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Research Article

Assessment of Water and Soil Conservation Schemes in the Arid Zone of Taadmit (Djelfa, Algeria)

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Abstract | Serious environmental issues, such as soil erosion, diminishing water quality and quantity, and biodiversity loss, are present in the Djelfa region of Algeria. The aim of this research was to determine and evaluate the present state of different methods and approaches for conserving soil and water in the arid region of Taadmit (Djelfa, Algeria). The approach was founded on field observations and surveys with farmers and government organizations to ascertain the size, composition, and efficacy of water and soil conservation (WSC) structures as well as to elucidate their connections to the agro-ecological and climatic conditions of the study area. The assessment of the status of these developments showed that the study region offers a wide variety of WSC strategies and demonstrates a form of human adaptation to severe physical constraints. The results obtained show that the traditional cultivation techniques used, such as windbreaks, ridging and hilling, manure have had a significant positive effect on the preservation of water and soil on cultivated land. In addition, the anti-erosion techniques (torrential correction, hill retention, reforestation, pastoral planting, rustic fruit planting, seguia, Sed, biological fixation of dunes, protection, stone bunds) show that they are largely effective and have a positive impact on the conservation of water and soil. The WSC developments carried out have a positive impact that can be Cultural practices (such as stone removal, fallow, fertilization and rotation), mechanical (banks, terraces, benches, dry stone bunds, etc.) or biological treatments (choice of crops, reasoned fertilization, vegetation) which constitute a very effective means of anti-erosion. Analysis of field results showed that the actions undertaken aimed at water and soil conservation and management (WSCM) were numerous and diverse. Analyzing the main factors in time and space will help understand degradation phenomena and propose appropriate biological control strategies and techniques for sustainable natural resource management. In order to guarantee this beneficial effect on land productivity and lower the risks of degradation, these two forms of development must always be combined. Public authorities and farmers have undertaken efforts to restore and protect soils through land-use planning and the adoption and improvement of soil and water conservation measures on agricultural lands to improve ecosystem functioning in drylands. This study aims to assess WSC, in terms of farming practices and research activities, by analyzing the stability, rehabilitation, and effectiveness of existing anti-erosion developments, and exploring how WSC technologies and practices offer a way to restore soils to good condition and improve sustainable agriculture in this study area, in the face of low rainfall on fragile lands.

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Introduction

Drylands are characterized by water scarcity and seasonal climate extremes and unpredictable rainfall patterns (Davies *et al.*, 2017). Water scarcity is increasing, and in many regions desertification is spreading, leading to serious human and environmental consequences (UN, 2016).

They are threatened worldwide. Despite their importance, drylands are degraded by a complex combination of climatic (decreased rainfall and water evaporation) and human-induced (unsustainable agricultural techniques, mining and overgrazing) stresses (UN, 2016). Climatic factors that can affect soil degradation, particularly rainfall variation, also poor agricultural practices such as continuous cultivation with little or no amendment, low organic matter content due to the removal of crop residues, overgrazing, successive tillage and cultivation on marginal lands have been identified as major elements of agricultural soil degradation (Nezomba *et al.*, 2017; Jones *et al.*, 2015), causing a decrease in biodiversity, a decrease in organic matter content, fatigue and exhaustion, which endangers the long-term survival of agricultural production and soil (Nezomba *et al.*, 2017; Jones *et al.*, 2015).

Agricultural land degradation is a complex phenomenon that combines the reduction of the quantity of nutrients and organic matter in soils, their physical, but also biological degradation (Dugué *et al.*, 2024). In semi-arid areas, after erosion, most soils are crusted on the surface and give rise to surface runoff of organic matter and nutrients from the surface horizons (Roose, 1989; Melalih, 2012).

Algeria's arid and semi-arid regions frequently deal with severe environmental issues like degraded soil, inadequate management of water resources, inadequate conservation of soil, and inadequate management of vegetation cover. Livelihoods are diminished and crop and livestock productivity is restricted by these issues. Erosion, water resource depletion, and biodiversity loss are some of the factors that contribute to this state of affairs; these are all connected to the accelerated process of soil degradation. The loss and degradation of soil is extremely advanced, and because of the climate and strong human activity that reduces vegetation cover, large amounts of soil are lost and washed away annually by wind and water erosion (Morsli *et al.*, 2012, 2013; Hassani, 2019; Boucherit *et al.*, 2021).

Water erosion is one of the main factors of land degradation and environmental problems. It has socio-economic repercussions at the local, regional and national levels. These phenomena are aggravated by production systems, methods and soil working tools (Zaghouane *et al.*, 2006; Hassani, 2019).

Environmental degradation and changes can be mitigated by adopting appropriate agricultural practices that can sustainably restore the productivity of degraded soils and ensure food security for rural populations (Hien *et al.*, 2012).

Water and soil management and conservation (WSMC) aims at agricultural development through good use of water and soil to develop the fertility and production potential of the land and to reduce erosion problems and solid transport downstream. This strategy relies on the farmer, as the main operator in the agricultural development of his land and the protector of the environment, integrated into an overall plan for land use and development (Roose, 1994; Arabi, 2021).

The aim of this project is to determine, gather, and assess the present condition of soil and water conservation methods and agricultural practices in the Taadmit region (Djelfa, Algeria). In this study, the primary methods for conserving water and soil in arid environments are examined, and the effects of these anti-erosion strategies on WSC and agricultural productivity enhancement in the Taadmit region are assessed.

