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# Evaluation of the Sustainability of Urban Market Gardens in the City of Meknes (Morocco)

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**Abstract**

Market gardening constitutes a basis for food security of urban and peri-urban households. However, market gardening is subject to the use of chemical inputs, selected varieties, and genetically modified organisms. These practices are increasingly controversial and are likely to affect the sustainability of vegetable farms. This study assessed the sustainability of 120 randomly selected market garden farms (Meknes) using the surveys and the market garden production sustainability indicator. The results show that the majority of the farms identified are characterized by low sustainability, with the agroecological dimension being the limiting factor. The improvement of the components "Ecological diversity", "Spatial organization", and "Agricultural practices" are the ways to improve the global sustainability of vegetable production in Meknes. The socio-territorial sustainability of production is characterized by a lack of training for producers, a lack of hygiene and safety in production activities, and a low contribution to employment. The economic dimension is characterized by low viability, low economic transmissibility, and financial autonomy. To perpetuate the market gardening in the city of Meknes, it appears necessary to promote ecological intensification, integrated diversification, and promotion of local inputs to the various types of market gardening farms

**Keywords:** Meknes, Sustainability, Evaluation, Market gardening, Morocco

## I. Introduction

In the face of global changes, several African countries, as well as nations around the world, have embarked on the green revolution, which involves the use of chemical inputs for intensive agriculture (Ahouangninou, 2013). This intensive agriculture puts a strain on natural resources and challenges the sustainability of farms (Lal, 2015). It mobilizes chemical inputs that negatively affect the quality of soils, living beings both, human and animal, and threatens biodiversity in general. As a result, the second sustainable development goal of eliminating hunger and ensuring food security, improving nutrition, and promoting sustainable agriculture by 2030 is threatened (FAO, 2020). Thus, the promotion of sustainable agriculture becomes one of the alternatives for respecting the environment and maintaining economic and social production goals (FAO, 2020).

Market gardening is a rapidly growing sector due to population growth and increasing food needs in urban and peri-urban areas (Maseko et al., 2017). To meet these food’s needs, producers in general and vegetable farmers, in

particular, use chemical inputs, selected varieties, genetically modified organisms, and wastewater irrigation (Ahouangninou, 2013). These practices are likely to negatively affect soil quality (Van Jaarsveld et al., 1999; Raffa and Chiampo 2021), water (Detroux, 1996; Houze, 2003; El Azzouzi et al., 2014; Maldani et al., 2017; Naamane et al., 2020; Berni et al., 2021a), air quality (FOCUS, 2008; Chahine, 2011; Ahouangninou, 2013; Guiral et al., 2016), biodiversity (El Bakouri, 2006) and human health (Carvalho, 2006; Idrissi et al., 2010; Morillon, 2016; Belhadi et al., 2017; Saadane, 2018; Berni et al., 2021b). In Africa, several authors have worked on assessing the sustainability of the market gardening (Cissé et al., 2003; Traoré et al., 2006; Assogba-Komlan et al., 2007; Ahouangninou, 2013; Bayendi et al., 2017). However, there is no equivalent work in Morocco, especially in Meknes city.

Meknes is a Moroccan city that was renowned for its agricultural wealth and its characteristics like a garden city, or orchard city (Abdouh et al., 2004). It owed this reputation to prosperous agriculture that fulfilled a double function: first, to supply the city with food products that the disjointed and discontinuous state of city-countryside exchanges could not always ensure, and second, to serve as recreational areas for the city's population, which used to frequent them as part of the *Nzaha* (weekly recreational outings) (Abdouh et al., 2004; Rhaidour, 2013). In Meknes, market gardening is a booming sector and is attracting an increasing interest due to the high demand for vegetables (Rhaidour, 2013; Dugué et al., 2015). However, most producers in urban and peri-urban areas opt for productivist systems that favor quantity over quality and do not always guarantee the sustainability of production (Abdouh et al., 2004; Rhaidour, 2013). The purpose of this study is to describe market garden farms in the city of Meknes and to assess the sustainability of these farms based on a systemic field survey. To address this, the sustainability of 120 vegetable farms, located in the urban area of the city of Meknes, was assessed using the "Indicator of sustainability of vegetable production" (IDPM) tool.

