Application of GIS and remote sensing

To the management and optimization of irrigation in

The Dahmouni agricultural perimeter

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Dedication

I thank God for his success in the academic journey. I dedicate this work to the honorable parents, Dahane Rabeh, and the dear mother, Kebbane Fatema, for their support and for staying up late, thanks to God.

Then you were able to achieve this achievement. I do not forget Brother Abdelrahim, Sister Nour Elhouda, Hadjer, and the family of Kebbane, Dahane, Ait amer and Hattabi.

And friends Houssam_,Adel, Hadj, Oussama, Alaa Eldine, Abdeldjalil, Ibrahim, Abed, Benoure and Abdelkader.

You are a true pillar in my life.

Again, I thank you from the bottom of my heart and want you to know that I am grateful to you.

DAHANE Abdelghani

Dedication

Above all, I thank God for granting me success throughout my academic career. So, I dedicate this humble work:

*To my dear mother, **Tayeb Aicha**, for all her sacrifices, love, and prayers that always accompany me.*

*To my second mother, my sister **Khaldia**, for her constant encouragement to complete my studies with all seriousness and diligence. Thank you for all the support and love from my childhood.....*

*To my sister's husband, **Rachid**, for supporting me as a brother throughout my career.*

*To my uncle **Ben braika** and his honorable family.*

*To my brothers **Sofiane** and **Mohamed**.*

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- To the companion of the path, Ikram.

*To my friends, **Bouchra. Khadidja. Chaima. Sondos. Nariman**. **Sarah**. **Dhahab** and **Hakima**.*

*- To the precision agriculture batch **2021_2023***

- To everyone who supported me with the kind words

*- **This work is dedicated to my father... God Almighty have mercy on him***

SENOUCI SOUAD

List of abbreviations

A: Clayey.

C: carbon.

CA: active limestone.

Caco3: calcium carbonates.

DHT: Direction of hydraulics of the wilaya of Tiaret.

DSA :Degree of Sodium Adsorption

CT: total limestone.

FAO: Food and Agriculture Organization.

GIP: Public interest group.

GPS: The Global Positioning System

L: loamy.

Lf: fine silty.

Ls: sandy loam.

NaCl: Sodium chloride.

NO2-: Nitrites.

PH: Hydrogen potential

PVC: polyvinyl chloride

QGIS: A Free and Open Source Geographic Information System

SAR: Synthetic Aperture Radar

S: sandy.

Sl: sandy-loamy.

UTM: Universal Transverse Mercator

TD or EW: dew point temperature

NaPO3: Sodium hexametaphosphate

Na2CO3: Sodium carbonate

pH: The hydrogen potential

H2O: dihydrogen monoxide, molecular formula of water

KCl: potassium chloride

CaCl2: calcium chloride

K+: Potassium ions

Ca+: Calcium ions

H+: Hydrogen ion

EC: Electrical conductivity

Mg2+: MAGNESIUM

NH4+: ammonium

SO42-: sulfites

Cl-: chloride ion

HCO3-: bicarbonate or hydrogen carbonate

N:Nitrogen

P:Phosphorus

K: Potassium

CO2: carbon dioxide

HCl: Hydrochloric acid

CaCO3:calcium carbonate

KMnO4: potassium permanganate

H2SO4: sulfuric acid

OM:Organic matter

VCI: Vegetation Condition Index

VHI: Vegetation health Index

TCI: Temperature Condition Index

ATP: Adenosine Triphosphate

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Introduction

Introduction

Introduction

Climate change and water scarcity are major challenges facing agriculture, leading to deterioration in soil quality and its negative impact on agricultural production. One of the most widespread harmful practices resulting from water scarcity is indiscriminate irrigation, which is an inefficient and unsustainable use of water in agriculture.