Materials and Methods

Study area

The Taadmit area covers an area of 788.56 Km^2; it is located in the southwest part of the wilaya of Djelfa (Algeria). It is 70 km away from the capital of Djelfa. It is limited between 34°3'N, 34°38'N and 2°45'E, 3°15'E (Figure 1).

In this study area, this is part of the high steppe plateau of Algeria, its reliefs range from 728m to 1595m, with peaks exceeding 1300 m, such as Djebel Toughersane at 1315 m.

The commune of Taadmit has 22,525 residents as of 2023, representing a 45 percent increase from 2008 (10,359 residents) to 2023. Because of the increased demand for food and agricultural land brought on by population growth, covered land has been deforested in order to exploit it (DBPM-Djelfa, 2024).

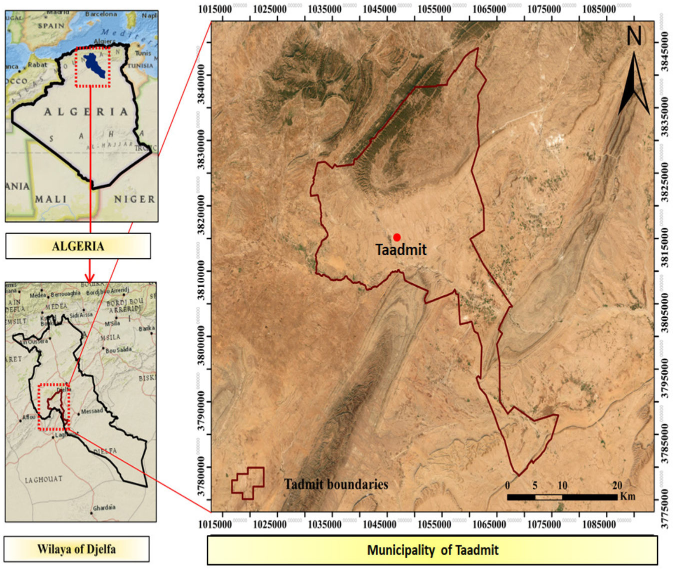

Figure 1: *Geographic location of the Taadmit area (Djelfa, Algeria).*

The climate in the Taadmit region is characterized by an average annual temperature of 19.92°C. The average annual precipitation recorded in the Taadmit area over the last 30 years is 115.51 mm. The Taadmit region belongs to the arid bioclimatic zone (Boussaïd *et al*., 2012; ANRH-Djelfa, 2023; Power Nasa Data Access Viewer, 2022). Torrential rains exceeding 200mm/year in some years can damage the WSC infrastructures and developments. However, the damage recorded on these developments is often repaired by the owner or through *touiza* (a social organization for collective work), a very common method in Algeria where maintenance is carried out collectively by the beneficiaries of these developments.

The majority of the study area is covered by calcareous-magnesian soils (brown calcareous soils, rendzinas, brown soils with calcareous accumulations, gypsum-encrusted calcareous soils, isohumic soils, poorly developed soils, and raw mineral soils (lithosols, regosols)) (Halitim, 1988; Bourahla, 2017; Benaradj, 2017; Boucherit, 2018). The most commonly encountered soil types in the *Pinus halepensis* forests of the Saharan Atlas are generally brown calcareous soils (Kadik, 1983). Overall, the soils are skeletal and poor in organic matter, often less than 1%. These soils are severely affected by water erosion and wind erosion. According to our surveys and observations, we found that in Taadmit, the areas affected by water erosion and wind erosion represents approximately 40% and 30%, respectively.

Methodological approach

The Taadmit area is rich in traditional water and soil conservation (WSC) techniques and developments.

The methodology adopted consisted of first conducting an inventory of water and soil conservation, a physical and institutional assessment of this inventory, and an evaluation of the actions implemented within the strategies.

The field surveys and explorations, using the questionnaire developed near to 30 farmers, allowed us to collect all the relevant and necessary information to conduct a diagnosis of the selected survey sites and to carefully analyze the traditional WSC developments inventoried in the Taadmit region.

The inventory consists of open-ended and closed-ended questions to obtain as much information and data as possible on water and soil conservation techniques, and methods for improving the fertility of their agricultural soils.

A questionnaire was developed, consisting of a series of questions designed to gather more information about the sites and farms studied, the different crops grown, the various existing soil conservation techniques, constraints, etc.

This questionnaire was pre-tested to ensure that the questions were understandable and could yield the sought-after information. A survey using questionnaires (face-to-face interviews supplemented by photos) was conducted with 30 farmers in the study area to collect quantitative data and the desired information. The sampling was carefully considered to provide a representative sample of the region.

Furthermore, this study emphasizes the participation of various stakeholders in WSC; thus, the implementation of these techniques in the field, rehabilitated either by farmers or by the relevant government services. Additionally, a survey was carried out with relevant institutions such as the Directorate of Agricultural Services (DSA), Forest Conservation (CF), the High Commission for the Development of the Steppe (HCDS) and the National Institute of Forest Research (NIFR) to gather as much information as possible. An agronomic and environmental assessment at different scales was conducted at the plot, farm, and territory levels.