## II. Materials and methods

### II. 1. Study area

The study was conducted in the city of Meknes, located at 33°53′42″ N and 5°33′17″ W (Figure 1). This city has a population of 632,079 (General Census of Population and Housing, 2014). The region is characterized by a semi-continental Mediterranean climate with cool, rainy winters and hot, dry summers. Urban agriculture in the Meknes agglomeration (urban communes of Meknes center, Ouislane, and Toulal) is found almost exclusively in the valleys of the 3 wadis: wadi Boufekrane, wadi Ouislane, and wadi Bouisshak (Figure 1). The cultivable and irrigable area in these valleys varies according to sources. It is about: 1400 ha for Mechkouri and Mabrouki (1992), 1520 ha

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for El Addouli et al. (2008), and 913 ha according to the 1996 agricultural census (cited by Abdouh et al., 2004). The choice of this study area is due to its high contribution to local market garden production and its potential to feed the inhabitants of the Fez-Meknes region.


**Figure 1**. Geolocation of the study area

## II. 2. Research units and sampling

The research units were vegetable farms in the urban areas of the city of Meknes (Morocco). A total of 120 vegetable farms were surveyed (Table I). Due to the lack of an official database of vegetable farms in this locality, we adopted a simple random sampling.

**Table I**: Number of farms surveyed by study area

| Area | Type of area | Number of farms |
|---|---|---|
| Ouislane Valley | Urban | 50 |
| Boufekrane Valley | Urban | 40 |
| Bouishak Valley | Urban | 30 |
| **Total** | | 120 |

## II. 3. Sustainability assessment method

The Vegetable Production Sustainability Indicators (IDPM) assessment method was used to analyze the strengths and weaknesses of vegetable production farms. Like the IDEA method (farm sustainability indicators), the IDPM uses a multi-criteria approach to measure the sustainability of vegetable production systems, to draw up a profile of farms

at a given time from an environmental, social, and economic point of view, and to identify the possibilities for improving these systems (Viaux, 1999).

The IDPM consists of three equally weighted sustainability scales which are the agro-ecological, socio-territorial and economic dimensions. Each sustainability scale is itself broken down into 3 or 4 components that are more characteristic of a sustainable agricultural system (Ahouangninou, 2013). The agro ecological sustainability scale analyzes the technical system's readiness to combine the efficient use of environmental resources, respect for ecological costs, and technical-economic viability (M'Hamdi et al., 2009). The socio-territorial sustainability scale is analyzed using indicators that promote the objectives of human development, quality of life, employment and local development, ethics, and citizenship (Vilain et al., 2008). The economic sustainability scale analyzes the performance of the production system in the medium and long term through the viability, transferability, independence, and efficiency of the system. All ten sustainability components are subdivided into indicators. In total, 40 indicators are obtained, which are composed of several items for the IDPM (Table II).

**Table II**: Indicators of the agroecological, socio-territorial, and economic dimensions (Ahouangninou, 2013).

| **Dimensions and Components** | **Indicators** | **Maximum potential (Maximum potentially attainable)** | |
|---|---|---|---|
| **Dimension** | **agroecological** | | **100 pts** |
| Ecological diversity | Diversity of traditional cultures | 8 | 30 |
| | Diversity of exotic cultures | 8 | |
| | Associated plant diversity | 2 | |
| | Valuation and conservation of genetic heritage | 5 | |
| | Preservation of biodiversity | 7 | |
| Spatial organization | Crop rotation | 10 | 25 |
| | Plot size | 10 | |
| | Crop rotation and succession | 5 | |
| Agricultural practices | Fertilization | 12 | 45 |
| | Plant protection | 12 | |
| | Soil protection | 3 | |
| | Water management | 3 | |
| | Chemical packaging management | 8 | |
| | Energy dependency | 3 | |
| | Organic material management | 4 | |
| **Dimension** | **Socio-territorial** | | **100 pts** |
| Human development | Contribution to a balanced alimentation | 7 | 34 |
| | Training | 5 | |
| | Working environment | 7 | |
| | Quality of life | 4 | |
| | Health and safety at work | 8 | |
| | Geographic and socio-cultural isolation | 3 | |

