



## **Monitoring of the Project to Convert Cereal Production into Olive Plantations in the Province of Tetouan (Northern Morocco)**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The agricultural sector occupies an important economic and social position in Morocco. In this sense, in recent years our country has adopted a new strategy for the agricultural sector called the "Green Morocco Plan". This plan is based on two pillars, the first is that which provides agriculture with high added value, high productivity, and competitiveness, the second is that which offers solidarity-based agriculture, based on the fight against poverty, increasing the income of small farmers, particularly in disadvantaged areas (such as unfavourable stock areas, mountains or oases, plains and plateaus in semi-arid regions).

In our present study, we are particularly interested in the project to convert 760 ha of cereal crops into olive groves in the province of Tetouan. On the one hand, all stages of olive tree planting in cereal crops were monitored, as well as a comparison of yields, area, income, productivity and employment before and after the project was carried out. And on the other hand, an analysis of the various positive (social, economic and environmental) and negative (ecological) impacts of the

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project on the rural population in the province of Tetouan and on the environment in general. On the contrary, this project encountered several constraints, including natural, economic and social constraints.

*Keywords: Green Morocco plan; olive tree; planting; province of Tetouan; reconversion project.*

## 1. INTRODUCTION

The Maghreb countries occupying the Northwestern part of the African continent have great geographical similarities and experience the same topographical contrasts, which extend from the shores of the Mediterranean to the south of the Sahara desert [1].

Among these countries, Morocco is characterized by a high altitude of its mountains and by the relative size of its plains, and with its location in the western corner of North Africa, is characterized by an arid and semi-arid climate, enjoys a significant natural capital that includes, among other things, water resources, soil heritage, forest heritage and rangeland. Thus, it has very high originality that makes it one of the most interesting regions in terms of biology and biogeography. Several factors have combined to offer this floristic, faunistic and landscape diversity, of which these natural resources constitute an essential component in the life system of the majority of the rural population [2,3].

The country includes twelve regions, themselves divided into provinces and prefecture (urban equivalents of the provinces). One of these regions is Tangier-Tetouan-Al-Hoceima.

Concerning our study, we are addressing precisely the province of Tetouan, whose natural environments at the level of the latter are heavily subjected to anthropic pressure, this is due to the demographic growth that has occurred in the area in the last few decades, and which results in the excessive and irrational exploitation of all-natural resources.

Among the major activities encountered at this level, we can distinguish agriculture, livestock, forest use, fishing, industry and crafts, etc.

Heavy human activity generates a range of environmental problems, including land degradation, water resource management; soil conservation and vegetation cover management. This dysfunction is reflected in several manifestations such as soil erosion, a decrease in water quality and quantity, and the loss of

biological diversity, partly linked to the acceleration of the degradation of natural environments [4,5].

In this context, to contribute to this problem, a study is based on the identification and analysis of existing water and soil conservation techniques in the province of Tetouan, show the objective of our work. The specific objectives of this work are to promote the sustainable management and rational use of natural resources, to achieve the reduction and control of erosion processes at the study area level and to improve farmers' performance and soil conservation against erosion.

## 2. METHODOLOGY

### 2.1 Study Area

#### 2.1.1 Geographical location

Morocco is located in the western part of North Africa. It is divided into 12 economic regions, which are themselves divided into provinces and prefectures (urban equivalents of the provinces) [6]. This study is located more precisely in the province of Tetouan, which is a subdivision of the region of Tangier-Tetouan-Al-Hoceima that is located in the far north of Morocco. This area has a total population of 550,379 inhabitants, including 152,401 rural and 397,973 urban, and then the number of agricultural holdings is 17,820 [7,8].

The province of Tetouan (35.5888995° N; 5.3625516° W) is one of the eight provinces/prefectures that make up the Tangier-Tetouan-Al-Hoceima region. This province is located in the far North of the Kingdom of Morocco, covering an area of 190,000 ha [8,9] (Fig. 1).

#### 2.1.2 Administrative situation

According to the latest administrative division, the province of Tetouan consists of 2 municipalities and two rural circles comprising 8 caïdats (Mallalienne, Bni Hassan, Ben Karrich, Ain Lahcen, etc...), containing 20 rural communes (Al Hamra, Azla, Saddina, Mallalienne, etc...) [11].

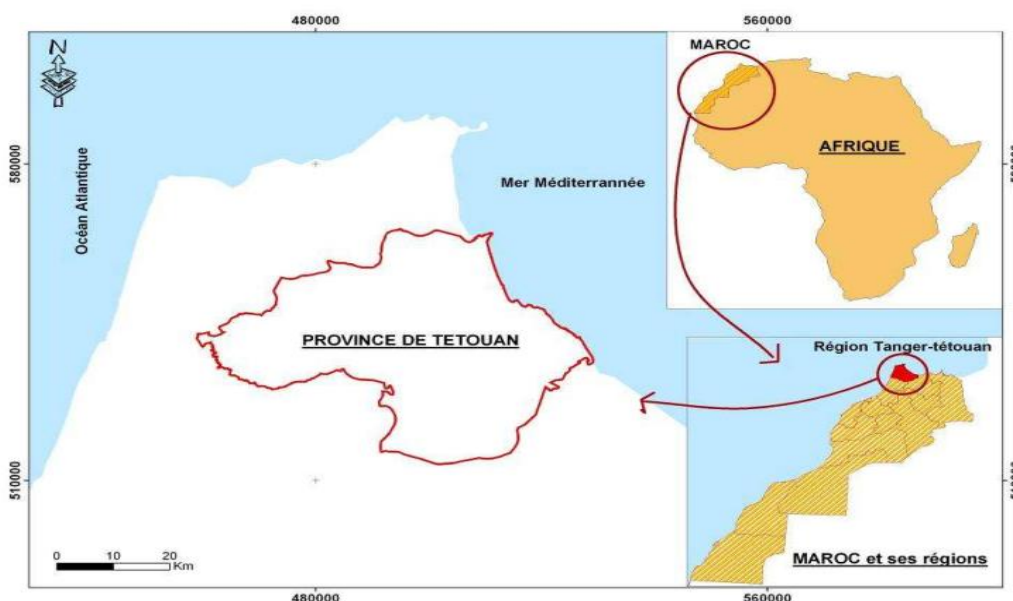


Fig. 1. The geographical location of Tetouan province [10]

### 2.1.3 Geographical data

From a geological point of view, the province of Tetouan extends over a geographical area characterized by an essentially mountainous landscape (located in the western part of the Rifaine chain) with very rugged and tormented topography, except certain areas of low relief and some very narrow Mediterranean plains, such as those of Martil, Ajas, Oued Laou and Mallalienne [9].