The identification (surveys and field surveys), inventory, and classification of these water and soil conservation techniques (traditional and modern techniques) are based on field work and the examination of pre-established questionnaires, and the location and spatial distribution of certain water and soil conservation techniques (hydraulic works, pastoral development, mechanical and biological developments).

The method used is part of a descriptive and explanatory approach. It is based on the exploration and field observation of water and soil conservation techniques and/or practices encountered in the study area.

The analysis of various factors, including the techniques' adaptability to the natural environment, farmer adoption, efficiency, sustainability, reproducibility, etc., forms the basis for the evaluation and classification of WSC techniques (Alkarkouri *et al.*, 2002; Boucherit, 2009; Boucherit *et al.*, 2012, 2021; Morsli *et al.*, 2013).

Results and Discussion

Analysis of agricultural data in the region of Taadmit

While in the Taadmit area, which is an agro-pastoral area, it was noted that the dominant crops are fodder crops with 41%, cereal crops with more than 23%.

Vegetable production

Indeed, the total agricultural areas (TAA) are 48 975 ha or 62.10% of the total area of Taadmit, whose agricultural areas usable (AAU) is 17 480 ha, 13.44% is irrigated (Table 1). Unlike this type of earth, pastures and routes represent almost the entire total surface. It is 3 1495ha, where 64.31% of the agricultural areas usable (DBPM -Djelfa, 2024).

Plant production includes cereal farming over an area of 1354 ha, market garden cultures on 472 ha and arboriculture on 144 ha (Table 2).

Table 1: *General land distribution in the commune of Taadmit.*

Categories	Area (ha)
Total agricultural areas (TAA)	48 975
agricultural areas usable (AAU)	17 480
Utilized irrigated agricultural area (UIAA)	2 469
Steppe rangelands	31 495

Table 2: *Taadmit plant production (DBPM-Djelfa, 2024).*

Crop	Area (ha)	Production (Qx)
Cereals	1 578	43 180
Forage Crops	326	15 300
Market Gardening	381	76 420
Fruit Trees	184	11 120

Production animale

The socioeconomic activity that occurs in the study area in question is closely linked to the Agropastoral System, where a significant number of sedentary and nomadic people live and the majority work in agriculture and sheep and goat farming. Indeed, the courses which dominate the distribution with 65763.57ha, representing 71.15% of total area of the Taadmit region.

Table 3: *Production animale de Taadmit (DAS-Djelfa, 2022; DBPM -Djelfa, 2024).*

Type of livestock	Number of heads
Sheep	109300
Goats	13300
Cattle	710
Camel	40

Taadmit's economy is mainly based on farms, particularly sheep, with 109,300 heads, followed by goats with 13,300 heads and that of cattle with 710 heads. Camelin farming represents a number of 40 heads, while the number of hives existing in the study area is 30 hives (Table 3).

This can be remedied by avoiding overgrazing and respecting the appropriate number of animals on plots, especially those with fragile soil and low vegetation cover. Pressure on vegetation cover can also be reduced through certain rehabilitation and rangeland productivity improvement measures, such as the establishment of protected areas (Grazing exclusion area) and the diversion of wadi waters onto rangelands to improve the water balance and, consequently, land productivity. These improvements have shown good results in enhancing plant productivity and thus represent alternatives to alleviate pressure, particularly on degraded rangelands (Benaradj *et al*., 2017; Boucherit *et al*., 2017; Khalid *et al*., 2015; Anteur *et al*., 2022; Benamara *et al*., 2023).

Applied development measures

Surveys and observations made on the ground and the counting of questionnaires have enabled us to identify a heritage very rich in water and soil conservation techniques (WSC). The inventory consists in exposing all the traditional techniques and arrangements WSC identified in Taadmit region during Investigations. On the ground, it appeared that the Taadmit region had a diversity of actions aimed at preserving water and soils. The techniques can be readily categorized at the study area level based on the new techniques put in place by the State and the conventional techniques that farmers adopted at the plot level. Each group of methods has a well-established classification based on how they are extended.

The analysis of field results has shown that the actions undertaken aimed at managing and conservation of water and soil (WSC) were numerous and diverse. Two techniques of conservation of water and soils in progress have been observed, namely: traditional techniques and modern techniques.

The choice of the most suitable methods for conserving water and soil, considering natural data and socio-economic factors, is essential. Techniques for managing water like seguias have shown to be beneficial in combating runoff and erosion, ensuring effective soil management while dissipating runoff energy.

The principle of the Seguias (open-air and sometimes underground conduits) is to divert runoff water and irrigation water and transport them by gravity from the water intake point to the crop fields to be irrigated, which are located at a lower point downstream. The Seguias absorb the strong energy of water erosion by channeling rainwater, which can then be used to irrigate agricultural plots. This reduces the adverse effects of water erosion. By channeling rainwater runoff, these Seguias prevent the concentration of runoff water that can cause damage, especially on sloping areas.

The Taadmit region is a mountainous area with a mosaic of reliefs, sparse vegetation cover, and fragile soil texture. A trend toward wind, sheet, and claw erosion has been noted.

This technique allows the wadi's water to be oriented, captured in the soil, and, most importantly, used to trap the fine soil particles and organic matter that are mobilized upstream of the slopes by water erosion. Additionally, farmers employ other cultural practices that are significantly significant in terms of plots but are less well-known and uncommon. The most striking are the use of manure, rustic fruit arboriculture (Olive, Fig tree and Pomegranate tree), wind breezes created by willows, and curfs in bowls.

