Sustainability assessment of Tunisian olive growing systems

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Abstract

This paper aims to assess and to analyze the sustainability of Tunisian olive growing system. Results show two types of farms in this sector. The first one is the traditional farms. The second is the modern farms. The Sustainable Value method (SV_method) inspired from the "ADVANCE" approach showed that those who adopt the modern management of the olive tree are more sustainable than the traditional type. In fact, the modern group presents a positive Sustainable Value. However, the traditional group recorded less efficient values than the Benchmark. Indeed, its Sustainable Value is negative, which means that the farms belonging to this group are not economically viable. Therefore, the traditional mode of management and the lack of innovation threaten future farming and viability of traditional olive tree farms. Furthermore, since most of these farms are familial type, the cultural utility, which explains the current existence of these farms, will be insufficient and decision-makers must enhance the adoption of new governance models.

Keywords: *Olive tree, Sustainability, Viability, Institutions, Opportunity costs, Added value, Performance.*

1. Introduction

In Tunisia, olive growing is a strategic sector. The area occupied by olive trees exceeds one third of the useful agricultural land and currently holds 1,788,000 hectares, representing 80 percent of the total area devoted to tree crop plantations (Weber *et al.*, 2020). With 5 percent of the world's total olive oil exports, Tunisia is the second world producer after Spain. This sector contributes about 50% of Tunisian agro-food exports (ONAGRI, 2017). On the social level, it accounts for 65% of all farmer's jobs in Tunisia and provides more than 40 million working days per year. It also operates more than 1700 oil mills (Bayoudh, 2014). Therefore, it is a factor of stability and a source of income for the populations in rural areas.

The olive tree area has increased in the last two decades (Figure 1). Demand and prices increase are the major factors of this expansion of olive tree area. In addition, the climatic variability and water scarcity lead to the transformation of production systems towards olive growing systems (Sansa *et al.*, 2018). Due to low water and soil resources requirements, the olive tree is a crop that the public authorities have sought to promote and farmers embrace

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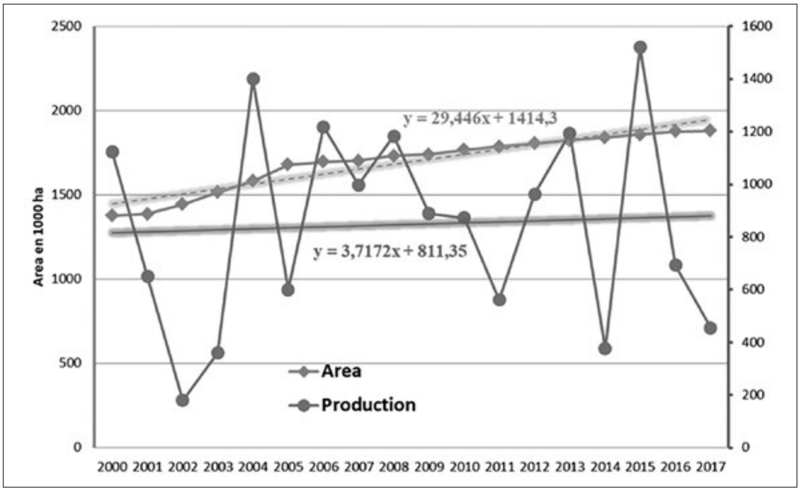


Figure 1 - Area and production evolutions of olive tree.

Source: DGPA, 2016-2018; Sai and Msallem, 2005; DGDEA, 2017.

this choice, by reason of the resilience of the olive tree to climate change.

Area increases were accompanied by a small production increase. In fact, despite the new extensions of the areas, the olive production has increased slightly from an average of 826,300 tons/year during the decade 2002-2011 to 867,000 tons/year during 2012-2017. However, analysis of the evolution of yields shows a downward trend (Figure 2). The average yield of olive farms was around 489 kg/ha during 2002-2011. This yield is very low compared to the potential of olive trees, which can exceed 900 kg/ha. Moreover, Tunisia lags behind its competitors in the EU and the MENA region in terms of olive yield during the same period.

Yield decreases are an indicator of efficiency and performance drop of Tunisian olive oil sector. This can threaten farmers' incomes and farms 'sustainability level'. If promoting the need for sustainable farming has become universal, agreement as to what is required to achieve it has not. This paper aims to analyze the sustainability of the Tunisian olive sector and its determinants. Results can constitute a crucial step for decision-makers and other stakeholders to accomplish Sustainable Development Goals in this sector.