The province of Tetouan is distinguished by the existence of a varied soil structure, due to climatic variations, geological formations and relief. These factors have an impact on the evolution of soils in this area. This area has four main soil types: Hamri (29%), sandy (27%), clay (25%) and tirs (19%) [9].

### 2.1.4 Climatologically data

The climatology at the level of the province of Tetouan has diversity comparable to that of the relief. In general, the existence of two different seasons, namely a rainy and humid season from October to April and another dry season from May to September, which classifies the province of Tetouan among the regions with a Mediterranean climate [8,12].

In the province of Tetouan, temperatures are influenced by a Mediterranean climate, resulting

in a mild climate; this study area has an average annual temperature of 22°C. The maximum temperatures of the warmest month in the province of Tetouan are 35°C, and for the minimum temperatures of the coldest month is around 8°C [9].

Due to its geographical location and relief, the province of Tetouan is home to abundant rainfall. The latter is characterized by great variability, both in time and space [13]. According to climatic data recorded in the province of Tetouan, average annual rainfall reaches 650 mm [9].

The territory of the studied area is very windy; it is characterized by the predominance of two winds during the year: one of Atlantic origin (Gharbi) and the other of Mediterranean origin (Chergui) [9]. The westerly winds, of oceanic origin, predominate from November to March and cause precipitation, while the northwest winds, predominant in spring and summer, give rise to cloudy weather in spring and favour dry and fairly stable weather from May onwards.

### 2.1.5 Hydrological data

The province of Tetouan is located in a water-rich region, the study area is crossed by several wadis; among the main ones, we can mention the Oued Martil and Oued Laou, etc. Similarly, there are 1,326 wells and 50 main water sources, allowing irrigation [9].

### 2.1.6 Monographic data of the study area

The land in this area is unscrewed as follows: rangelands and uncultivated land (24,350 ha), useful agricultural area (UAA) occupies an area of 57,000 ha (irrigated land contains an area of 6,480 ha, and for non-irrigated land (bour) occupies 50,520 ha), and forests occupy an area of 108,650 ha. The latter is characterized by the presence of the following forest species: Cork oak (*Quercus suber*), holm oak (*Quercus ilex*), Zen oak (*Quercus canariensis*), maritime pine (*Pinus pinaster*), cedar (*Cedrus*) and fir (*Abies*) [8].

The Bour system corresponds to all crops grown in dry conditions. Bour crops occupy most of the useful agricultural area in Tetouan province and provide subsistence for the majority of farmers. They are practised in the direction of the slope with plots parallel to each other and perpendicular to the crest line of the calcaireo-dolomitic massifs. They are practised on small plots, sometimes not exceeding half a hectare [14]. The main uses of Bour land in the study area are as follows: cereal crops, fodder, market gardening, olive groves, legumes, almond trees, etc. [9].

The irrigated farming system occupies only a secondary place in the farming systems in our study area (occupies just 307 ha). This system is characterized by intensive agriculture [9].

Land for cultivation is an essential resource in our study area. The legal status of land for cultivation is mainly governed by unregistered private property (the Melk) [9].

### 2.1.7 Production system

The agricultural production system is essentially based on extensive livestock farming; livestock farming plays a key role in the province of Tetouan. Indeed, it is the main source of currency in the operation. Besides, it contributes significantly to the daily coverage of the population's protein needs by providing milk and meat [9].

For the Bour fields, cereals are the main crops grown in our study area. Cereal soil is characterized by the clear dominance of wheat (durum and soft wheat), the main source of food [9]. Barley comes in second place, with the presence of other cereals (maize, sorghum....).

Then, fruit arboriculture (more precisely olive growing) is the second position after cereals, followed by fodder crops, dominated by bersim, fodder barley, oats, corn, and then market gardening crops (such as potatoes, tomatoes, onions and others) [9].

For irrigated land, fodder crops mainly occupy it; the latter is characterized by the dominance of bersim, maize, forage, sudangrass and alfalfa. Thereafter, there are market gardening crops; there is a range of crops such as tomatoes, onions, potatoes, carrots, cures, etc. On the other hand, fruit trees are poorly represented in this case irrigated crops [9].

The constraints of the plant system are many and varied: climatic, physical, land, technical and socio-economic.

Climate constraints: Although the precipitation is generally abundant in the study area, its distribution over time is very irregular and too concentrated over time, which negatively affects crop management [14]. The second major climatic constraint is the importance of the frequency of high winds. The most formidable of them is the Chergui, which blows for much of spring and summer. The negative consequences of these factors affect spring and summer crops (market gardening and arboriculture) much more.

Physical constraints: Several physical factors are major constraints that prevent any attempt at agricultural development in our study area. These constraints concerning the relief and soils.

The altitude slopes and outcrops of hard rocks are the main relief factors that pose problems both in human terms, the problem of isolation, and in terms of land use, essentially the problem of erosion. These constraints not only limit any expansion of crops in the study area but also threaten the sustainability of the agricultural production system [14].

Soils are generally very heterogeneous and their contribution depends strongly on the geochemical nature of their mother rock, the nature of slopes, anthropogenic actions and the current dynamics of physical factors. These soils are subject to worrying degradation, since erosion, in its various forms, is very active in the study area [14]. The extent of erosion is accelerated by the uncontrolled dynamics of crop expansion at high altitudes and by the abundance of heavy rains [15].

Land constraints: the constraints posed by the land component are inherent in the ambiguity of the legal status of the land, in the fragmentation and distribution of parcels in space. In addition to the State domain, the collective, in its various forms, and the registered Melk, a whole range of indigenous practices persist, which remain, at present, the basic reference in the internal management of land heritage. This situation of being a municipality of property rights generates chronic conflicts on the ground between the population and the state [9,14]. The land structure is characterized by the dominance of micro property, a direct consequence of fragmentation. This last factor is a challenge to any attempt at agricultural development. Very small and widely scattered plots explain, largely, the use of rudimentary techniques and hence the low yield levels. The dispersion of plots also poses two other problems. The first is related to the working conditions of the land since a lot of energy and time is lost in travel. The second is a conflict between farmers and herders, since

small ruminant herds, mainly goats, cause enormous damage to crops during their crossings.