These latest techniques are highly effective in semi-arid regions, such as Benhar which is located in the north of Djelfa, where farmers use them extensively on their plots.

Addressing the grave, frequent erosion and flood events happening in the researched region, government bodies have started multiple initiatives to alleviate these issues in the Taadmit area, utilizing more costly methods compared to those employed by agriculturalists. Regarding slopes, the strategies implemented are primarily those of governmental departments (HCDS, forest Conservation), including seguias and derivation channels, all of which are constructed with concrete and commonly used within the area.

Employing this method enables a reduction in runoff velocity, which enhances water retention in the earth, and furthermore, it helps to ensnare minute soil particles dislodged from the slopes upstream by water erosion.

After our surveys in the Taadmit area, we noticed that mechanical developments are in the order of 12.12%, while biological developments and agricultural practices, each one with a percentage of 43.94%.

Biological measures

The study region's forest inheritance covers more than 17,222 hectares and is primarily made up of scrubland that occupies the mountains, insulating reliefs, and artificial stands that take the shape of bands, belts, and afforestation (Table 4).

Table 4: *Biological development in the Taadmit area (*HCDS, 2023*;* FC- Djelfa, 2023*).*

Place	Biological techniques	Area (Ha)	Observation
Menkeb	Protection of pasture	370 ha	HCDS
Menkeb Benhamed		457 ha	HCDS
Fekrine		100 ha	HCDS
Elsemima		70 ha	HCDS
Hiouhi		19000 ha	HCDS
Hiouhi		3219 ha	HCDS
Benhamed		11769+ 4050ha	HCDS
Houdh Naoum	Windbreak	20Km	FC
Toughersane		4Km	FC
N'thila	Dune stabilization	25ha	FC
Toughersane- Djellal	Hardy fruit plantation (olive tree)	71ha	FC
Magtaa el wast		10ha	FC
Aouf		10ha	FC
Houdh		10ha	FC
Foures		10ha	FC
Hiouhi		10ha	FC
Toughersane	Reforestation	240Ha	FC
Djellal gharbi		70Ha	FC
Forestry group 1, 2 and 4		107Ha	FC

Biological fittings with a large volume divided between reforestation, fruit plantation, exclosure.

Exclosure technique

This method entails creating steppe routes by allowing them to rest for a predetermined amount of time (three to five years) so that the natural plant cover can regenerate. The routes' fodder effort then rises as a result (Figure 2 and 3).

One pastoral improvement strategy that has been tested to counteract these ecological wrongdoings is defense, which seeks to reactivate the biological rise. Through this full protection, it is a question of promoting the regeneration, restoration and development of spontaneous vegetation to ensure soil protection (Benaradj, 2009; Benaradj *et al*., 2012).

Among the pastoral remedies offered for the rehabilitation of these degraded routes, the technique of pastoral improvement "defenses" has recorded ecological advantages. This technique promotes natural regeneration, the most suitable for inducing the natural biological rise of steppe species. Defense has a positive impact in terms of organic rise. Defense allows a quantitative and qualitative increase in floristic wealth, the development of pastoral species, in particular therophytes. This results in a significant phytomasse, and a recovery of relatively high vegetation. The floristic composition is very diverse. It has favored the resettlement and reappearance of endangered species (Benaradj, 2009; Benaradj and al., 2010, 2013a, b, 2017; Khalid and al., 2015; Amghar *et al*., 2016; Boucherit *et al*., 2017; Anteur *et al*., 2022; Benamara *et al*., 2023).