The most common definition of sustainability comes from the 1987 Brundtland Commission report for the United Nations. It defines the concept as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Farming sustainability is characterized by simultaneous concern for the environment, maintaining social equity and ensuring economic profitability of the conducted activity. Supporting farm viability is one of the key objectives of agricultural sustainability. Economic viability measurement has received consideration

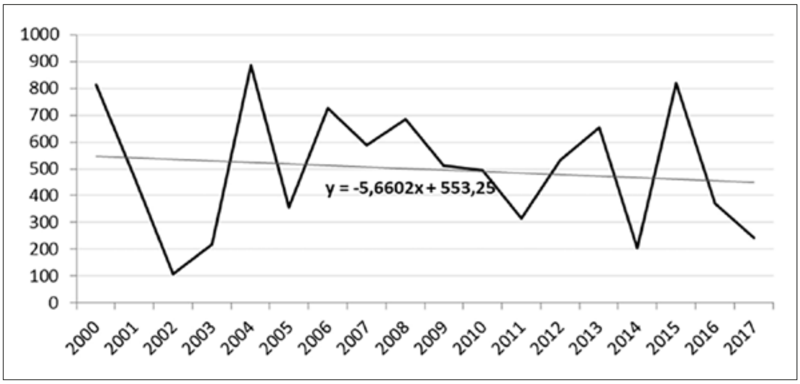


Figure 2 - Evolution of olive yields in kg/ha.

Source: Sai and Msallem, 2005; DGPA, 2016-2018; DGDEA, 2017.

at different periods in different areas, often at periods of difficulty within the sector. For researchers in the USA and Canada, viability is defined as the income needs for family farms (Adelaja *et al.*, 2004; Frawley and Commins, 1996). The main issue among European researchers focuses on farm viability as an opportunity cost measure (Aggelopoulos *et al.*, 2007; Scott, 2001; Argilés, 2001; Vrolijk *et al.*, 2010; Berkum *et al*., 2016). The most common principle of farm viability for these approaches is a comparison between the income produced by farms and a reference income (O'Donoghue *et al.*, 2016).

In the Tunisian context, concerns have been raised regarding sustainability of different sectors. Particular attention was given to the sustainability of agricultural sectors by several Tunisian researchers (Laajimi and Ben Nasr, 2009; Ben Nasr *et al*., 2014; Ben Abdallah *et al.*, 2018; M'hamdi *et al*., 2017; Attia *et al.*, 2021; Jellali *et al.*, 2021).

Several methods have been used to assess farms sustainability. The IDEA method ("Indicateurs de Durabilité des Exploitations Agricoles" or Farm Sustainability Indicators), which is a global method for evaluating the sustainability of farming systems according to the agro-ecological, socio-territorial and economic dimensions and the five properties of sustainable agriculture (autonomy, territorial anchorage, global responsibility, robustness, productive capacity and reproductive capacity of goods and services) is one way of giving practical expression to the concept of sustainable farms (Zahm *et al*., 2008; Alary *et al*., 2022). A "self-assessment" tool shows technical weaknesses and possible avenues for progress (Vilain, 2008; IDEA, 2021). Laajimi and Ben Nasr (2009) and then Ben Abdallah *et al*. (2021) used the IDEA Method to assess the sustainability of Tunisian olive sector. They showed that organic olive farms are more sustainable than conventional framers.

As well, Life Cycle Assessment (LCA) is a method of quantifying the environmental impacts of a product throughout its life cycle (e.g. agriculture, transport, packaging etc.). This method takes into account all stages of a product's life cycle. Additionally, it takes into account several major environmental issues, not only climate but also water quality, air quality, soil impact, and climate change. At each stage of the chain, material, energy and pollutant emission balances are carried out and aggregated in the form of a set of environmental indicators (AGRIBALYSE, 2020). Ben Abdallah *et al*. (2021) used this method to analyze and to compare olive cropping systems in Tunisia. Results showed that innovative systems are more sustainable than traditional ones.