Technical constraints: the production techniques used in the study area, largely because of the combination of physical and land constraints. Input use remains very limited by physical environmental and land conditions. On very small, scattered plots, located largely on steep slopes, cultivation techniques can only be traditional. The wooden or iron peacock does the sloughing. Exclusively draught animals and family labour provide work energy. The seeds used, mainly produced locally, are of low productivity. Harvesting is a manual based on sickles [14].

## 2.2 Materials

The material used in this study is signage panels, metric meter, tacheometer, hoe, reed, olive trees, compost (25 kg bag), water tanks, hose, auger, shears and raffia (Fig. 2).

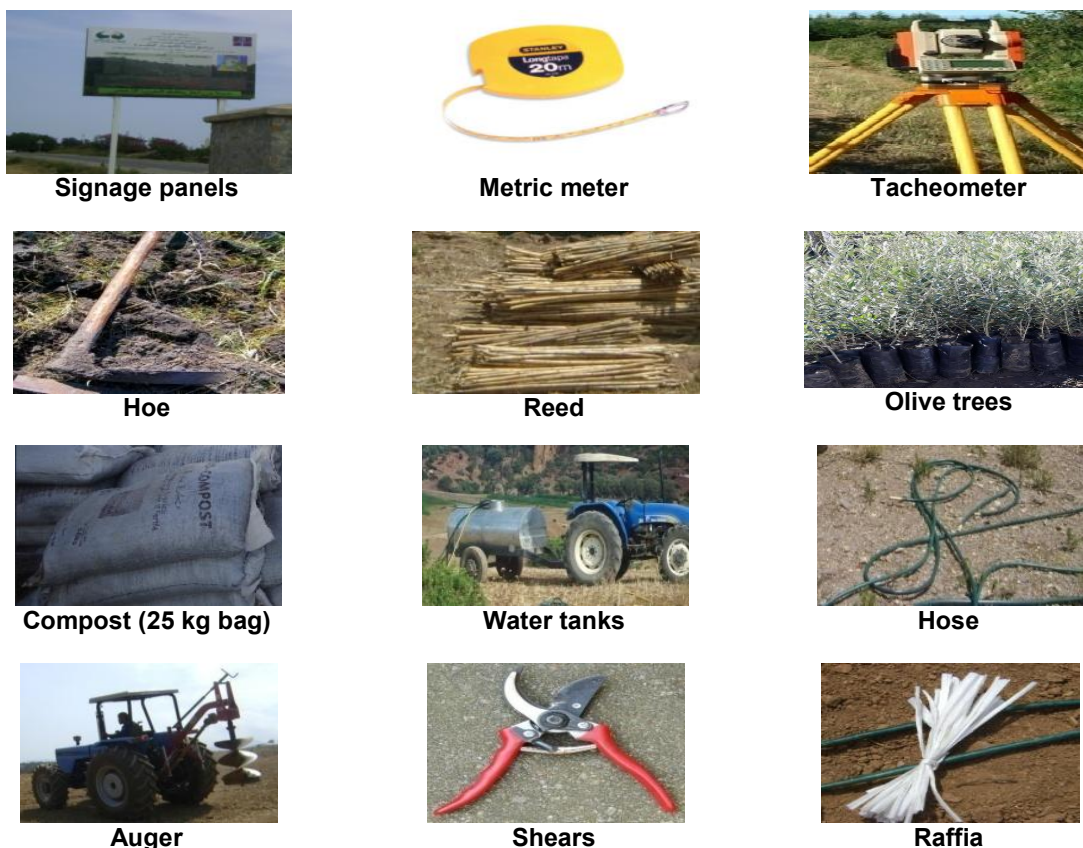


Fig. 2. The material used in the field

## 2.3 Methods

Before the start of the conversion project, several actions are carried out in this direction. First, awareness and training days were held by the DPA team and technical assistance (TA) to explain farmers of the importance of this project, second, the identification of beneficiaries through the establishment of lists, as well as the identification of perimeter boundaries (delimitation).

The latter consists in identifying the plots that will be planted at the level of each douar. Work has begun to begin as soon as the delimitation is finalized. This delimitation will be materialized by a plan developed by the TA technician using a GPS and then incorporating the data on a georeferenced system.

To start the work, field visits and meetings were carried out in the presence of the Tetouan DPA officials, members of development associations and contractors.

The work on the planting project is divided into three parts: Pre-planting period, planting period and plantation maintenance period.

### 2.3.1 Pre-planting period

This period is characterized by the presence of several successive stages:

- Plotting and picketing: Plotting and picketing will imperatively follow the layout of the master curve that follows the contours and staggered layout. The tracing is carried out by the topographers (by using the total station device or tacheometer) or by the workers and under the supervision of the technicians. The stakes, showing the locations of future plants, must be 1 m long above ground level and firmly anchored in the ground. These posts are made by using reeds.

Concerning the technical specifications for the planting of olive trees in each perimeter are as follows:

- Distance between plants: 8 m
- Distance between lines: 8 m
- Number of plants/ha: 156 plants
- Preparation of planting holes: The planting holes are 70x70x70x70 cm or having an equivalent volume if using an auger. On

shallow soils or in the presence of limestone crusting, the unearned depth is replaced by the width. The planting holes are made either manually by the workers or mechanically by using an auger.

After the opening of the planting holes at each perimeter, a team (technical assistance) checks the depth of each hole and also the dimensions of the planting holes, for the validation of this step.

- Preparation of the plant reception area: The reception area, chosen on flat ground, is cleaned. A relative area of 80 plants per m<sup>2</sup> should be provided. The area must be subdivided into planks. The width of the boards must not exceed 1.5 m. It is forbidden to put 2 different varieties in the same board. The floor of the boards must be turned over to ensure that the stability of the plastic bags containing the plants is maintained.