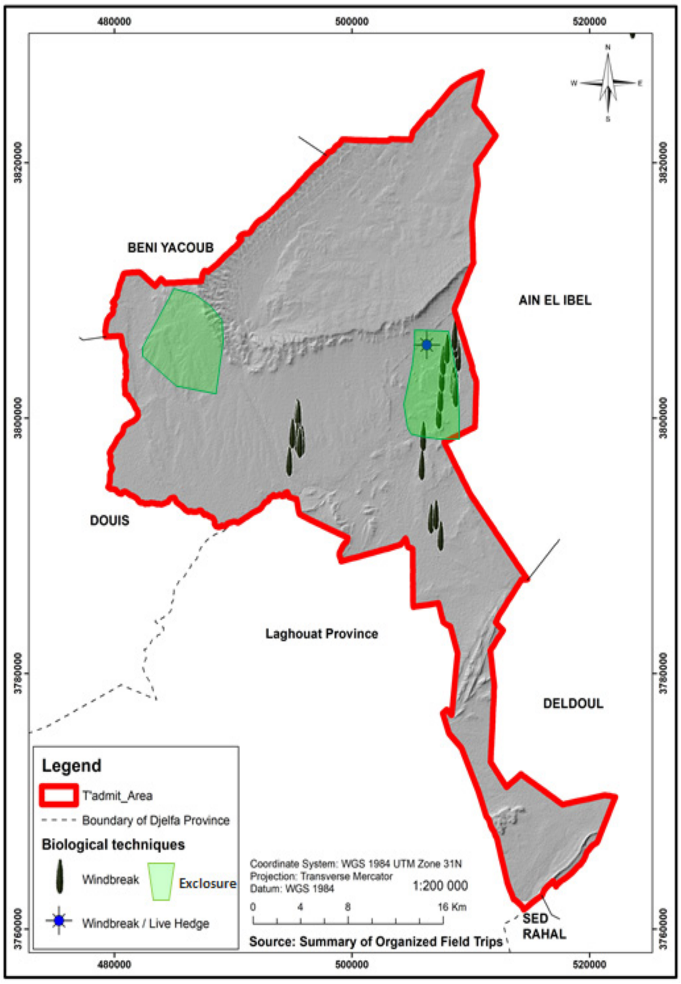

Figure 2: *Biological techniques of water and soils in the area of Taadmit.*

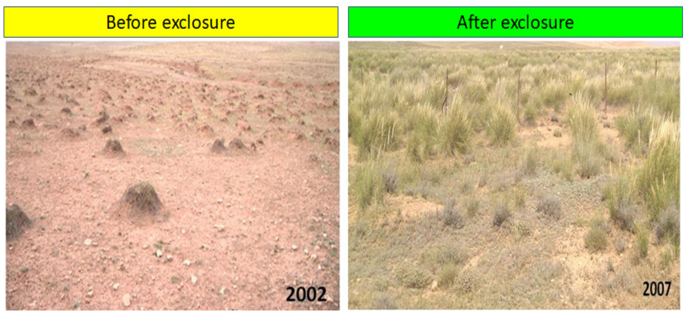

Figure 3: *Effect of the exclosure technique on vegetation cover in degraded steppe rangelands with Stipa tenacissima in the Taadmit region.*

Defense areas actually play an important ecological role. They make it possible to protect fragile ecosystems, to promote the regeneration of vegetation and to limit the effects of erosion, thus contributing to the conservation of biodiversity and contribute to the fight against desertification (Benaradj *et al*., 2017; Boucherit and Benaradj, 2024).

Pastoral plantation

The selection of plants and crops to be used in the framework of WSC on agricultural land is determined by the agro-ecological conditions of a given area (Nicol *et al*., 2015).

Utilized as a pastoral plantation, *Atriplex carescens* is an important species for conservation and soil quality improvement. It is a fodder shrub that can be used in a variety of arid climates and soil types, which allows it to be utilized in a variety of agro-ecological settings (HCDS, 2023).

Winds and live hedge (living fence)

Planting trees are usually in a direction perpendicular to the wind. The reed plant and casuarina are two of the most commonly used species (Figure 4). According to El-Yadari *et al.* (2019), live hedges, the use of perennial species to delimit fields (fence) or to protect them from livestock.

Figure 4: *Windbreaks made in the Taadmit region.*

Cultural practices

The territory is converted rationally by using appropriate agricultural methods (diversification of production, use of appropriate irrigation techniques, avoid extensive cereal farming, respect for soil capacity to support cattle herds) and by installing sustainable crops such as fruit plantation such as the olive tree, the pomegranate tree and the fig tree (Figure 5).

This allows the soil fixing and improves the ecosystem. Fruits such as vineyards, plum, nectarine, apple tree, fig and grenadier, the apricot tree have a relative success rate.

According to Habit *et al.* (2020), this dynamic of agricultural development, based essentially on the mobilization of natural resources (water and soil), has contributed, in certain areas, significantly in the improvement of income and job creation, which has generated flow of agricultural products. The data gathered from the interviewed individuals indicates that the manner of utilizing their land is distinctly geared towards a plant-based production for survival. This involves engaging in diverse farming methods to fulfill their family's immediate requirements and to deal with climatic challenges and risks (Boucherit *et al*., 2012).

When combined, these methods greatly increase the effectiveness of WSC structures. According to the findings of Morsli *et al.* (2008), it has been shown that these simple cultural practices are very effective at controlling erosion and conserving water.