One of the recent famous methods for measuring firm sustainability that incorporates the environmental, the social and the economic dimensions, is the Sustainable Value (SV) approach. It is called the triple bottom approach and it simplifies the measurement of company sustainable performance by expressing sustainability in monetary value called "sustainable added value (Hahn *et al*., 2015; Kassem *et al*., 2016). This approach is now widely used to asses agricultural sustainability in many regions around the world and it shows relevant and satisfactory results (Van Passel *et al*., 2009; Gómez-Luciano, 2019; Halland *et al.*, 2020; Thomas *et al*., 2020; Triyono *et al.*, 2021; Cammarata *et al*., 2021; Moretti *et al*., 2021). Hence, and according to data availability, the SV approach was adopted here to assess the sustainability of Tunisian olive farms. The first part of the paper will present the methodology adopted. The second part will be dedicated to the presentation and discussion of the results obtained.

2. Materials and methods

2.1. *The sustainability assessment method "Sustainable Value Approach"*

Compared to other methods, the Sustainable Value Approach measures the use of natural, physical and human capitals in a new way. It translates the environmental and sustainability terms and performances into investor and manager languages. From this point of view, farms create value whenever they use inputs and resources more efficiently than other farms. Hence, the ADVANCE guide published by (Figge *et al.*, 2006; Hahn *et al.*, 2007), provides a comprehensive and a practice method to assess environmental performance of firms in various sectors.

According to this approach, in order to assess farms' sustainability, we need to assess the use of the entire bundle resources and capitals. However, in the conventional economic approach analysts focus on only financial capital. Therefore, to assess sustainability of Tunisian olive farms we calculate the "Sustainable Value", which takes into account economic, social and environmental capital. Hence, a farm creates Sustainable Value when the economic, environmental, and social resources used are more efficient than the "Benchmark". This value is intended by calculating the opportunity cost of these resources.

2.1.1. *Capital and resources identification*

In our case, we focus on the performance of both human and natural capitals used by farms in olive production. For the human capital, labor, particularly family labor measured by the share of the farm manager's time devoted to the farm, reflects the human capital. This share is evaluated at 20% of the farmer's time for traditional farms and at 40% of the farmer's time for modern farms. Since the olive tree is mainly carried out in rain-fed mode, the natural capital was limited to land resources measured by the farm area.

2.1.2. *The choice of Benchmark*

In our case, this is the estimated "added value" for each farm. We will compare the observed value added of the farms to the frontier farm. The economic viability of a farm is assessed by its capacity to remunerate the production factors used at their opportunity costs. These costs would be approximated by the long-term remuneration of the production factors taken into account. The long-term equilibrium ensuring these remunerations would be characterized by constant returns to scale. In the case of these returns, and in application of Euler's identity, the "added values" generated by the different farms would be just sufficient to remunerate the factors of production.

$$VA_j = \sum_{xi=1}^{n} X_i \frac{\partial Y_j}{\partial Xi} \quad (1)$$

With:

VA_j : Value generated by the farm j

X_i : The production factor (i) to be remunerated

$\frac{\partial Y_j}{\partial Xi}$: Marginal productivity of factors x_i equal to its opportunity cost in the long-term equilibrium.

The following model is used to estimate the marginal productivities of these factors of production as an acceptable approximation of their opportunity costs:

$$VA_j = \propto L_j + K_j + \in \quad (2)$$

With:

VA_j : Added value generated by the farm j

L_j : Family labor force used by farm j

K_j : Value of the land planted for farm j

α and β: coefficients to be estimated

$\in$: Error term.

2.1.3. *"Sustainable Value" estimation*

Firstly we proceed by the calculation of the "added value" of the Benchmark for each resource used, and this by the calculation of the "Efficiency of Benchmark" by dividing the "added value" of the Benchmark (Y^*) by the amount of resource used X_i^*.

$$SV_B = \frac{Y^*}{X_i^*} \quad (3)$$

Then we proceed by the calculation of the "added value" achieved by the olive farm by subtracting the intermediate consumption from the profit. Then we calculate the "Efficiency of Exploitation" which is calculated by the "added value" of the farm divided by the amount of resource used. The "Contribution Value" calculation expresses the difference between the value added created by the farm and the opportunity cost of each resource used. This is done by comparing the value added with the calculated opportunity cost, which represents the value added that should have been created by each resource used.

$$SV_{ji} = \frac{Y_j}{X_{ji}} - \frac{Y^*}{X_i^*} \quad (4)$$

With:

SV_{ji} : Sustainable Value generated by the farm j using the resource i

Y_j : Added value generated by the farm j

Y^*: Added value generated by the Benchmark

X_{ji} : Quantity of resource i used by the farm j

X_i^*: Quantity of resource i used by the Benchmark.