After the last plants have emerged from the receiving area, the land will be cleaned of all debris (branches, foliage, plastic, other) and ploughed to restore its previous appearance before use.

### 2.3.2 Planting period

This period is defined by the presence of several successive stages:

- Incorporation of compost into the soil of the planting hole: A quantity of 2 kg of compost will be incorporated per plantation. The compost is mixed with the soil before being put back into the hole.

At each perimeter, a storage area is provided to allow the compost to be received before it is moved to the planting holes. Compost must be of good quality delivered by a specialized supplier and packaged in 25 kg bags. The compost must be clean of all landfill waste (plastic, fabric, paper...).

- Filling of planting holes: Filling of holes should be done once the hole opening work has been received by the DPA and AT. The filling should never be carried out under wet conditions. The hole will be filled to the top 30 cm of its depth, making sure to put the topsoil first, followed by the soil that was in the deep layer.

- Supply and reception of plants: For the supply of plants, the presence of labour is necessary for the plant transport operation. For loading and unloading, they are the responsibility of the contractor.

To avoid varietal mixtures, tarpaulins or separation nets must separate between the different varieties that are in the same load. The olive trees, as soon as they arrive at the perimeter, are unloaded in the reception area. The bags must be arranged straight. To avoid varietal mixtures, clear separations must be made in the reception area between varieties. The purchase of the plants is the responsibility of the company, which can only obtain its supplies from nurseries that must comply with the following requirements: have a phytosanitary certificate issued by the Plant Protection Service, the varieties required are the Moroccan Haouzia and Menara varieties, each with 50%.

The plants supplied must comply with the following requirements:

- Age of the plants between 12 and 18 months.
- Height of plants between 70 and 120 cm.
- Raised in plastic bags from 17 to 25 cm minimum.
- Root hairs of the well-developed plant exploiting the entire substrate.
- The root hair of the plants must be sufficient for a good start.
- Absence of roots coming out of the plastic bag.
- The plants must be defoliated at the time of delivery, free of all diseases and parasites.
- Pre-watering of plants in bags: The plants in bags are watered, with water of the required quality, until saturation 24 hours before planting to compact the soil of the clod and prevent it from disintegrating when the plastic bag is removed.
- Single stem pruning: Before removing the plastic bag, the plant is pruned on a single stem. The main stem is chosen, and the other competitive stems are eliminated. Pruning wood must be removed from the perimeter and burned.
- The placement of the plant: The plant is installed in the planting hole instead of the post to respect the spacing between lines and between plants. And to avoid varietal mixtures, once a line of one of the varieties

has been planted, the second variety will be planted while indicating the variety of the starting line to allow the recognition of the varieties planted at the level of each plot.

The plastic bag is removed, avoiding crumbling the soil containing the roots. Then the plant is covered with soil at the height of its root ball, making sure to pack the soil around the plant to minimize air pockets that promote desiccation. The bags must be collected and disposed of within the perimeter in an environmentally friendly manner.

- Staking: Each plant is staked by staking to which it is attached by raffia. The stake can be a reed, dry, disease-free and pest free, straight, rigid, from a height between 1 and 1.2 m.

The attachment of the plant to the stake must be loose (5 to 7 cm apart) so as not to strangle the stem of the young plant following the instructions and instructions of the workmaster.

- Making of the bowls: When the slope of the land to be planted is less than 5%, it is recommended to make the basins with a radius of 1 m immediately following planting.

### 2.3.3 Plantation maintenance period

This period is characterized by several successive stages:

- Watering: The first 30-litre watering is applied immediately after planting. Then, it is necessary to supply of 30 litres per plant with a rate varying according to the climatic conditions. During the entire summer period, the contractor must provide six irrigations per year for the entire planted area according to the schedule. And in the case of water stress, it must provide additional irrigation for the entire planted area (30 litres of water for each plant).
- Fertilization and phytosanitary protection: In the first year, foliar fertilizers will be used. A foliar fertilizer (20-20-20-20 + trace elements) will be provided on 3 occasions, the dates of which will be determined by the workmaster. In the second year, a contribution per plant of 50 g N- 25 g P- 35 g K plus the contribution of 20-20-20-20 foliar fertilizers + trace elements will be made.



About the protection of these plants, the contractor is required to monitor the phytosanitary condition of the plants and intervene to control diseases and pest attacks.

- Hoeing and weeding: Hoeing to break the surface crust of the soil in the plant bowl whenever the crust is formed to prevent shrinkage cracks from forming. Hoeing will also be done whenever weeds invade the entire bowl. Hoeing has a benefit, it will save water in the soil and eliminate weeds at the same time.
- Pruning: During the maintenance period of the plants, pruning will be limited to favouring the main stem chosen for planting, by improving any growth in competition with the main shoot.
- Filled: During this stage, any dead or dying plant, for any reason, will be replaced by the contractor.

### 3. RESULTS

#### 3.1 Case of the 760 ha Project to Convert Cereal Production into Olive Plantations

Following the actions and techniques used at the 760 ha project level for the conversion of cereals into olive groves, several objectives and results have been achieved in this direction.

**Area:** The area targeted by this project has seen an increase in the area planted with olive trees, all 760 ha is completely planted. This increase in the area planted contributes to the protection and conservation of the soil against erosion (Fig. 3).

**Production:** Before the project was carried out in 2013, agriculture in the chosen area was based on cereal crops, with a total production of 760 T.

After the implementation of this project, it can be seen that there is an increase in production which reaches 1,310 T in 2018 thanks to the presence of cross crops between olive trees and cereals (in this year the age of the olive tree is 5 years), and this value can reach 3,800 T in the coming years (i.e. after 8 years or more) (Fig. 4).

According to the results obtained and with the presence of a crushing unit in the area used by this project, the production process in 2018 reached a value of 216 T, and over time this can increase to 648 T.

As far as pomace production is concerned, it reaches 550 T in 2018, but in the future, this value may reach 3,040 T (Fig. 5).

**Performance:** Based on the results obtained, there is an increasing change in performance before and after the conversion project is completed. The latter is based on intercropping (olive and cereal crops). This yield has changed from one T/ha in 2013 - which was characterized by the presence of only cereal crops up to three T/ha in 2018 (intercropping) (Fig. 6).