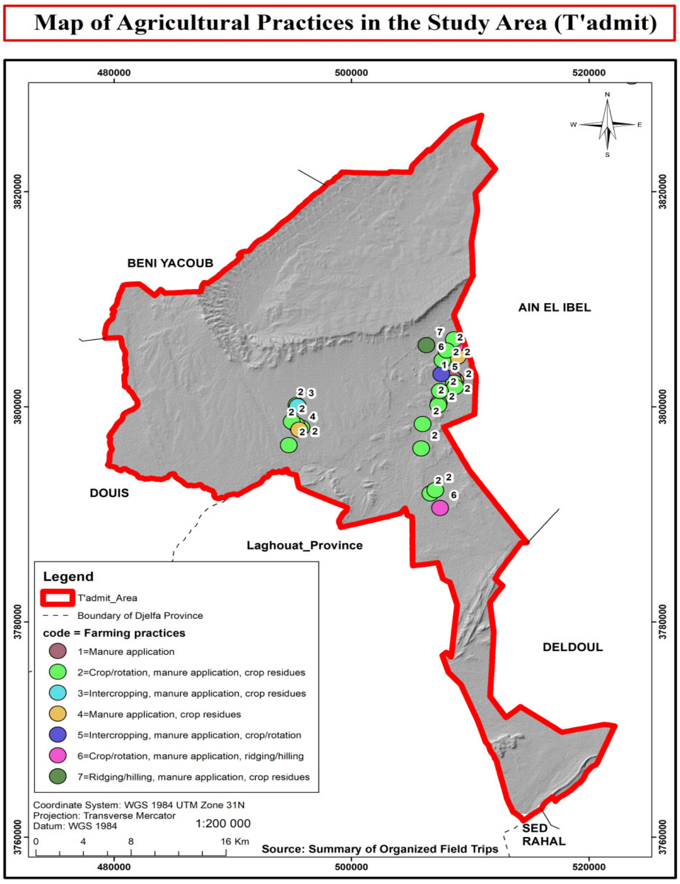

Figure 5: *Cultural practices in the Taadmit region.*

Trees also have other functions: Creation of hedges and wind breeze, constitution of coppice, etc. Interventions include the diversification of crops, the rotation of crops, conservation agriculture, agroforestry, water collection and small irrigation systems, the case of seguia. Enhancing the suitability of proper species and varieties utilized with climate conditions. Mixtures of species can allow better resistance of cultures to drought episodes.

Hydraulic measurements

Among the other traditional techniques of conservation of water and soils observed, there are techniques in the form of a land work such as the cords (in stones, vegetable or mixed), water derivations (Seguias, seds and diguettes of spreading of flooding).

Table 5: *Pastoral hydraulic works carried out in the Taadmit region (Souissi, 2015; HCDS, 2023).*

Hydraulic structures	Forage	Source	Sed	Seguia
Number	3	1	1	7,865m

These actions will additionally enable the installation of native flora (oleander, tamarix, etc.) on areas at risk from erosion, to construct in watercourses, to organize the banks with irrigation channels. In our study region, (14,917 m^3) of the work was undertaken during the timeframe (2004 to 2024) (HCDS, 2023; CF-Djelfa, 2023).

These volumes are separated into 2 kinds of labor, namely: the derivation Seds that have been made of concrete, and the seguias. The utilization of irrigation based on hill reservoirs aided the evolution of agriculture and the augmentation of cultures. In the field, the gravity irrigation method is installed in two forms: Square basins and rectangular basins (more utilized in the north of the study area) (Table 5).

These systems have proven effective in conserving and managing water, but when used in conjunction with other, more expensive, modern irrigation systems, they require particular up keep. Whereas in the south, where agricultural activities are near wadi, farmers utilize wadi water by seguias to irrigate their plots whose breadth and length are clearly defined according to the surface and the slope of the terrain.

The dam of the Taadmit wadi, which was built by the HCDS in 2005 at a cost of 5,000,000 DA. The dam is a weir built on a wadi or tributary, which ensures the collection or diversion of surface water via a traditional canal (seguia) that transports the water to the fields.

Mechanical measurements

The state incorporates a variety of mechanical projects, including concrete spills, to accomplish flood protection and torrential correction work in the wadis, stabilize the banks and the ravine bottom to prevent the river bed from widening, control flow, and store sediments. In addition, the state has undertaken several conservation interventions for the fight against erosion (slopes, low walls, cords the terraces, bench terraces, small dikes, dikes, earth cords, stony cords, dry stones, hedges, lively hedges, benches and correction of ravines) (Figures 6 and 7).

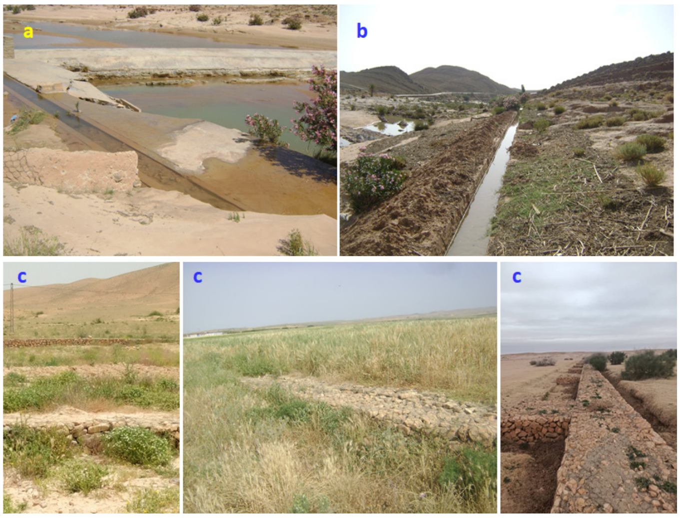

Figure 6: *Mechanical measurements carried in the Taadmit region (a- Sed; b- Seguia; c- gabionage).*

In the Taadmit area, mechanical arrangements are divided into several types of works (stony cords, gabion thresholds and dry stone walls) were made following a request filed by the farmer from forest services to protect these agricultural land against the risks of flood. These practices are used to curb runoff, stop the progress of the ravines and considerably reduce runoff.

Stony cord (Rows of stones)

Hien (1995) claims that stony cords are filter barriers that reduce runoff velocity; they also enable the sedimentation of particles (sands, fine earth, and organic matter) upstream of the the bund (small dike), increasing the amount of watering water that infiltrates.

The techniques of the stony cords have a high priority by the fact that they have a great capacity to combat erosion and are more durable. These results have shown that stony cords are systems resistant to the erosive effects of water and wind compared to any other techniques (Bationo *et al*., 2012).