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| | | | |
|---|---|---|---|
| Management and quality of the production | Food quality | 12 | 33 |
| | Management of production waste | 8 | |
| | Client and visitor reception | 3 | |
| | Accessibility of the space | 4 | |
| | Strength of the network of relationships with clients and suppliers | 3 | |
| | Information to customers on product quality | 3 | |
| Employment and local development | Valuation by short channel | 5 | 33 |
| | Direct employment contribution | 7 | |
| | Collective work | 6 | |
| | Perenniality | 3 | |
| | Acceptability of the implementation by the neighborhood | 3 | |
| | Social implication | 7 | |
| | Participation in the elaboration of the sector's policies | 2 | |
| **Dimension** | **Economic** | | **100 pts** |
| Viability | Economic viability | 20 | 30 |
| | Production diversification | 10 | |
| Transmissibility | Transmissibility | 20 | 20 |
| Independence | Financial autonomy | 15 | 25 |
| | Aid sensitivity | 10 | |
| Efficiency | Use of resources | 25 | 25 |

## II. 4. Data analysis

The data from the calculation of the scores of the different sustainability indicators were entered into Excel 2010 to obtain descriptive statistics (absolute frequencies, relative frequencies, maxima, minima, means, and standard deviations).

## III. Results and discussion:

### III.1 Agroecological sustainability

The average agro ecological sustainability of market garden farms in 2021 is 44.84 points out of 100 with a range of 36 to 82 (Table III). This pillar of sustainability includes ecological diversity, spatial organization, and farming practices. Ecological diversity has an average of 9.4 points out of 30 with a maximum of 22 points. This average represents 31.33% of the theoretical maximum. Among the indicators of this component, only that of "Valorization and conservation of genetic heritage" has obtained an average that represents 64.25% of its theoretical maximum. This is related to the fact that farmers in Meknes do not use genetically modified organisms (GMOs) in market gardening.

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Concerning the component "organization of space", the average value is equal to 11.95 out of 25 points while the maximum is 22 points (Table III). This average corresponds to 47.8% of the theoretical maximum (Table III). As for the "crop rotation and succession" indicator, it presents an average of more than 92% of the theoretical maximum. The averages of the other two indicators "crop rotation" and "plot size" are 49% and 24.4% of the theoretical maximum, respectively. For agricultural practices, the average obtained is 23.49 points out of 45 and the maximum value is 35 points (Table III). The average of the "agricultural practices" component represents 52.2% of the theoretical maximum. The indicators "fertilization" and "plant protection" have averaged lower than 50% of the theoretical maximums. These results reflect the fact that the majority of farmers use phytosanitary products that present high risks for ecosystems and human health (El Ghazi et al., 2021).