Indiscriminate irrigation leads to an accumulation of salinity in the soil, which reduces the ability of plants to absorb water and essential nutrients. This affects plant growth and crop quality, and reduces the productivity of farmland **(FAO, 2020).**

Algeria faces particular challenges in terms of climate change and water shortages, and their impact on agriculture in the country. Indiscriminate irrigation is one of the main challenges facing agriculture in Algeria. In the absence of water, farmers resort to inefficient and unsustainable use of water for irrigation, increasing water wastage and degrading. This leads to a drop in the productivity of agricultural land and a negative impact on crops and agricultural production **(UNIDO, 2021).**

Algeria is committed to promoting sustainable agricultural practices and improving irrigation water management to adapt to climate change and ensure agricultural sustainability. These efforts build on numerous reports and studies on climate change, water scarcity and agriculture in Algeria **(UNIDO, 2021).**

One of the means of developing the agricultural sector is remote sensing applied to cultivation, through which detailed information can help make watering decisions at the right time.

Remote sensing is an important tool for determining soil moisture and where water accumulates in the field. Due to satellite images, it is possible to find out where water is needed. The spectral values can be correlated with the measured information to determine the problem.

The conducted study, consisting of five chapters, is illustrated as follows:

- first chapter is about irrigation system, Benefit of irrigation, Agricultural irrigation techniques and the basic factors of irrigation

- The second chapter describes application of Remote sensing and GIS

- The third chapter is devoted to a study DAHMOUNI area, which includes a general presentation of the study area, followed by geographical maps of land uses, soil types, and cultivation.

- The chapter 4 presents the methodology adopted in the monitoring of irrigation, vegetation health (VHI), drought (VCI) using Google earth engine (using image SENTINEL 2).

- The chapter 5 is devoted to the study, interpretation and discussion of the results obtained. The objectives in this study are to use the application of remote sensing and GIS in monitoring irrigation and crop health and drought in the DAHMOUNI study area.

This study was carried out under different periods in the study area.

General conclusion summarises all the results obtained and research prospects are proposed

Part

Bibliographic

Chapter 1
Irrigation system

1. Irrigation system

1.1. Introduction

When adequate water supply is necessary for plant growth or vegetative development of crops, irrigation measures are necessary to meet crop water requirements when rainfall is insufficient. Irrigation is a powerful tool for farms to increase productivity and regulate irrigation on a regular basis, provided that farmers can control irrigation to achieve technical (performance) and economic (optimal cost) goals. The performance of the irrigation system depends on the correct selection of the technology, the irrigation system and the correct installation of the equipment based on accurate knowledge **(Gabriel Katul, 2019)**.

1.2. Definition of irrigation

Irrigation can be defined as the set of socio-technical devices that allow artificial inputs of water to facilitate the growth of crops, trees and pastures. The methods differ depending on whether the water flows onto the soil "surface irrigation" is sprayed under pressure "sprinkler irrigation" or is brought directly to the plant "localized irrigation" **(FAO.2, 2012)**

1.3. Benefit of irrigation

Irrigation is one of the key factors in plant cultivation and development as it provides sufficient water to plants. Irrigation has many benefits and contributes to increased crop productivity and sustainable agriculture**.** The benefits of irrigation**:**

•Increase Crop Yields: High and sustainable crop yields can be achieved by providing the right amount of water at the right time. Irrigation enhances the maximum use of light energy and nutrients, which contributes to an increase in the size and weight of the crop.

•Improves plant quality: Irrigation helps improve plant quality by providing the water needed for metabolism and food purification, and increases plant tolerance to harsh environmental conditions.

•Organizing production scheduling: Irrigation allows production scheduling and continuity of crop supplies throughout the year. Farmers can avoid the consequences of not having enough water from the rains and ensure that the necessary water is available at all vital stages of the crop.

•Reduce environmental risks: Irrigation can effectively reduce the drought effect caused by lack of water or excessive salt in the soil. Irrigation achieves environmental sustainability by achieving an

optimal balance between water use and maintaining soil and ecosystem health (**Martin A. Burton, 2010**).

1.4. Agricultural irrigation techniques

Agricultural irrigation techniques are methods of bringing water to crops to increase their production, and allow their normal development in the event of a water deficit induced by a rainfall deficit and are classified into surface irrigation, sprinkler irrigation and micro irrigation. Deciding whether to select one irrigation technique or switch to a more efficient is complicated. From a water conservation point of view, the choice is simple, the water savings increase when switching from surface irrigation to sprinkler and spraying with micro irrigation. However, the success of an irrigation technique will be very depending on the site, situational factors as well as the level of management used. The technique existing irrigation system must be assessed very carefully before switching to another technique. (**Rachel Barta, 2015**).