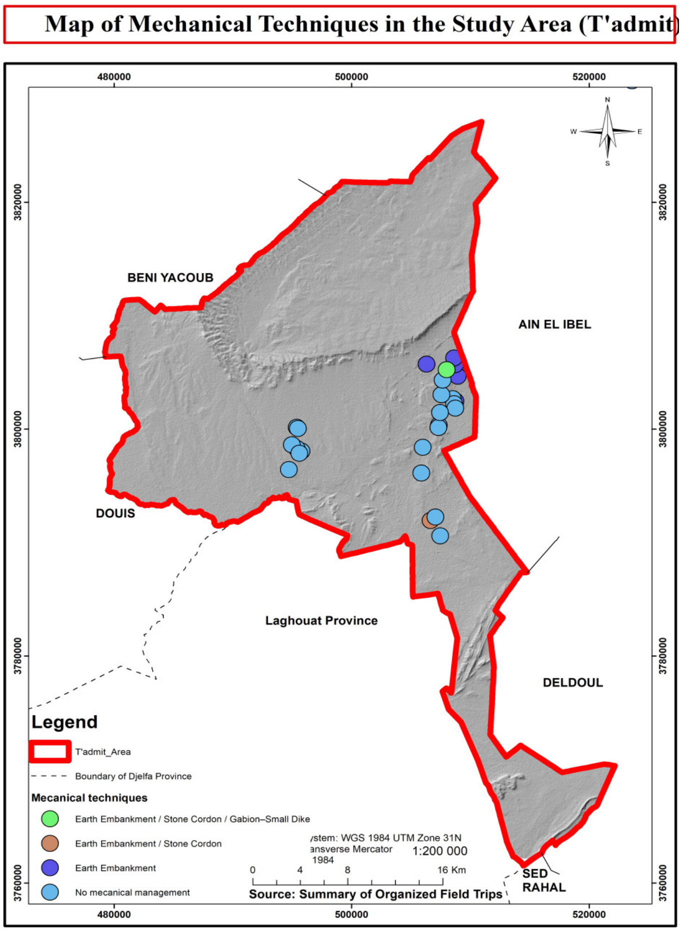

Figure 7: *Mechanical Technical distribution of water and soils in the Taadmit region.*

Infiltration bowl or planting pit

This technique is based on creating tiny holes with a hoe (depth 5–15 cm, diameter 10–30 cm, and spacing of 50–100 cm) where the plants will be placed. Downstream of the pits, use the remaining soil to form a small dike and enrich it with compost, fertilizer, or grass straw (Kanté, 2001; Bayen *et al.*, 2012). Indeed, the fittings of the slopes (terraces and individual basins) still plays their roles for which have been built (improvement of infiltration, soil capture and runoff) and have proven their high efficiency in the face of different forms of erosion.

Embankment (lifting of earth)

The crests are parallel to the contours lines: These are small embankments in the ground (15-20cm high), between which is a groove which collects the runoff of a strip cultivated between the Billons (Anschűtz *et al.*, 2003; Nafi, 2020). Among the examples of production surface development, terraces with stone walls or with a simple embankment are a widely used phenomenon in Tellian Mountains, as well as individual infiltration cups (Mazour *et al.*, 2008).

Assessment of traditional anti -erosive techniques

WSC and the productivity of the developed land were both positively impacted by the analysis of these traditional developments in the various study areas.

Analysis of traditional developments has revealed that windbreaks, seguias, and manure are meant to improve soil quality while protecting developed plots from runoff energy. Manure is used for stability, fertility, and soil productivity. These are techniques judiciously used in the study area and of variable size.

The soil's type and depth determine the dimensions. When combined with a variety of biological measures, cultural practices, or structures (such as an earth embankment in conjunction with manure), their stability is linked to good water infiltration or drainage.

Based on our polls, the behavioral findings illustrate water and soil protection initiatives regarding efficiency, endurance, viability, output, and their performance with respect to runoff and erosion (Table 6).

Table 6: *Analysis of techniques implemented in the Taadmit region (farmer's perception scores, 2023).*

Techniques	Effectiveness	Stability	Sustainability	Productivity
Works and structures				
Stone barrier	+	+	+	+
Windbreak	++	++	++	++
Seguia	+	++	++	++
Earth embankment (bank)	++	+	+	+
Cultivation techniques				
Manuring	++	++	++	++
Intercropping	+	++	+	++
Rotation and crop rotation	++	++	++	++

+, medium; ++, high

Controlling runoff and the positive impacts of erosion control measures on it will improve agriculture through water conservation, stabilize the population, mobilize runoff, and preserve its quality. Pastoral planting and protected areas are biological developments that have proven effective in regenerating rangelands.

Due to our efforts and to transmit land degradation management practices, the following suggestions should be heeded:

- Create an economic strategy with the goal of logically utilizing natural resources to enhance rural residents' quality of life through government-backed initiatives;
- Create a system to support livestock feed (concentrate or dry barley) to preserve pasturevegetation within protected areas;
- Use water resources sensibly and build pastoral hydraulics (storage infrastructures like diversion and storage seds, hill reservoirs, dikes) (Boucherit *et al*., 2021).

In the Taadmit area, seguias have proven effective: Runoff water is collected and then channeled through seguias, improving infiltration and correcting the slope. This effectiveness is multiplied if the seguias are developed and, more importantly, combined with cultural practices such as the use of manure.