**Table III**. Average values of the indicators of the Agroecological dimension

| Components | Indicators | Average (%) | Standard deviation | Minimum | Maximum | Terminals |
|---|---|---|---|---|---|---|
| **Ecological diversity** | Diversity of traditional cultures | 2.69 (33.62) | 1.08 | 0 | 8 | 0 - 8 |
| | Diversity of exotic cultures | 2.47 (30.87) | 1.18 | 0 | 8 | 0 - 8 |
| | Associated plant diversity | 0.59 (29.5) | 0.44 | 0 | 2 | 0 - 2 |
| | Valuation and conservation of genetic heritage | 2.57 (64.25) | 0.31 | 2 | 4 | 0 - 4 |
| | Preservation of biodiversity | 1.08 (15.42) | 0.47 | 0 | 7 | 0 - 7 |
| | **Total** | **9.4** (31.33) | **3.01** | **5** | **22** | **0 - 30** |
| **Spatial organization** | Crop rotation | 4.9 (49) | 1.08 | 3 | 10 | 0 - 10 |
| | Plot size | 2.44 (24.4) | 0.88 | 2 | 10 | 0 - 10 |
| | Crop rotation and succession | 4.61 (92.2) | 0.94 | 0 | 5 | 0 - 5 |
| | **Total** | **11.95** (47.8) | **2.69** | **4** | **22** | **0 - 25** |
| **Agricultural practices** | Fertilization | 4.87 (40.58) | 0.91 | 4 | 12 | 0 - 12 |
| | Plant protection | 4.42 (36.83) | 1.07 | 3 | 12 | 0 - 12 |
| | Soil protection | 2.10 (70) | 0.12 | 1 | 3 | 0 - 3 |
| | Water management | 2.83 (94.33) | 0.15 | 1 | 3 | 0 - 3 |
| | Chemical packaging management | 3.21 (40.12) | 0.64 | 1 | 4 | 0 - 8 |
| | Energy dependency | 2.76 (92) | 1.27 | 0 | 3 | 0 - 3 |
| | Organic material management | 3.30 (82.5) | 0.70 | 0 | 4 | 0 - 4 |
| | **Total** | **23.49** (52.2) | **1.54** | **19** | **35** | **0 - 45** |
| **Total agro-ecological dimension** | | 44.84 (44.84) | 6.50 | 36 | 82 | 0 - 100 |

The vast majority of farms (96.76%) have an agroecological sustainability score below 65. About 80.24% of the farms have an agroecological sustainability score below 55. This score reflects the market gardening characterized by intensive use of chemical inputs. This result is in agreement with those of Ahouangninou et al. (2015) who showed that in vegetable production in southern Benin, producers make intensive use of chemical pesticides while not respecting the standards for storage of these products as well as the management of their packaging.

The agroecological sustainability of market garden farms in the city of Meknes is higher than that reported by Ouédraogo et al. (2020), who found agroecological sustainability of 19.97% in the province of Houet in Burkina Faso. On the other hand, this agro-ecological sustainability of farms in the city of Meknes is lower than that reported by Ahouangninou et al. (2015), in the study of the sustainability of farms in southern Benin: 50.16%. It is also lower than that reported by Ndjadii et al. (2021), in the vegetable farms of South Kivu in the east of the Democratic Republic of Congo.

**III. 2. Socio-territorial Sustainability**

Socio-territorial sustainability averaged 54.36 points out of 100 in 2021, with a range from 40 to 78 (Table IV). This dimension of sustainability has three components: human development, production management, and quality, employment, and local development. The human development component has an average of 19.71 and a maximum of 26 points. This average represents 57.97% of the theoretical maximum of 34 points (Table IV). Within this component, the "Training" indicator has the lowest average (0.92 points), or 18.40% of its theoretical maximum of five points. This activity contributes to food security by offering vegetables to consumers, but there is a lack of training and a lack of work hygiene among producers.

For the "production management and quality" component, the average is 18.15 for a total of 33 points while the maximum is 24 points (Table IV). This average corresponds to 55% of its theoretical maximum. For the "food quality" indicator, the average is 55.75% of the theoretical maximum. For the indicator "management of production waste", the average is 64.25% of the theoretical maximum. The averages of the other indicators of this component are above 50.00% of their theoretical maximum. This component of sustainability can be improved by the practice of organic farming and the use of organic fertilizers.

