. Such an approach could include training farmers in agroecological practices and production methods adapted to local realities. These practices, in addition to being more respectful of the environment, should aim to strengthen the resilience of farming systems while promoting their social inclusiveness. Such support would not only make up for identified shortcomings, but also promote more sustainable agriculture that is better adapted to the region's climatic and water-related challenges.

**Disclosure Statement**

- **Ethics approval and consent to participate:** Not applicable
- **Consent for publication:** Not applicable
- **Availability of data and materials:** The raw data required to reproduce these findings are available in the body and illustrations of this manuscript.
- **Author's contribution:** The authors confirm contribution to the paper as follows: study conception and design: Haoua, SE, theoretical calculations and modeling: Haoua; data collection: Haoua, data analysis and validation: Haoua. draft manuscript preparation: Haoua, SE.
- All authors reviewed the results and approved the final version of the manuscript.

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## Open Access



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