There are also very common practices, such as living fences, also known as windbreaks, which are essential for demarcating plots and protecting orchards from the wind. Drought-resistant species are used in the design of fences (Casuarina, cypress, reed, pomegranate, and sometimes olive).

Moreover, ridging has a favorable impact on water and soil preservation and on boosting the output of cultivated areas, especially when aligned across the slope of the terrain.

Water is transported from the spring and wadis to the irrigated plots via a seguia, a main canal composed of concrete or beaten earth. The local population uses the water from the sed (dam) and ponds for livestock watering and domestic use. Their effectiveness depends on the maintenance of this type of infrastructure, which is ensured by a volunteer project (*Touiza*).

The effectiveness of these conservation techniques can also be increased by using other cultural practices, such as biological pest and disease control, which contribute to agricultural sustainability and resilience to climate change (Nciizah *et al*., 2021; Kuyah *et al*., 2021).

Integrating trees into crops through agroforestry allows for agricultural production that is less sensitive to periods of drought (Kessler and Boni, 1991).

The majority of the reservoirs are not operating because of the infrastructure's degradation, This analysis was done in order to safeguard the study area and prevent siltation of hydraulic infrastructure and irrigated areas downstream of floods. However, the concrete seguia works perfectly because it is maintained daily by the beneficiaries and its location was well chosen.

The contribution of these structures to flood control is considerable at the local level, and their effectiveness is recognized as essential across the study area, particularly for the seguia examined, which has a high efficiency rate. This also applies to the stability and adaptability of the hydraulic installations (El-Abassi, 2000; Hassani, 2019).

However, regular maintenance of these structures is imperative to ensure their effectiveness during periods of heavy rainfall. They constitute the most effective method for land protection and flood control in terms of hydraulic management. The implementation and sustainability of these techniques ensures sustained long-term productivity, not only ecologically, but also biologically, economically, and socially (CRSTRA, 2008).

Conclusion

The study of agricultural practices and WSC techniques in the Taadmit region reveals that erosion, accelerated land degradation, soil depletion, and a shortage of arable land under unprecedented demographic pressure are the major and most frequently discussed environmental problems. In response to this situation, multiple traditional water and soil conservation measures have been implemented in the arid climate of the Taadmit region.

Traditional techniques (mechanical, biological, and cultural practices) are generally used by farmers (windbreaks, stone barriers, earthworks, and manure use, cultivation in basins and on ridges). They have a significant impact on WSC in farmed plots. The area thus provides a rich hydro-agricultural legacy by exhibiting a range of WSC management techniques and a human adaptation to extreme physical limitations. These kinds of actions typically improve the productivity of farmed land and conserve water and resources.

Plain, cheap, and modified techniques, which have been embraced and perfected by growers, have shown to be the most beneficial. Yet, these systems stay broadly scattered and occasionally restricted; some have been discarded, whereas others are extensively utilized because of their benefits.

The completed projects consist primarily of mechanical structures, representing a volume of over 14,917m^3 spread across five types of structures (gabionage, torrent correction, sed, seguia, opening of agricultural tracks), as well as biological developments covering an area of 19,670 hectares divided between pastoral planting, reforestation, restocking, fruit planting, biological dune fixation and green dam, and 19,038 hectares of protected areas.

It is nearly essential to combine these two forms of development mechanical and biological in order to guarantee a very favorable effect on land productivity and lower the risk of degradation. Among the many opportunities that WSC strategies offer are enhancing soil productivity, raising crop yields and, consequently, income, protecting biodiversity and the environment, adjusting to climate change, and raising farmers' standards of living. Their contributions to soil condition include preventing soil erosion, recycling nutrients, preserving soil organic matter, which enhances the physicochemical qualities of the soil, preserving soil water availability for plants, and affecting soil microbial activity.

Based on these findings, it's evident that these SWC methods, which have demonstrated their usefulness through the years, and particularly those that farmers have embraced, modified, and perfected, can be enhanced to adjust to present and forthcoming environmental and socioeconomic circumstances, and incorporated into a fresh participatory approach to water and soil preservation. These methods should be given special consideration by policymakers in their sustainable land management strategies and their developmental endeavors.

The role of technology dissemination and investigation for development is crucial to diminish soil degradation and reinforce WSC techniques, to enhance animal and plant yield, and guarantee food and nutritional security in arid and semi-arid areas. Within this context, it is necessary to take actions aimed at creating (WSC) techniques best suited to agro-ecological conditions and traits.

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Novelty Statement

The objective of the study is to determine, gather, and assess the present condition of soil and water conservation methods and agricultural practices in the Taadmit region (Djelfa, Algeria). In this study, the primary methods for conserving water and soil in arid environments are examined, and the effects of these anti-erosion strategies on WSC and agricultural productivity enhancement in the Taadmit region are assessed.

Author's Contribution

Fatima Zohra Benrekia: Conceptualization, Data Curation, Format Analysis, investigation, Methodology, Resources, Validation, Writing-Original Draft,
Abdelkrim Benaradj: Conceptualization, Format Analysis, Supervision, Validation, Visualization, Writing-Original Draft, Writing-Review and Edition
Boutkhil Morsli: Format Analysis, Supervision, Validation, Visualization, Writing-Original Draft

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Generative artificial intelligence or AI-assisted techniques were not used in the preparation, writing, or editing of this manuscript

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The authors have declared no conflict of interest.

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