**Employment:** In general, reconversion projects create several new jobs. In this respect, the implementation of the 760 ha project to convert cereal cultivation into olive groves in the province of Tetouan has provided the population in the targeted area with several new jobs, including 1,000 new jobs created in 2018. However, the latter did not exceed 120 positions in 2013.

This growing importance in terms of workstations is directly due to an increase in working days (WD); i.e. the creation of additional working days. 11,400 WD, however, thanks to this project, their number has increased to 22,800 WD in 2018, and may reach 46,100 WD in the future (Fig. 7) have quantified the number of working days in 2013.

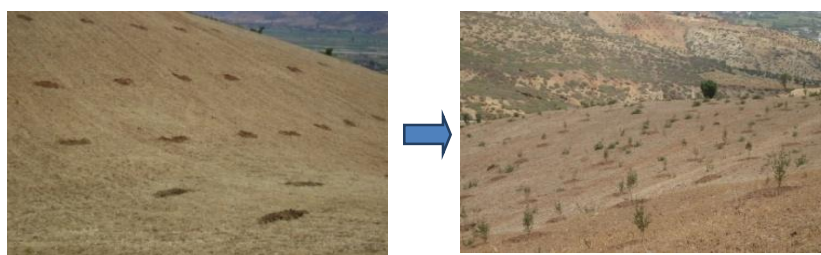


Fig. 3. The field before and after the project is completed



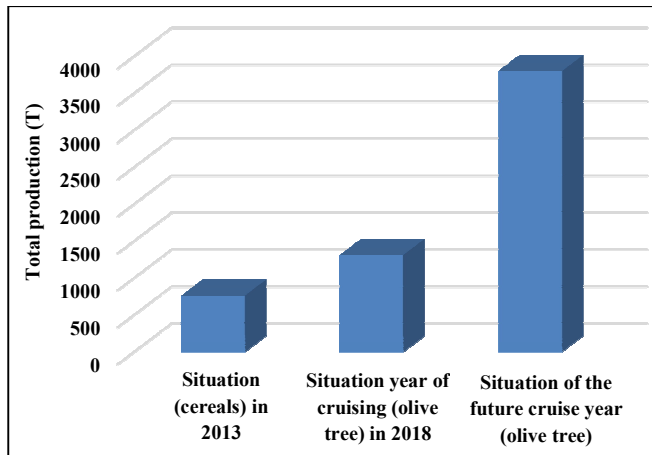


Fig. 4. Production rate at the project level

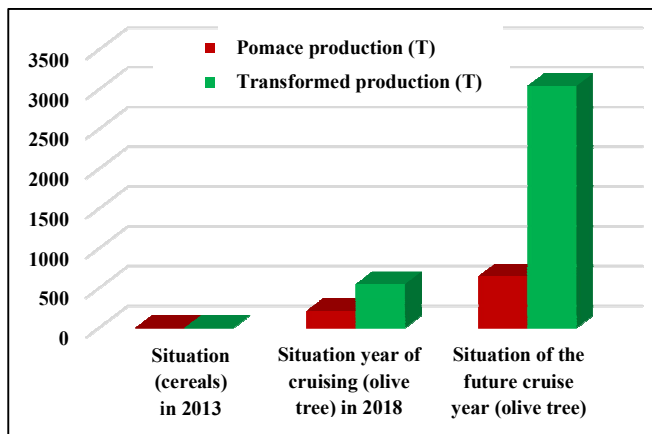


Fig. 5. Pomace production and processed production

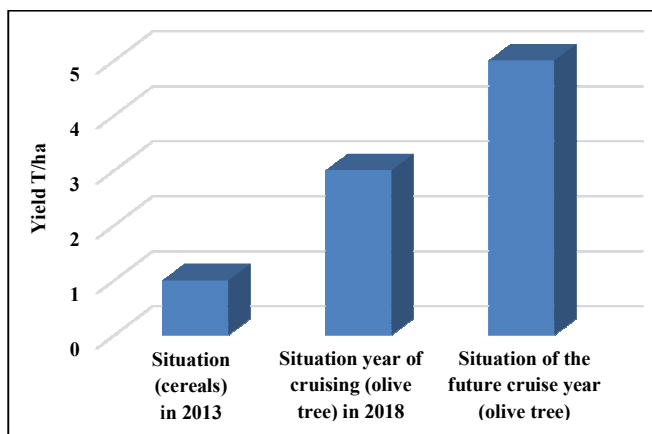
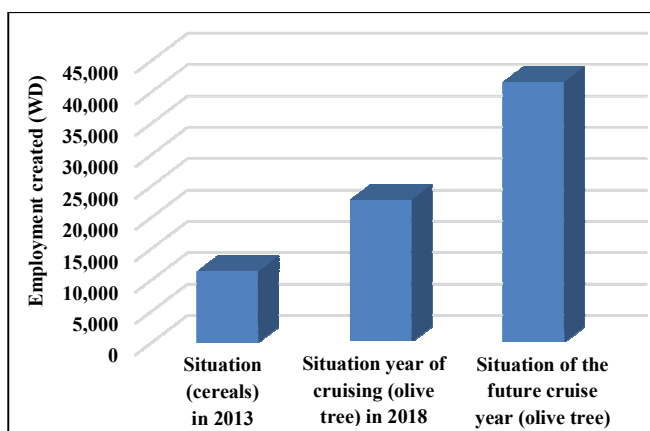


Fig. 6. Returns achieved at the project level

Income: About income, according to the results obtained, there is a gradual increase in the gross margin (total income) from 2,040 DH/ha in 2013 to 6,720 DH/ha in 2018, i.e. after the project is

completed. As well as an increase in value-added growth from 1,400 DH/ha to 5,500 DH/ha in 2018. The latter can reach 8,000 DH/ha over the next few years.



**Fig. 7. Employment rate during the project**

Similarly, the income obtained by each farmer has been gradually improved, from 29,870.28 DH in 2013 to 33,343.88 DH in 2018, and this improvement can always be changed over time.

Indeed, this increase in income makes it possible to improve the living conditions and quality of life of the local population and to reduce the phenomenon of the rural exodus (Fig. 8).