Regarding the "employment and local development" component, the average obtained is 16.50 points out of 33 and its maximum is 25 points (Table IV). The average of this component represents 50.00% of the theoretical maximum (Table IV). The average of the indicators ``direct contribution to employment" and "collective work" is low, below 33% of the theoretical

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maximum (Table IV). The low scores for "direct contribution to employment" re associated with the lack of permanent labor (Rhaidour, 2013). Producers resort to casual labor when necessary. Furthermore, the weakness of collective work can be explained by the fact that production is practiced in urban areas where solidarity is rare. Most farms (97.63%) have a socio-territorial sustainability score below 65. About 77.54% of the farms have a socio-territorial sustainability score between 55 and 65 points out of 100. The low scores of socio-territorial sustainability can be linked to the omnipresence of the conventional mode of production (Figure 2) and the poor development of the production areas (absence of storage buildings for equipment, often poor access to the field). This is because a large number of market garden producers operate perimeters that they do not own (Rhaidour, 2013). These perimeters are very often acquired by donation or lease, any situation that prevents significant long-term investments.


(a). Market gardener in the valley of the oued Boufekrane (May 2012). (b). Market gardens in the valley of the oued Bouisshak (June 2013)

**Figure 2**. Use of the traditional techniques in market gardening (Dugué et al., 2015)

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**Table IV**. Average values of the indicators of the Socio-territorial dimension

| Components | Indicators | Average (%) | Standard deviation | Minimum | Maximum | Terminals |
|---|---|---|---|---|---|---|
| **Human development** | Contribution to a balanced alimentation. | 5.52 (78.85) | 0.63 | 3 | 7 | 0 - 7 |
| | Training | 0.92 (18.4) | 0.46 | 0 | 5 | 0 - 5 |
| | Working environment | 3.64 (52) | 0.60 | 2 | 5 | 0 - 7 |
| | Quality of life | 3.58 (89.5) | 0.51 | 1 | 4 | 0 - 4 |
| | Health and safety at work | 3.12 (39) | 0.75 | 2 | 8 | 0 - 8 |
| | Geographic and socio-cultural isolation | 2.93 (79.66) | 0.46 | 2 | 3 | 0 - 3 |
| | **Total** | **19.71 (57.97)** | **2.78** | **14** | **26** | **0 - 34** |
| **Management and Quality of the production** | Food quality | 6.69 (55.75) | 0.82 | 3 | 6 | 0 - 12 |
| | Management of production waste | 5.14 (64.25) | 0.66 | 2 | 4 | 0 - 8 |
| | Client and visitor reception | 2.47 (82.3) | 0.51 | 1 | 3 | 0 - 3 |
| | Accessibility of the space | 2.84 (71) | 0.47 | 1 | 4 | 0 - 4 |
| | Strength of the network of relationships with clients and suppliers | 2.26 (56.5) | 0.32 | 1 | 4 | 0 - 4 |

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|---|---|---|---|---|---|---|
| | Information to customers on product quality | 1.59 (53) | 0.33 | 0 | 2 | 0 - 3 |
| | **Total** | **18.15 (55)** | **1.29** | **12** | **24** | **0 - 33** |
| **Employment and local development** | Valuation by short channel | 3.81 (76.2) | 0.31 | 2 | 5 | 0 - 5 |
| | Direct employment contribution | 2.20 (31.42) | 0.62 | 1 | 5 | 0 - 7 |
| | Collective work | 1.71 (28.5) | 0.3 | 1 | 3 | 0 - 6 |
| | Perenniality | 2.52 (84) | 0.49 | 1 | 3 | 0 - 3 |
| | Acceptability of the implementation by the neighborhood | 2.74 (91.33) | 0.37 | 1 | 3 | 0 - 3 |
| | Social implication | 2.85(40.71 ) | 0.35 | 1 | 4 | 0 - 7 |
| | Participation in the elaboration of the sector's policies | 0.67(33.5) | 0.38 | 0 | 2 | 0 - 2 |
| | **Total** | **16.50 (50)** | **2.19** | **10** | **25** | **0 - 33** |
| **Total socio-territorial dimension** | | 54.36 (54,36) | 6.30 | 40 | 78 | 0 - 100 |