Finally, the "Sustainable Value" is calculated by dividing the sum of the "Contribution Value" by the number of resources considered. Value is created only when the value added exceeds the cost.

$$SV_j = \frac{1}{R}\sum_{i=1}^{R} SV_{ji} \quad (5)$$

With:

SV_{ji}: Sustainable Value generated by the farm j using the resource i

R: number of resources used by the farm j.

2.2. *Data collection and study area*

2.2.1. *Study area*

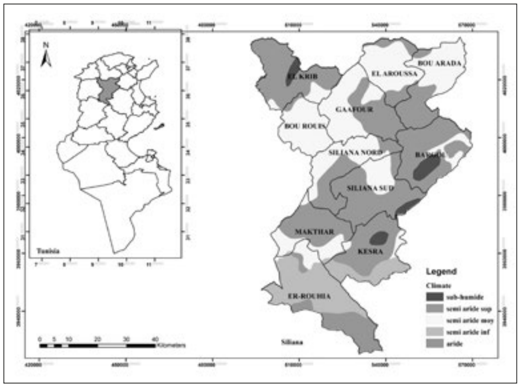
Based on the research activities carried out by the researchers of the Olive Tree Institute (Mokrani *et al.*, 2019; Hammami *et al.*, 2018; Sai *et al.*, 2013), the governorate of Siliana has been identified as a region that best illustrates the above-mentioned problem. The situation of our study area in the north of Tunisia is a faithful representation of our problematic of the low productivity growth of the olive sector and is in line with our observation that the extensive solution has reached its limits, hence the necessity to act through the intensive solution for better productivity results.

In our study area, the olive tree is expanding. In addition, there has been a transformation of the total cultivation system due to the reduction of risk, the relatively lower cost, and the adaptation to climatic conditions, in addition to sufficient rainfall to move farmer towards olive growing.

In addition to a promising olive oil market which attracts farmers thanks to the increase in exports. Indeed, the exported quantities of olive oil in 2010 were equal to 108800 T to reach 372800T in 2020, passing by 288500T in 2015 (ONAGRI, 2021).

The prices of extra virgin olive oil are following an upward trend to reach 3.28 euros/kg in Spain, 4.23 euros/kg in Italy, 3.05 euros/kg in Greece and 2.67 euros/kg in Tunisia. This will continue until September 2021. However, this upward trend remains quite high compared to the previous year. Indeed, the average price of olive oil during the first three months of the 2021/2022 campaign has increased by 40% compared to the same period of the previous campaign with a variation from 21% to 56% (ONAGRI, 2022).

Figure 3 - Location and bio-climate of the Siliana study area.



2.2.2. *Data and survey*

Data used here were collected by a survey conducted among 21 farms. To assess value we proceed by: firstly, a farm's characterization, then an identification of inputs and resources used by the farm, the production level, and the production value. The sample shows two types of farms. The traditional farms constitute the first type. The term "traditional" refers to farms that are related to climatic conditions and to olive growers who adopt the extensive system to manage their olive groves. They are characterized by low productivity and an economic viability of their farms that is threatened in the long term. The modern farms represent the second type. "Modern" refers to farmers who follow the technological package recommended by the specialized institutions. They provide the necessary inputs to the olive grove. They represent a higher productivity and economic viability by ensuring the sustainability of their farms.

The parent population was identified from the list of all olive farmers in the study area provided by the regional services of the Ministry of Agriculture, i.e. about 300 farmers. This list, with the help of local services, was subdivided into two groups of farmers according to their membership in the two types of management systems, modern or traditional. The modern farmers represent 40% of the total number of farmers on the list and the remaining 60% are traditional farmers. A random sample

Table 1 - Average's characteristics of two farms types.

Characteristics	*Traditional Farms group*	*Modern Farms group*
Added Value (TD)	3059	7317
Area (ha)	7	5
Yield (Tonne/ha)	1	2
Number of olive tree / ha	106	99
Ploughing cost (TD)	1477	1013
Total labour force (TD)	3884	2959
Pruning cost (TD)	1129	746
Fertilisers cost (TD)	0	437
Farmers age (years)	53	56

was drawn from these two groups. The structure of this sample is consistent with the structure of the parent population. Since the same practices and farm's characteristics are observed within the same group. Such a size was considered sufficient. It is composed of 13 farmers from the traditional group and the remaining 8 modern farms.