**Agricultural machinery and equipment:** To ensure the continuity of this project and the sustainability of planting activities, a range of agricultural machinery and equipment is distributed and provided to beneficiary professional organizations (farmers) at the level of the planted areas. The following table summarizes the data linking the 760 ha project (Table 1).

### 3.2 A Case of the Morocco Plan: Conversion Projects

The strategy of the Green Morocco Plan (GMP) and more precisely the pillar II conversion projects, allowed the conversion of agricultural land to high value-added cultivation, with the establishment of fruit trees (such as the olive tree

which is the subject of our study). The latter has a positive effect on the rural population and the soil; we are talking about the area planted and the rate of erosion.

**Area:** The province of Tetouan has seen a significant increase in the area planted with olive trees, from 13,000 ha in 2008 to 27,163 ha in 2017, and by 2020, this area will reach 30,113 ha. This increase in the area has a positive effect as it helps to reduce the erosion rate in the province of Tetouan (Fig. 9).

**Production and income:** The Tetouan Provincial Directorate of Agriculture provided us with the results regarding production and income obtained after the implementation of the GMP strategy in Tetouan province.

The latter has seen a significant increase in production, from 13,000 T in 2008 to 17,751.9 T in 2017. Thus an increase in income, which reached 31,850 KDH in 2008, and 52,985.53 KDH in 2017. Finally, a positive change in total value-added, from 6,531.85 KDH in 2008 to 16,350.79 KDh in 2017 (Fig. 10).

**Table 1. Project material**

Designation	Quantity related to the project
Olive harvesting vibrator with 12v/80 amp battery of the first choice	2
Atomizer with the 15-litre capacity backpack	4
Backpack sprayer	14
30 m <sup>2</sup> harvesting net	32
Size kit	27
First choice two-handed pruning shears	11
Aluminium harvest ladders 10 steps	8
Plastic boxes	350

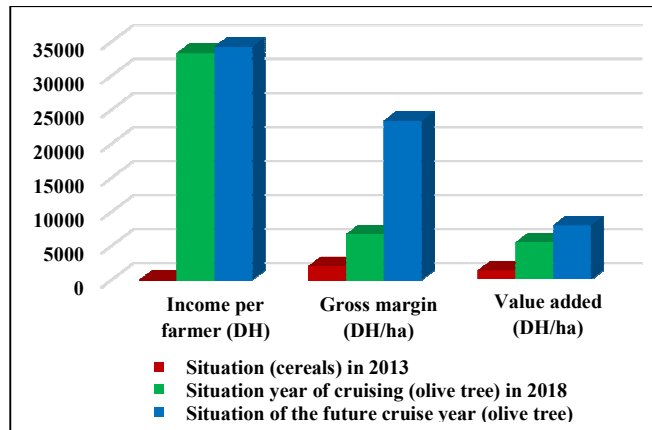


Fig. 8. Income obtained during the project

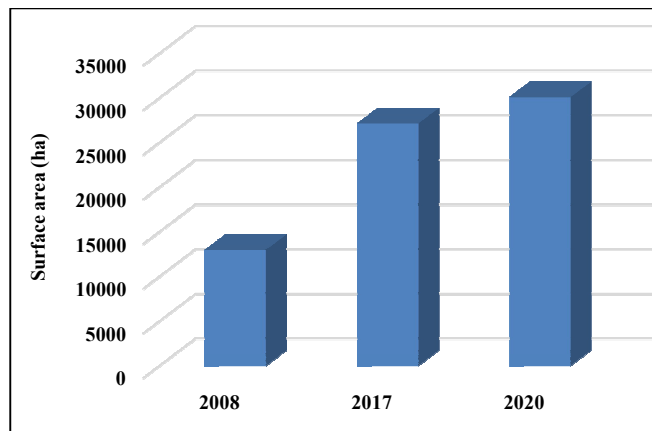


Fig. 9. Areas planted with olive trees

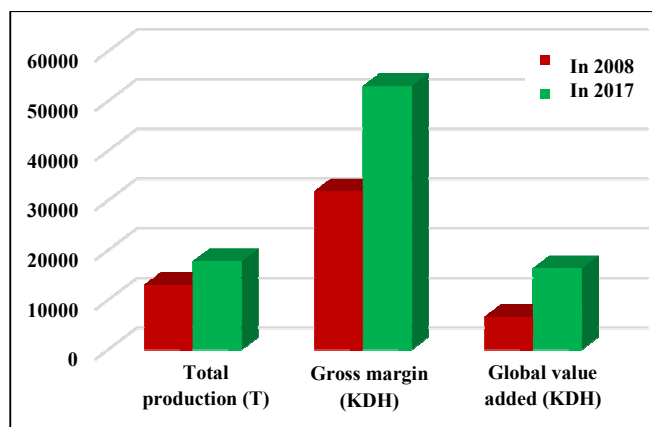


Fig. 10. Production and income rates during the GMP

Employment: One of the objectives of the Green Morocco Plan is to create new jobs to improve the living conditions of rural populations. In the province of Tetouan, the GMP's Pillar II

conversion projects until this year have created several new jobs. This increase reached 195,000 workstations in 2008 and 679,075 workstations in 2018 (Fig. 11).

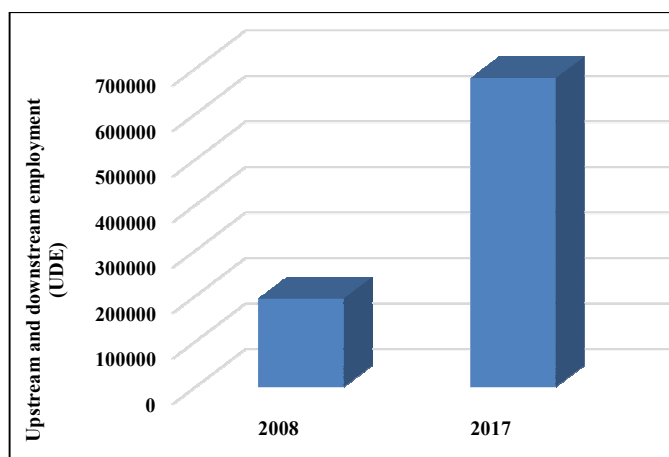


Fig. 11. Employment rates during GMP

## 4. DISCUSSION

### 4.1 Constraints on Reconversion Projects

When carrying out a project in any field, there are always several constraints that can block its continuation. Also, in our case, the case of projects to convert cereals from cultivation to olive cultivation in the province of Tetouan, there are three types of constraints: natural, human and technical.

