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Abstract

Mountain forests in Algeria are strongly affected by climate change. Land degradation is accentuated by overgrazing, deforestation, poor land management linked to difficult mountain topographic conditions, and the overuse of agricultural land dominated by cereal cultivation. The organic carbon stock was assessed at a depth of 30 cm for soils in two different ecosystems in Sidi Bel Abbes region North-West Algeria, the forests of Tessala Mount and the adjusted cereal plain. The influence of different plant formations as well as the geographic characteristics and physicochemical properties on the amount of carbon stored in the soil was investigated. The critical threshold, the saturation point, and the organic carbon deficit of the soils for both sites were evaluated. Correlation between the geographic characteristics, the soil physicochemical properties, and the soil organic carbon stocks was determined using principal component analysis and other statistical tools. The results of the study showed that the organic carbon stock in mountain soils of Tessala area has an average value of 77.4 t ha⁻¹. The organic carbon sequestration of the topsoil in Tessala region was positively correlated with coarse silt, elevation, and northern exposure, but negatively correlated with calcium carbonate contents. The current carbon contents of Tessala topsoil is 22 g C kg⁻¹ which is very low and closer to the critical threshold (11 g C kg⁻¹). The estimated maximum storage capacity is 160 g C kg⁻¹. In the agricultural plain, the average of the soil organic carbon stock has been estimated at 46 t ha⁻¹. The results indicate that lowland agricultural soils are far from the saturation point (21.5 g C kg⁻¹) of organic carbon with an average of 13 g C kg⁻¹ and below the critical threshold (15 g C kg⁻¹). The study of the evolution of the average organic carbon stock revealed a worrying situation, since it went from 66 t ha⁻¹ to 46 t ha⁻¹, a decrease of about 20 t ha⁻¹ from 2000 to 2020. The forest soils under current natural conditions as well as agricultural soils are low in organic carbon content which is close to the critical threshold, this indicates an alarming situation as these areas are exposed to further degradation in the absence of reclamation strategies.

Keywords: Soil organic carbon stock, Forest soils, Agricultural soils, Tessala Mount, Critical threshold, Saturation point, Organic carbon deficit, Algeria.

Introduction

Soil is a natural resource whose destruction is difficult to reverse. Their use and future represent a major collective challenge for sustainable development. Knowledge of their state and evolution is essential for maintaining human activities and preserving the quality of our environment through its various ecosystem services.

In this perspective of sustainable development and in a global context of seeking food security, it is essential to ensure the sustainability of the soil resource. Soil knowledge becomes the basis of any sustainable development program, aiming at better use of soils as well as rational management of this precious resource.

Two billion hectares of land are currently degraded in the world (human activities and global warming). Algeria loses nearly 300,000 hectares of its utilized agricultural area every year. Only 5% of Algerian soils are mapped on a medium scale. Soils are therefore not inventoried and their distribution in space remains poorly known.

The current study focuses on two representative areas of north-western Algeria: the mountains of Tessala and the plain of Sidi Bel Abbes.

The mountains of Tessala, located in the north of western Algeria, are part of the Tell Atlas and have particular characteristics in terms of geographical isolation, climatic conditions, and ecosystems that is considered fragile. The forest vegetation consists of a matorral of green oak and oak kermes located on the northern slope, a guarrigue, and a forest of Aleppo pine and Eucalyptus on the southern slope.

The plain of Sidi Bel Abbes is an agricultural zone mainly dedicated to cereals and is fairly representative of the whole of the interior plains of Algeria in terms of soil classes. The plain belongs to the semi-arid stage, its climate is described by hot and dry conditions that last for more than five months, and a cool-season where the characteristics of the Mediterranean climate predominate, especially through its highly contrasted rainfall regime.

Objectives

The main objective is to evaluate the situation of soil organic carbon stock (SOC) in the semi-arid region of Sidi Bel Abbes through:

- Estimating the organic carbon (OC) stock of agricultural soils under cereal crops.
- Evaluating the OC stock of forest soils under different plant formations.
- Highlighting the main problems that can affect the quality of soils and their ecosystem services.