Depending on how water is brought to the field and how it is distributed, three major modes are usually practiced (**Figure 1**).
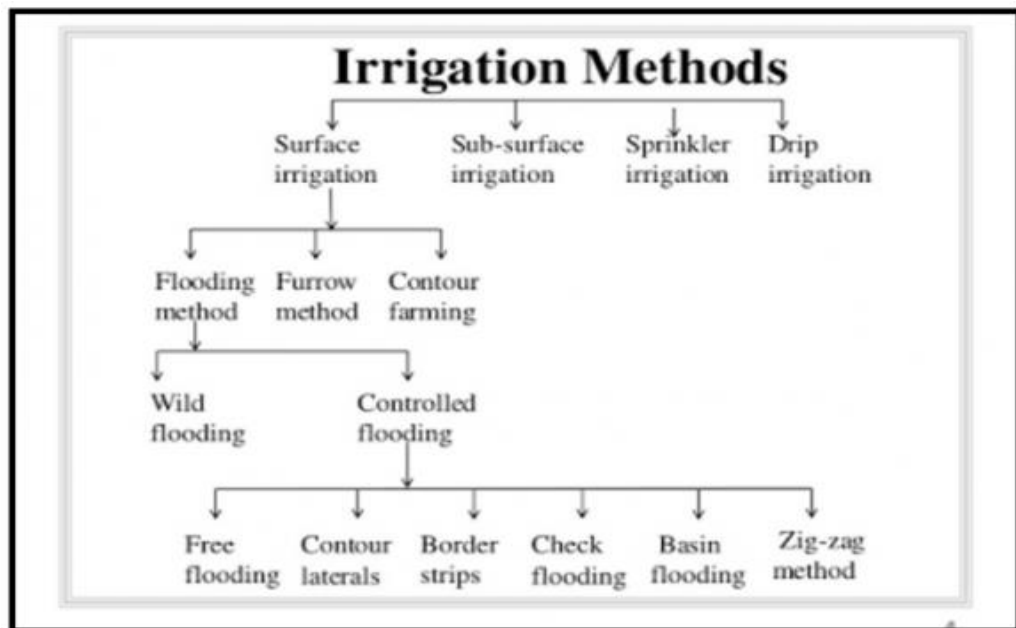
Figure 1: Different irrigation systems (Rachel Barta, 2015) .

1.4.1. Surface (gravity) irrigation systems

Surface irrigation systems are ranked in ascending order of their efficiency by:

1.4.1.1. Border irrigation

Irrigation by board consists in running a thin layer of water on an inclined ground of 0,23%. The discharge rate depends on the slope, width and length of the board. This method is by far the most difficult as it is necessary to adjust the irrigation flow of each board with all other variables. One of the practical formulas is that of Cravat which consists in determine the length of the board that depends on soil infiltration, which would correspond to the runoff time.

In other words, the trefoil opens the valve and waits for the water to reach the bottom of the board, and at that moment it closes the inlet valve.

Figure 2: Border irrigation

1.4.1.2. Furrow irrigation

Furrow or furrow irrigation is ideal for soil with a slope between **0.2** and **3%**. The furrows are separated by a distance varying between **0.6** and **1.25 m**, depending on the type of soil and culture. Depending on the flow rate available, one or more furrows can be irrigated at a time. The rays can be parallel or perpendicular to the permanent water supply channel. In a general way, the irrigation is carried out according to a single flow rate or according to a succession of two different flow rates, a first high bit rate which is called attack bit rate and a second lower bit rate which is called maintenance flow. Furrow irrigation lends itself better to mechanization by siphon, ramp with gates, by flexible sheath or by Tran's irrigation. **(AZOUGGAGH)**

Figure 3: furrow irrigation (**Pr. AZOUGGAGH,M, 2001).**

I.4.1.3. Irrigation by basins

Basin irrigation is the best known in gravity irrigation. Its practice on level ground (slope **0.1** to **1%**) as well as the simplicity of the operation, which consists in filling the pool, mean that this technique is frequently used, the size of the pools is **40** to **50 m²** and this technique is known as "Robat". The latter causes a significant loss of surface area, due to the large number of partitions (**Pr. AZOUGGAGH,M, 2001).**

Figure 4: Irrigation by basins (**Pr. AZOUGGAGH,M, 2001)**

1.4.2. Sprinkler irrigation

Sprinkler irrigation is recommended in the following cases:

• Shallow soils, which cannot be properly leveled for irrigation of surface, while maintaining sufficient depth.