The socio-territorial sustainability of farms located in the city of Meknes: 54.36 % is lower than that of market garden farms in southern Benin (58.2 8%) reported by Ahouangninou et al. (2015). In contrast, the socio-territorial sustainability score of farms in the city of Meknes is higher than that reported by Ndjadi et al. (2021): 50.7% of vegetable farms in South Kivu in the east of the Democratic Republic of Congo. It is also higher than that reported by Ouédraogo et al. (2020): 35.27% in Houet province in Burkina Faso.

### III.3 Economic Sustainability

Economic sustainability is composed of four components: viability, transmissibility, independence, and efficiency. Viability has an average of 10.07 points with a maximum of 30 points. This average score represents 33.56% of the theoretical maximum (Table V). Of all the indicators in this component, the "economic viability" indicator has the lowest average (3.13 points), which corresponds to 15.65% of its theoretical maximum (20 points). For this indicator, the values ranged from 1 to 20 points. Thus, the vegetable farms are economically unviable. These findings are related to the small area of land farmed, which does not allow producers to make high profits.

For the "transmissibility" component, the average is 2.90 points (Table V). It represents 14.50% of its theoretical maximum (20 points). For this component, the minimum and maximum scores are between 0 and 20 points. The vegetable farms have low transferability. This low transferability of the farms is attributed to their limited economic viability and to the small or non-existent number of descendants who work with the farmers. As for the "independence" component, it has an average of 20.59 points which represents 82.36% of the theoretical maximum. The minimum and maximum are between 20 and 25 points respectively. The majority of market gardeners are financially independent and do not receive financial aid or subsidies for their production. For the "efficiency" component, the average obtained is 14.26 points which represent 57.04% of the theoretical maximum (25 points). The minimum and maximum scores for this component are 14 and 24 points respectively. The farms are financially efficient. Urban vegetable production is economically profitable.

The vast majority of farms (88.60%) have an economic viability score below 65. About 57.53% of farms have an economic sustainability score between 45 and 55 points out of 100.

The economic sustainability recorded a score of 47.82% for farms located in the city of Meknes; it is lower than that reported by Ahouangninou et al. (2015), of 54.86% in the study of sustainability of farms in southern Benin. On the other hand, the economic sustainability score of farms in the city of Meknes is higher than that reported by Ndjadi et al. (2021): 44.8% of the vegetable farms of South Kivu in the east of the Democratic Republic of Congo. It is also higher than that reported by Ouédraogo et al. (2020): 43.2% in Houet province in Burkina Faso.

**Table V**. Average values of the economic dimension indicators

| **Components** | **Indicators** | **Average (%)** | **Standard deviation** | **Minimum** | **Maximum** | **Terminals** |
|---|---|---|---|---|---|---|
| **Viability** | Economic viability | 3.13 (18.65) | 0.64 | 1 | 20 | 0 - 20 |
| | Production diversification | 6.94 (69.4) | 1.79 | 4 | 10 | 0 - 10 |
| | Total | **10.07 (33.56)** | **3. 31** | **5** | **30** | **0 - 30** |

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| | | | | | | |
|---|---|---|---|---|---|---|
| **Transmissibility** | Transmissibility | 2.90 (14,5) | 0.35 | 0 | 20 | 0 - 20 |
| **Independence** | Financial autonomy | 11.12 (74.13) | 1 | 7 | 15 | 0 - 15 |
| | Aid sensitivity | 9.47 (94.7) | 0.66 | 8 | 10 | 0 - 10 |
| | Total | **20,59** (82,36) | **0,61** | **20** | **25** | **0 - 25** |
| **Efficiency** | Use of resources | 14.26 (57.04) | 2.6 | 14 | 24 | 0 - 25 |
| **Total of economic dimension** | | 47.82 (47.82) | 8.18 | 42 | 90 | 0 - 100 |

## III.4 Overall durability

The average sustainability score is 44.84 points out of 100 with a range of 36 to 82 (Table III, Figure 3). More than 25 % of the farms have an overall sustainability score of fewer than 45 points out of 100; 57 % have a score between 45 and 55 points out of 100; 12.70 % have a score between 55 and 65 points out of 100. Two percent of the farms have an overall sustainability score of 65 points or more out of 100.