Materials and Methods

Forest Soils

Six different sites were chosen to determine the variation in SOC Stock. These six stations have different characteristics, including vegetation type, exposure, and altitude. In this study, 32 composite samples were collected along an 8.5 km transect.

Agricultural Soils

The SOC stock was calculated under cereal crops for the five main soil types that cover the plain for agricultural soils. Using data from 35 composite samples, OC modeling and mapping were carried out for the agricultural soils to better understand its evolution over a 20-year period. The depth for all samples was 30 cm.

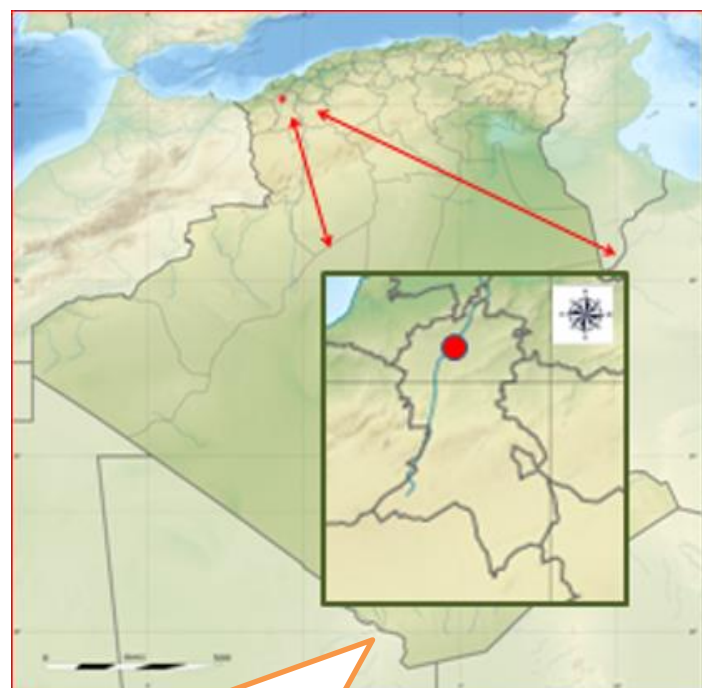


Figure 01. Geographical situation of Sidi Bel Abbes

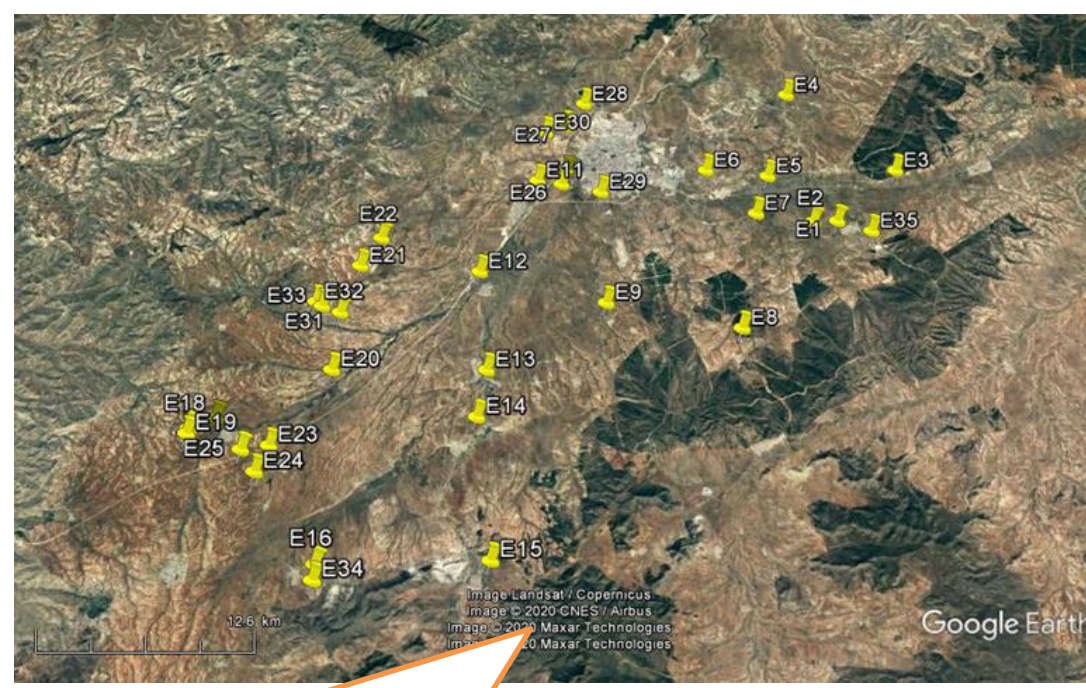


Figure 02. Location of Carbon checkpoints in the Sidi Bel Abbes plain

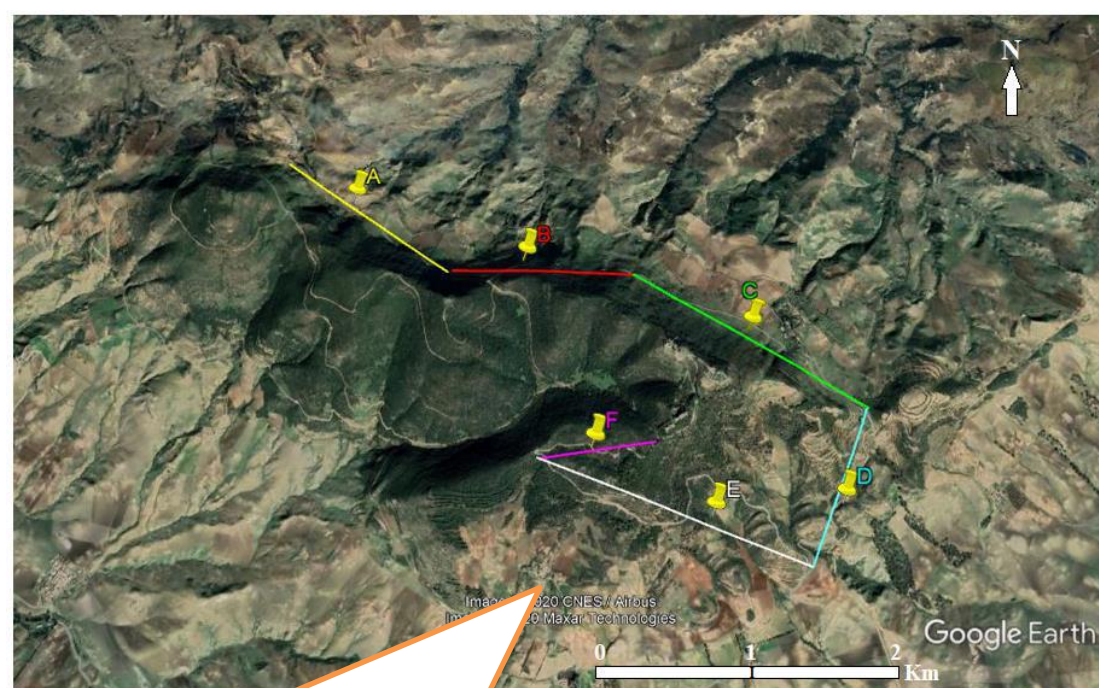