- Natural constraints: The natural constraints encountered in this type of project are primarily the topography of the land, which is highly rugged (steep slopes), characterized by the presence of large landforms and medium altitudes.

Secondly, the presence of heavy erosion of sloping land, due to the existence of multiple causes, such as the presence of torrential and irregular rainfall (Tetouan province is characterized by an intensification of torrential rainfall in winter), water erosion from intense runoff on gentle slopes and the use of agricultural practices on slopes, etc. Indeed, the slope intervenes in the phenomena of erosion because of its shape, its inclination and its length.

Thirdly, our study area is heavily windy, i.e. characterized by a high frequency of Chergui wind of Mediterranean origin. Finally, the isolation of mountain areas so these areas are isolated, difficult to access and poorly connected

to neighbouring areas. This insulation is considered one of the major constraints that prevent this type of project.

- Human constraints: The first known human constraint in Tetouan province is the phenomenon of illiteracy, which remains a characteristic of the female and rural population according to the High Commission for Planning (HCP). According to the latest statistics compiled by the HCP in 2014, the illiteracy rate is 36.9%, especially among rural women who are actively involved in the work of the farm, compared to the male population, which is 18.2%.

Besides, the second constraint is the weakness of farmers' supervision, i.e. farmers use agricultural practices or techniques inherited from past generations.

Concerning the third constraint, the rural populations in the areas studied are characterized by a difficult mentality, which makes contact with them difficult. Then there is grazing, which is considered to be the fourth constraint known during the implementation of this type of project; after the planting of the olive tree in the targeted areas and even with the presence of a guardian, animal breeders do not control their livestock. Grazing land, which is subject to erosion due to the reduction of vegetation cover, is even more vulnerable. Soil loss is also synonymous with biodiversity loss.

The last human constraint is the significant presence of cannabis cultivation and trade activity. The province of Tetouan has a small area suitable for extensive agriculture, which increases the pressure on forest areas. Also, illicit crops, exclusively cannabis, are cutting down quality forests and agricultural land each year, based on their clearing.

- Technical constraints: According to the projects studied in our work, several technical constraints hinder the continuation of this type of reconversion project. Among these constraints, we can mention first, the great weakness in terms of mechanization, given that the agricultural sector in our country remains weakly mechanized. It is, therefore, necessary to encourage even more the acquisition of new equipment or even its local manufacture, as agricultural mechanisation plays an essential role in the success of projects to convert cereals into olive tree crops, and in the success of the Green Morocco Plan in general, because of its impact on improving production techniques and increasing productivity.

The second constraint is the excessive fragmentation of agricultural holdings, which constitutes a major constraint to the development of agriculture in the province of Tetouan, given that most agricultural holdings are less than five ha in size.

## 4.2 The Impacts of Reconversion Projects

After the implementation of the GMP strategy, and more specifically the Pillar II projects for the conversion of cereals into olive groves in the province of Tetouan, several actions were carried out to this end. These actions result from the emergence of positive and negative impacts on the rural population and the environment.

### 4.2.1 Positive impacts

The positive impacts obtained from projects to convert cereal crops into olive groves in the province of Tetouan are divided as follows: social, economic and environmental.

- Social impacts: The first social impact is manifested in the creation of new additional jobs within the province of

Tetouan and more specifically for the rural population. The creation of these new jobs leads directly to an increase in the number of working days per year and also to an improvement in the incomes of 560 beneficiary farmers, which improves the living conditions and quality of life of the local population and reduces the phenomenon of rural exodus to the city of Tetouan, as well as the reduction of inequalities and gaps between the mountain areas (project area) and the plains where crops are grown with greater added value. On the other hand, the project has contributed to the strengthening of social cohesion through the establishment of the spirit of common work at the level of professional organizations and to changing farmer's behaviour, attitudes and practices through support and capacity building actions, which will lead to the development of local expertise.

As for the second impact, it is manifested in the creation of several days for the sensitization of farmers and the provision of specific and free training on planting techniques, on the different ways used for protection against any type of degradation and erosion. These training have an indispensable role in strengthening the spirit of collective work and in developing the knowledge (technical and administrative) of the beneficiaries.

The provision of agricultural tools and equipment is considered as a third-social impact. At the end of this project, several tools and materials were distributed to farmers (beneficiaries) in all targeted areas to ensure the sustainability of the project. Finally, the opening up of roads is the last impact, which makes it possible to facilitate transport between the various areas with rough terrain in the province of Tetouan.

- Economic impacts: The project to convert cereal crops into olive groves in the province of Tetouan, like all other conversion projects, has had a major positive impact on yields and income from olive trees and olive oil extraction. According to the figures obtained in our results, the yields and incomes of farmers in the targeted areas have increased significantly, with yields reaching three T/ha and incomes reaching almost 5,500 DH/ha.

- Environmental impacts: The planting of agricultural land with olive trees has many environmental impacts, it helps to preserve biodiversity and soil, by promoting its fixation, and by stimulating microfauna and microflora, and then to protect crops and animals from climatic hazards (sun, wind, rain).

Soil conservation and fertilization: According to the implementation of the project to convert cereal cultivation into olive tree planting in the province of Tetouan, several positive changes have been observed in the soils of the targeted areas. Erosion control is one of the actions used in this project and has several positive effects. A single erosive event can, in a few hours, because of the loss of topsoil layers on the soil surface. For this purpose, olive trees are planted in cereal crops. These plantations promote the infiltration of water and air at depth and limit runoff. The second effect is manifested in the enrichment of the soil by organic matter, the latter increases soil fertility and plays an essential role in soil structure and water retention.

Water quality: Adult olive trees have deeper roots; can reach a depth of 6 to 7 m or even deeper [16]. These adaptations modify their hydrological role, including the capture of nutrients or pollutants by the deep roots of trees. This mechanism (strong rooting) is very effective when the tree root systems are located below the root zone of the crop. In this case, the root system has a positive effect on the environment, from which it can limit any nitrogen leakage into the system, making it an excellent tool for protecting catchment areas and reducing groundwater pollution.