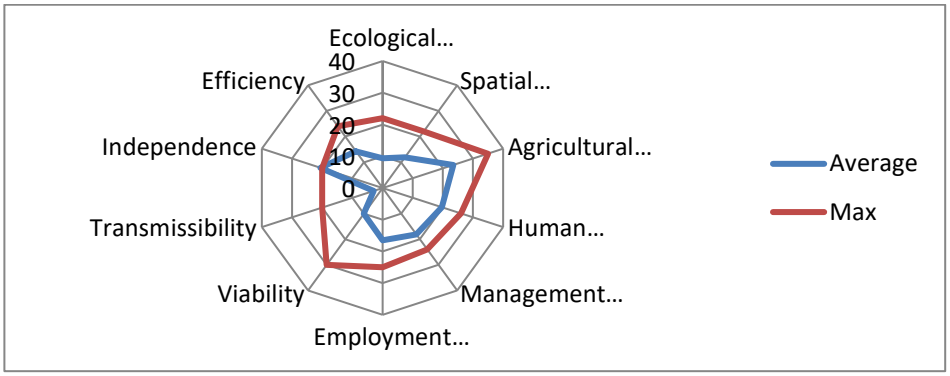


**Figure 3**: Theoretical averages and maxima of sustainability component scores

As in the three Vallès of the city of Meknes, other research revealed that the limiting value of the sustainability of vegetable farms was much more on the agroecological scale. Ahouangninou et al. (2015), showed that market garden farms in southern Benin have lower agroecological sustainability than their socio-territorial and economic sustainability. The assessment of the sustainability of vegetable farms in the province of Houet in Burkina Faso by Ouédraogo et al. (2020), showed that the economic scale had the highest scores, followed by the socio-territorial scale, while the agro-ecological scale had the lowest scores. Ndjadi et al. (2021), in their assessment of the sustainability of vegetable farms in South Kivu in the east of the Democratic Republic of Congo, found that the economic sustainability scale scored the lowest, preceded by the agro-ecological and socio-territorial scales.

## Conclusion

This study highlights that market garden production in Meknes is limited by its agroecological dimension. Improving this dimension of sustainability will increase the overall sustainability of vegetable production.

It is crucial to promote the training of farmers in the city of Meknes on the judicious use of plant protection products and fertilizers through the organization of workshops, demonstration sites, door to door, and the distribution of documentation so that they adopt new practices. It is essential to also test in this study area, biopesticides and biological control techniques and integrated agriculture, which have already demonstrated their effectiveness in many parts of the world and are less harmful to humans and more environmentally friendly. The development of resistant varieties would also be an interesting way to limit the use of phytosanitary products.

To move towards greater socio-territorial sustainability, farms should promote agricultural training for farmworkers and join together more to facilitate certain common operations (e.g., purchasing inputs) and join agricultural associations and cooperatives.

Direct public support and access to credit for farmers will improve economic sustainability scores.

**Conflicts of interest**

The authors declare no conflicts of interest about this article.

**Contributions of the authors**

Ibrahim El Ghazi: bibliographic research, data collection and processing, and writing of the manuscript. Janvier Egah and Claude Ahouangninou: drafting and proofreading of the manuscript. Imane Berni, Aziza Menouni and Sadik Soumia: proofreading of the manuscript. Marie-Paule Kestemont and Samir El Jaafari: supervision of the study and validation of the manuscript.

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