Figure 03. Representation of the soil sampling transects in Tessala Mount

Results

Agricultural Soils

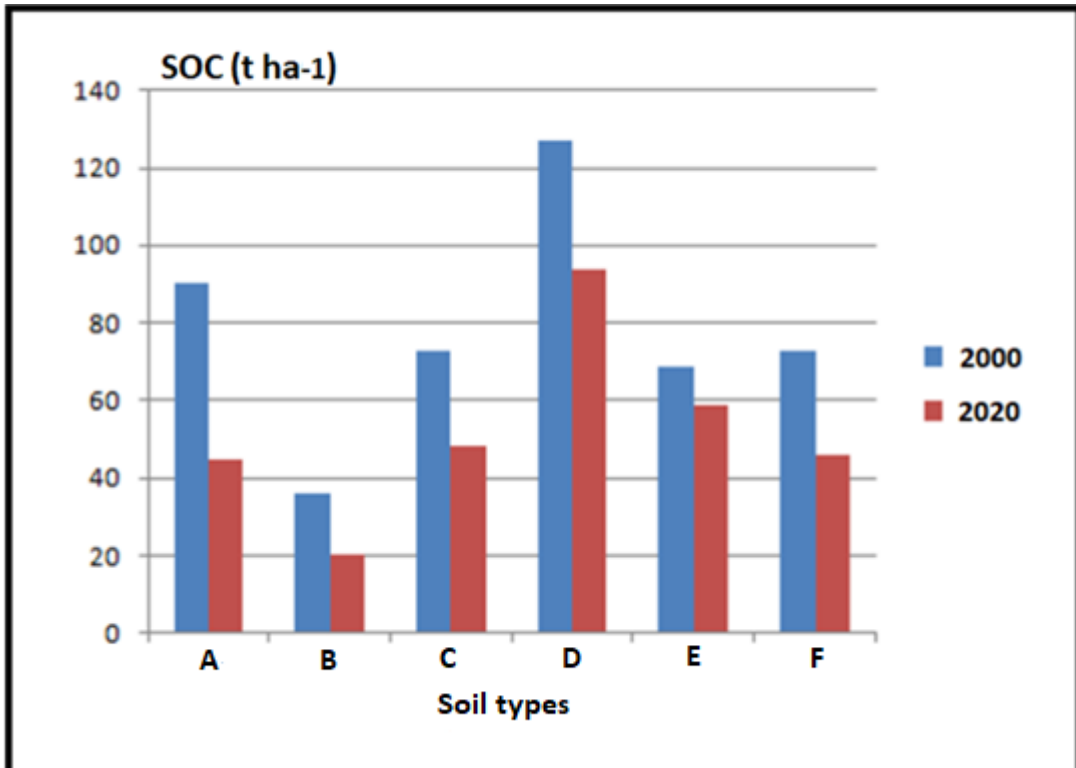


Figure 04. Average variation of the organic carbon stock in Sidi Bel Abbes plain between (2000 - 2020)
A: Cambisols Calcaric, B: Halpic Cambisols Calcaric, C: Fluvisols / D: Halpic Cambisols Eutric or Dystric Chromic / E: Colluvic Regosols / F: Halpic Cambisols Eutric or Dystric