3. Results and discussion

3.1. *Resource identification*

Results show the existence of two groups of management of olive trees: traditional one and modern one. The traditional one is characterized by farmers who have chosen to follow the traditional olive tree management. Their behavior is limited to the use of traditionally accepted resources such as soil ploughing, pruning every two years, dry farming of the olive tree and some are following the advice of referent farmers. Like leaders with long experience in olive management, who have remained a little permeable to official technical recommendations. Moreover, the modern ones are managed by "Intensifier" farmers who adopt new technologies to develop their farms and listen to the advice and recommendations of the extension services provided by the Ministry of Agriculture. They mainly adopt fertilizers as a modern technique to improve the productivity of their olive groves.

It should be noted that, according to the survey, the lack and scarcity of labor, accentuated by the orientation of young people towards other activities, could explain the presence of family labor in the two types of farms considered in our work. In addition, most farms are rainfed and irrigation is only present on a few farms, although it is complementary. Thus, the natural capital considered here is land.

According to Table 2, the traditional farms with 13 farmers in the sample record an average farm land around 7 ha and an average physical capital around 51692 dt. While the average of farmland is around 5ha to the modern farms including 8 farmers and an average physical capital of 35000 dt.

3.2. *Benchmark*

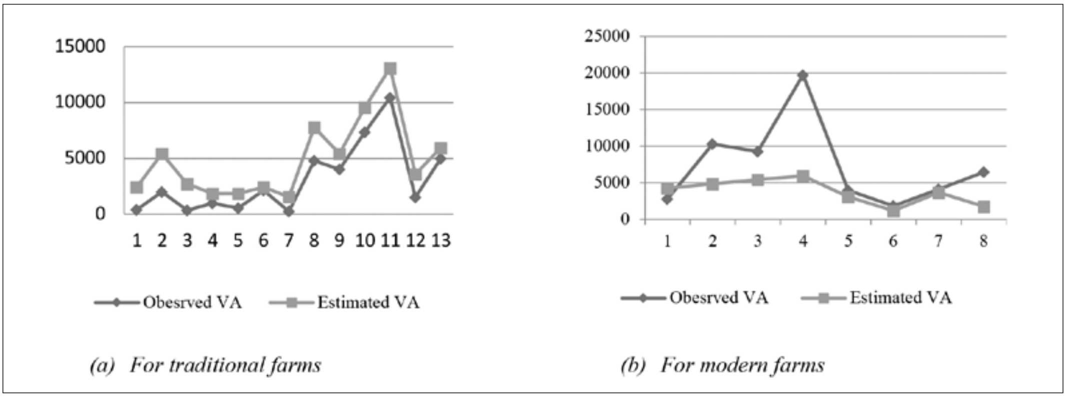
Using the model in equation (2), we estimated the value added used as a Benchmark for each farm.

Results show that the observed value added of modern farms (Figure 5b) is higher than the estimated value added. However for the traditional type of farms (Figure 5a), the observed value added is less than the estimated

Table 2 - Descriptive analysis of resource's exploitations.

		Human capital (days/year)	*Natural Capital (ha)*	*Physical capital (DT)*
Traditional Farms	Min	90	1.5	10500
	Max	1320	22	15400
	Average	420	7	51692
Modern Farms	Min	240	2	14000
	Max	1200	10	70000
	Average	600	5	35000

Figure 4 - Model results and comparison between observed and estimated value added of the farms.



value added. In other words, using all resources could produce more observed value added than estimated value added for modern farms. For example, the farm (4) in the modern group obtained observed value added around 19760 dt while estimated value added is around 5954 dt. For traditional farms, they could be using resources in a more productive way to improve its value added to reach estimated value added which is a Benchmark in our case.

3.3. "Contribution Value" of each resource

The results obtained allowed us to assess the "Contribution Value" of each resource used of the 21 olive farms surveyed. Figures below (5a, 5b, 5c) illustrate the resource value sustainability that expresses the comparison of the added value with the calculated opportunity cost, which represents the added value that should have been created by each resource used. In fact,

Figure 5 - Resources used Value Sustainability: (a) Labor Value Sustainability; (b) Capital Value Sustainability; (c) Soil Resource Value Sustainability.