Reduction of greenhouse gases: In our project, the planting of olive trees is an important lever to reduce greenhouse gas emissions, particularly through carbon storage. There are two ways to reduce the amount of CO<sub>2</sub> in the atmosphere, either by reducing greenhouse gas emissions or by storing them properly, i.e. by reducing carbon sources and increasing sinks that can be artificial or natural (storage in the soil and photosynthesis). Indeed, the photosynthesis process uses CO<sub>2</sub> and soil nutrients for the growth of trees and plants and produces oxygen. Besides, when trees decompose, carbon enters the soil again. Soil is the most important carbon sink in this case. Soil stores carbon as humus, which is formed by the action of microfauna, fungi and bacteria on plant residues.

Biodiversity: From the first year after the implementation of the planting project, a wide range of positive effects are observed in terms of biodiversity, this planting makes it possible to maintain new ecological networks in the province of Tetouan. As trees approach their adult size, they ensure a better distribution of populations of crop auxiliaries: pollinators, pest predators, and they are used in these periods as places to stay for certain species (such as birds, insects, etc.). These trees constitute refuge areas against certain predators or extreme climatic conditions, they also promote intra-specific trade and limit the risk of extinction of certain species by recreating areas of a habitat that allow certain species threatened by agricultural intensification to maintain themselves. In this sense, this type of planting project would reduce dependence on certain insecticides and pesticides.

#### 4.2.2 Negative impacts

The negative impact of the project to convert cereal cultivation into olive tree planting is reflected in the use of phytosanitary products (chemicals) during the plant maintenance period. These products have an adverse effect not only on the environment but also on human health (cause cancer, endocrine disruption, reproductive and neurological disorders, etc.). Phytosanitary products have direct ecological impacts, in particular in the destruction of living organisms targeted by the products (insects for insecticides, fungi for fungicides, etc.), and these products allow the reduction of species diversity. These products also have impacts on aquatic environments. Once applied locally, pesticides will be displaced by water runoff and can be infiltrated into the groundwater table.

## 5. CONCLUSION

The strategy of the Green Morocco Plan is based on two essential pillars, pillar I and pillar II. Pillar II contains several types of projects, and in this study, we focused on the conversion project.

In this context, a follow-up was carried out on the project to convert 760 ha of cereals from cultivation to olive tree cultivation in the province of Tetouan. Also, following the results obtained, we were able to discover the important role that olive trees play in soil conservation, which is reflected in the reduction of erosion. Besides, this project provides solutions to the main social and

environmental problems encountered in the study area.

However, these solutions have positive effects for the rural population, including; increasing biodiversity (growth of many species and habitats, etc.), improving soil quality from the growth of organic matter input and increasing soil carbon storage, etc.

Finally, this project also brings many economic and social benefits for producers and society in general through the creation of new jobs and increased income for the rural population.

The uses of plant protection products such as fungicides, pesticides, insecticides, have adverse effects on ecosystems and human health and causes disruption and imbalance in biodiversity.

The following recommendations are proposed:

- \* The use of agents for biological control: the use of predators (such as nematodes, arthropods, vertebrates and molluscs), parasitoids, pathogens (such as viruses, bacteria and fungi) and herbivores without the use of plant protection products.
- \* Indeed, most rural populations have a lack of knowledge and information about agricultural land use and the importance of intercropping. Moreover, for this, it is necessary: to inform the rural population about the reliable and correct use of their agricultural land and to schedule awareness days for farmers to discover the importance of intercropping.

Finally, the Green Morocco Plan strategy is considered almost complete, and these results are very satisfactory, so we would like to see similar new strategies applied.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Settouti B. French diplomacy and the Maghreb Mediterranean interests. PhD Thesis, Nancy II University, 2008;1-638. French.
2. Mhirit O, Blerot P. The great book of the Moroccan forest. Editions Mardaga, France, ISBN: 2870096860. 1999;280. French.
3. Laouina A. Sustainable agricultural development and the conservation of natural resources in Morocco. In: Traditional Techniques of GCES in the Mediterranean Environment, In Bulletin Réseau Erosion. 2002;21:11-20. French.
4. Roose E. Introduction to the conservative management of water, biomass and soil fertility (GCES). FAO Pedological Bulletin, No. 70. 1994;420. French.
5. Boughalem KM. Impact of management systems on soil vulnerability to erosion: Case of the Isser-Tlemcen watershed (Algeria). PhD Thesis, Abou Bekr Belkaid Tlemcen University. 2013;1-215. French.
6. Berriane M, Michon G, Skounti A, Moizo B, Romagny B, Tebbaa O. The rural heritage in Morocco: A new product of modern mobility? GéoDév.ma. 2015;3:1-14. French.
7. General Census of Population and Housing (GCPH); 2014. French.
8. Provincial Direction of Agriculture of Tetouan (PDA); 2016. French.
9. Agricultural Advisory Centre of Mallalienne (AAC); 2014. French.
10. Lanoue J. Establishment of waste management infrastructure in the province of Tetouan (Morocco). Which sites to best combine environmental, socio-economic and technical aspects? Graduation Project, Environmental Engineering, Water, Waste and Sustainable Development, AgroParisTech Institute. 2009;1-70. French.
11. Regional Direction of Tangier-Tetouan-Al-Hoceima (RDTTA); 2015. French.
12. Demdam H, Taiqui L, Seva E. Towards a spatial database of sacred sites in the Province of Tetouan (North of Morocco) - Contribution of official cartography. *Mediterranea*. 2008;19(2):9-68. French.
13. Directorate General of Local Authorities (DGLA), Report on the region of Tangier-Tetouan-Al-Hoceima, General Monography; 2015. French.
14. Rachidi F, Allali K. Agricultural yields. In Oued Nakhla Watershed. 1996;8-20:1-200. French.
15. Tayaa M. Physical and hydrological characteristics of the Nakhla watershed



- and determination of the rate of erosion. Project Durability of Water Resources of Morocco (DWRM) and Ministry of the Environment, Rabat. 1997;74. French.
16. Yankovitch L, Berthelot P. Report on the rooting of the olive and other fruit trees in Tunisia. Ann. Serv. Bot. Agron. Tunisia (SBAT). 1947;20:109-176. French.

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