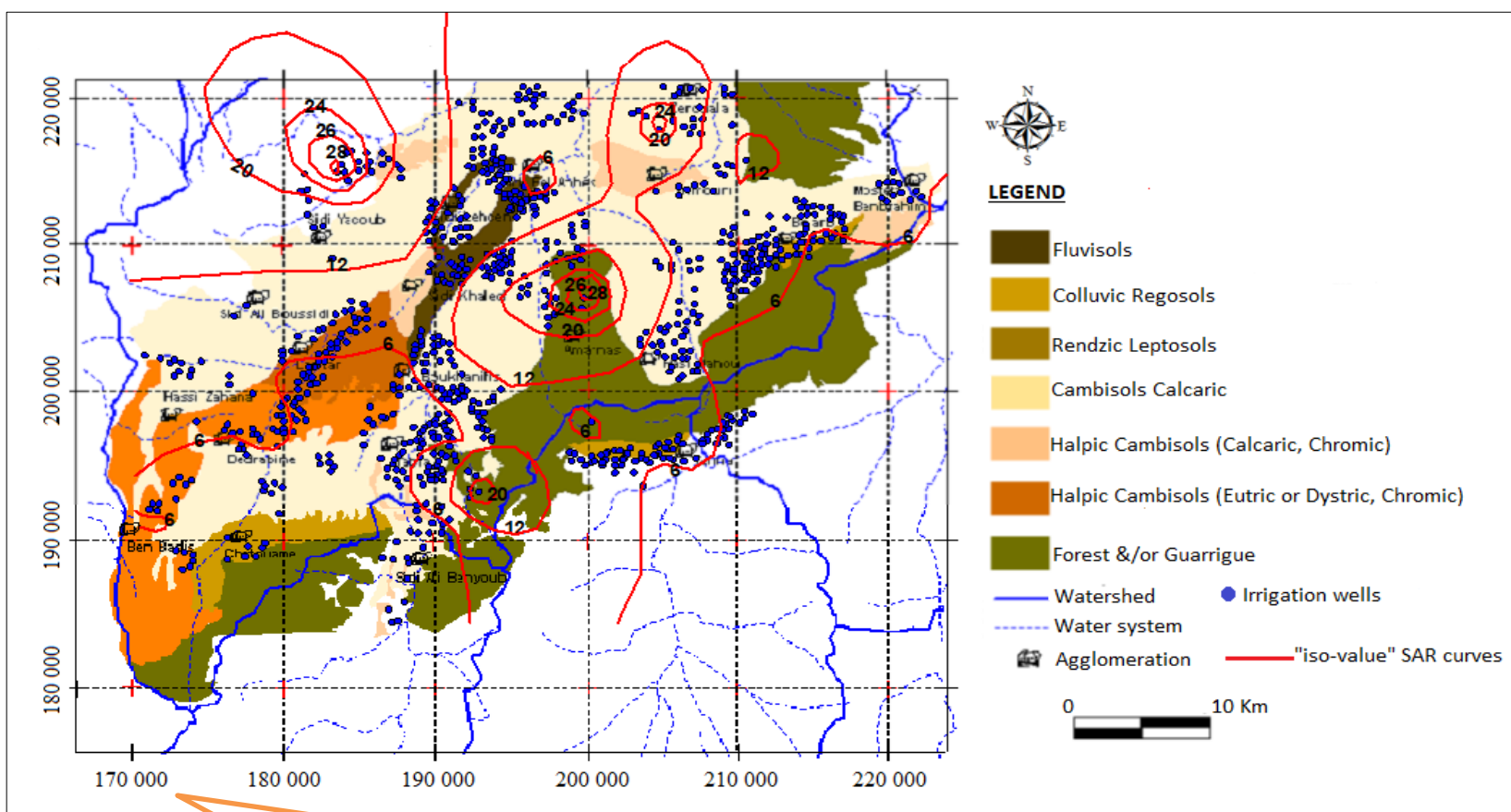


Figure 05. Map of soils, irrigation points and "iso-value" SAR curves.

Figure 04, shows the reduction of the OC content stored in all the soils of the plain. This decrease is more important for limestone soils, which go from 90 t ha⁻¹ to 45 t ha⁻¹ in 20 years. This is alarming situation as it is the dominant soil in the region.