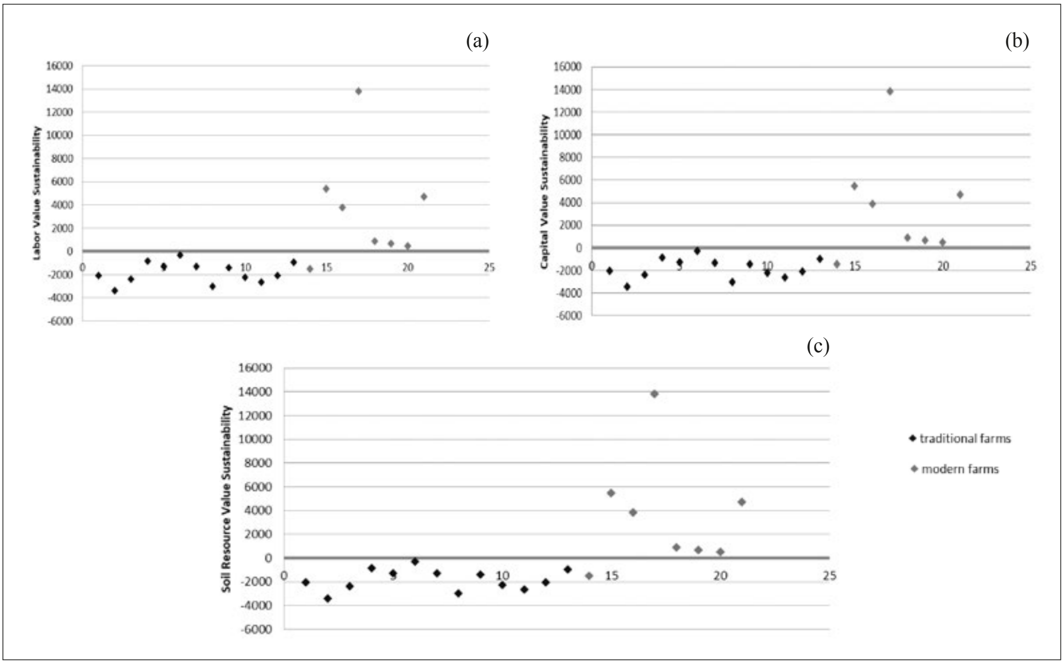
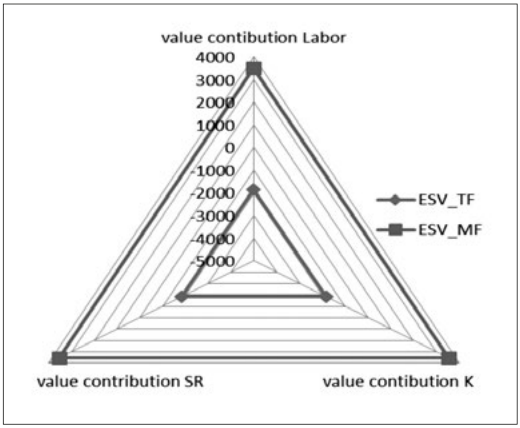


Figure 6 - The average of the "Contribution Value" relating to each resource.



ESV_TF: Estimated Sustainable Value for the traditional farm; ESV_MF: Estimated Sustainable Value for the modern farm.

the group of farms with a positive "Labor Value Sustainability" (figure a) represents the modern farms. As for the farms recording negative "Labor Value Sustainability", they are represented by farms whose farmers have chosen to follow the traditional olive tree management. In other words, its value added is lower than the opportunity cost of resources used.

Figures (5b) and (5c) show the same result of farm sustainability values for both traditional and modern groups. Although the modern group indicates a comforting economic viability, as a whole. In other words, its added value produced is higher than the opportunity cost of each resource used. Poor plantation management or other personal constraints could explain the economic unsustainability of the other group members' farms. The low productivity registered at farm level and the choices of olive tree management not oriented towards the technology adoption, can explain a negative result of the traditional group.

Figure 5 shows the average "Contribution Value" of each resource. Generally, it is negative for the traditional group and positive for the modern group, which is in line with the above results.

3.4. *Farm Sustainable Value*

Using the input efficient resource as a Benchmark to calculate the Sustainable Value of all farms, the Figure 6 illustrates the Sustainable Value from lowest to highest one relative to all the surveyed farms. The "Sustainable Value" shows that two management categories of olive tree farms with different behaviors have generated different "Sustainable Value" of which those adopting modern olive management are positive. Indeed, the farms, for example, 15, 16, 17, 18, 19, 20, 21, perform better by adopting the technological package recommended by the specialized institutions and have a positive Sustainable

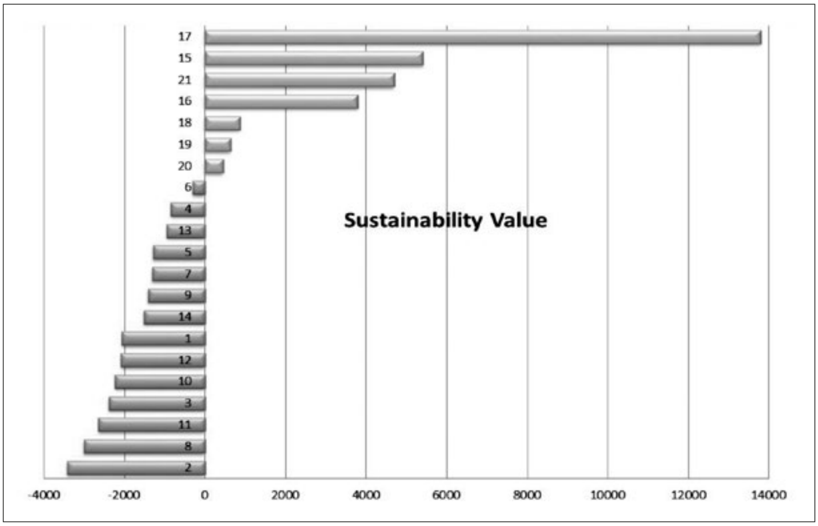


Figure 7 - Economic Sustainability Value of farms.

Value, as shown in Figure 6. In our case, farmers mainly use fertilizers to boost the productivity of their olive groves. That is, the values recorded by these farms are higher than the performance achieved by the Benchmark. This would indicate that the modern farms use all their resources in the most productive way.

However, the traditional group records less efficient values than the Benchmark. Indeed, its Sustainable Value is negative, which means that the farms belonging to this group are not economically viable. Indeed, these farms are related to climatic conditions and to olive growers who adopt the extensive system to manage their olive groves, like farms 2, 8, 11, 3, 10 as shown in Figure 6, which limits the achievement of a positive "Sustainable Value". In this case, farms can improve their Sustainable Value by applying their resources in a more productive way to moving towards the added value estimated that represents the long-term economic stability of farms. It is therefore preferable that they move towards the behavior of the modern group to avoid their long-term disappearance and improve the olive tree productivity of their farms. The negative results for the traditional group may indicate that the lack of non-agricultural employment opportunities and the desire to maintain the social status of landowner are explanatory elements for such a situation, which is not in line with the economic rationality that is supposed to guide the behavior of micro-economic agents.

The "Farm Sustainable Value" results also confirmed that modern and innovative farms moving towards the adoption of the technology package are more efficient and favors the sustainability of their farms, compared to the traditional or conventional olive groves that rely on extensive management of their production system.

5. Conclusions

This study proposes a new approach to assess the performance of Tunisian olive tree farms. This approach takes into account the principle of balance between the three pillars of sustainability, namely economic profitability, social equity and respect for the environment.

The application of the "Sustainable Value method" led to the assessment of Sustainable Value of each factor used in the olive production process, which allowed classifying farms according to both viability levels and sustainable values achieved.

The results showed two types of farms. The modern farms with a high level of viability and good economic performance and the traditional farms with a very low economic performance. In fact, for second type of farms, the values generated for each capital (Natural capital, physical capital and human capital) used are lower than the opportunity costs. The low "added values" and the technical inefficiency of resources threaten the economic viability of these exploitations. The current existence of these operations is explained by a cultural utility.

Overall, it appears that the two types of Farms have two different rationales: the economic rationality for the modern farms and the cultural rationality for the traditional farms. Given that, the most traditional farms are family farms and involve poor households, and to ensure inclusive development of these social categories, decision-makers must enhance the adoption of new technologies and new management methods for better economic viability and moving up at the scale of sustainability.

Thus, it is preferable to orient farmers more towards the modern olive management system. Moreover, to accommodate their situations by encouraging them to take advantage of the extension which needs to be intensified. In addition, it is recommended to have feedback from the farmers' experiences and to establish a continuous communication between the two interveners.

In the end, our study represents an extract of the situation of the olive-growing system in Tunisia, hence the interest to extend the study areas and to design other corresponding typologies according to an economic model. It is desirable to think of integrating the biophysical factor and the climate change impact to try to better explain and enhance the change of vocation of agricultural land. In our case, it is the change from cereals to olive trees in the northern region.

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