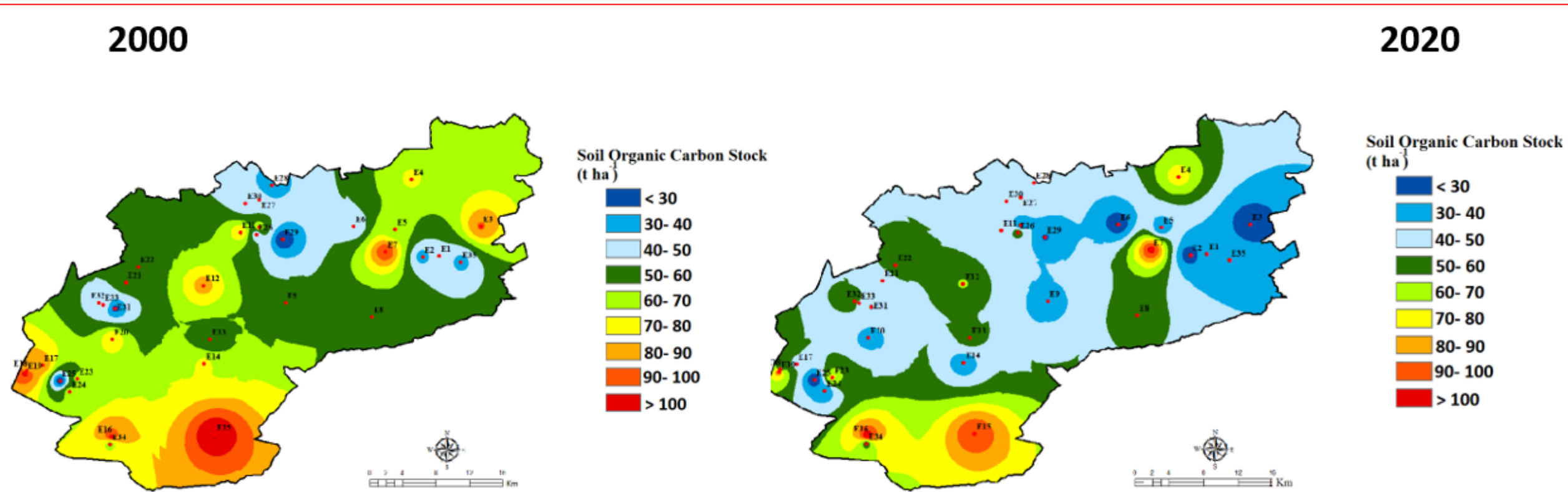


Figure 06. Spatial variation of organic carbon stock.

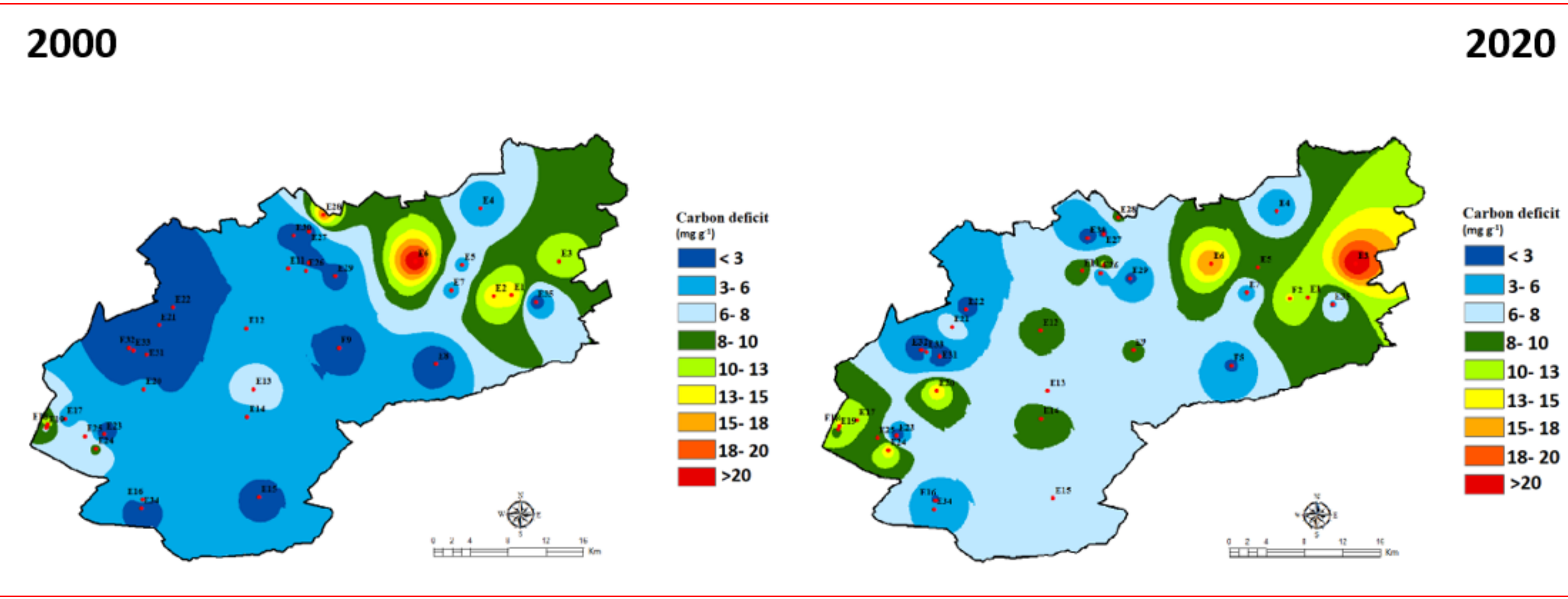


Figure 07. Spatial variation of the organic carbon deficit.

Forest Soils

Table 01. Variation of SOC stock under the selected vegetation covers

Carbon stock (t ha ⁻¹)	M	GC	F	GD	OL	TC	VH
Max.	286	163	64	115	165	76	72.5
Min.	37	20	18	46	17	69	36
Avg.	121	112	38	73	77	73	48

M :Matorral ; GC :Sparse Garrigue ; F :Forest ; GD :Dense Garrigue ; OL : Olive grove ; TC: Oak Coppice; VH:Heraceous vegetation.

Table 02. The actual content, critical threshold, saturation point, and deficit of OC of soils.

OC (g kg ⁻¹)	M	GC	F	GD	OL	TC	VH	AVg.
Actual	31.7	30	8.6	26.5	23.3	23	11	22
Critical	6.8	10	7.6	11.8	17.3	15.5	9.3	11
threshold								
Saturation	110	137	120	167	231.6	210	138	160
Saturation deficit	78.3	107	111.3	140.5	208.3	187	127	137

M :Matorral ; GC :Sparse Garrigue ; F :Forest ; GD :Dense Garrigue ; OL : Olive grove ; TC: Oak Coppice; VH:Heraceous vegetation.

Table 01 indicates that the maximum value of SOC stocks averages (121 t ha⁻¹) stored in Tessala Mount soils was noted dense matorral of green and kermes oak. The minimum SOC stocks average value is recorded under the clear forest of Aleppo pine and Eucalyptus with 38 t ha⁻¹.

Table 02 shows that the current carbon content of Tessala Mount soils is very low, and closer to the critical threshold than its maximum storage capacity represented by saturation carbon. The carbon deficit in soils of the study area is very alarming because it is very close to saturation levels.

Conclusions

The data collected over the last 20 years of work on the soils of the Sidi Bel Abbes plain have enabled us to draw up an initial assessment of the agricultural soil situation. It is clear that the soils on which the local population's agricultural production is based are marked by a remarkable decrease in organic capital and consequently a decrease in their fertility and productivity. Multiple factors could be at the origin of this degradation, our hypothesis retains essentially, the salinity of the irrigation water, the methods, and techniques of working the soil, a biological degradation, and finally the climate change.

SOC stocks in Mount Tessala are affected by vegetation type, topographical features, and soil physico-chemical characteristics. The maximum average of SOC stocks stored in the soils of Mount Tessala from 0 to 30 cm flows in this order: dense holm oak and kermes oak matorral> sparse scrubland> olive groves > dense scrubland and oak coppice> herbaceous vegetation> Aleppo pine and Eucalyptus. The geographical and physico-chemical characteristics represented by the northern exposure, the high altitude, and the high OC content, as well as the high ratio of coarse silt are factors that have favorably influenced the storage of SOC in Mount Tessala. In general, the current C content of the Tessala topsoil is very low and close to the critical threshold and a maximum storage capacity of 160 g C kg⁻¹. The findings indicate further loss of C which under the current natural conditions and management conditions.

Acknowledgements

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