• Too permeable soils, which do not allow a uniform distribution of water in the framework of irrigation with surface runoff.

• Irregularly sloping land with uneven microrelief, not allowing the establishment a free-surface gravity service.

•On the other hand, it should be ruled out in very regularly windy regions (winds above **4** or **5 m/s** considerably degrade the homogeneity of the watering) and also when the irrigation is

done with salt water on plants with salt-sensitive foliage. A pressurized irrigation installation is generally composed of equipment supplying the pressure necessary for its operation, measuring and control devices for flow, and a main pipe bringing water to the secondary and tertiary pipes.

Other elements can be used, in particular a filter or a bank of filters and a device for adding fertilizing elements.

The consideration of the following factors is necessary for the conduct of a project of sizing of any pressurized irrigation system:

•The size and shape of the area to be irrigated, its topography and the type of soil.

• Available or potential water sources and their characteristics

• The climatic conditions in the region, the accessibility to the plot and the cultivation to Irrigate
 (**Pr. AZOUGGAGH,M, 2001).**

Figure 5: Sprinkler irrigation (**Pr. AZOUGGAGH,M, 2001).**

1.4.3. Micro irrigation (drip)

Drip irrigation involves pressurizing the water in a system of pipes, usually made of **PVC**; this water is then distributed in drops in the field by a large number of drippers distributed throughout the rows of plantations. The moistened area of the soil is that located in the immediate vicinity of the plant roots. Therefore, this irrigation method has a high degree of efficiency of water distribution. Drip irrigation is also called micro-irrigation **(Vermeiren L. and Jobling, 1980)**

Figure 6: micro irrigation (drip) **(Vermeiren L. and Jobling, 1980).**

1.5. The basic factors of irrigation

1.5.1. Soil

The general character that needs special attention is the great heterogeneity of the soil, so it is essential to quantify certain soil properties **(Bauchamp, 2006)**

1.5.1.1. Physical properties

Topography Examine the slope (capital factor of irrigation) that determines the speed of water circulation on the surface, as well as the plot.

Soil Permeability and Water Capacity the water content is a function of the porosity and permeability of the soil. The maximum volume of water that a soil can retain is the capacity of the field or soil retention which depends essentially on the size of the soil. The greater the permeability, the lower the capacity **(Bauchamp, 2006)**

Cohesion Water plays a very important role in cohesion. Indeed, when the amount of water is very large, the soil particles are separated from each other and the cohesion of the soil is then zero. On the other hand, the presence of water can give certain cohesion **(Bauchamp, 2006)**

Heavy land has a high degree of cohesion, so it can use large water masses on relatively steep slopes. Sandy soils leave themselves willingly, because they are inconsistent, so great precautions must be taken to water them.

Sandy soils are the most difficult to irrigate with water. For the same soil, cohesion may vary significantly during crop rotation, depending on the state of looseness, nature and age of the crop **(Bauchamp, 2006).**

1.5.1.2. Chemical properties

Organic matter by providing the soil with permanent moisture, it achieves the ideal environmental conditions for a rapid transformation of organic matter. By accelerating the decomposition of organic matter, watering water tends to spoil the soil.

1.5.1.3. Mineral matter

The earth has a solid phase consisting of minerals, inert organic substances and living beings. The mineral elements come from the alteration of the rocks either mechanically or chemically, with transformations (which will produce the secondary minerals: clays, oxides for example). All secondary minerals form the weathering complex. At the agronomic level Sand and silt retain very little water (sand less than silt), they allow a soil to warm up faster in the spring and ease of work by the tools but having a significant wear effect especially with regard to the sands **(Bauchamp, 2006).**

1.5.2. Water

The quality of the water used for irrigation is an essential parameter for crop yields, maintaining soil productivity and protecting the environment. For example, soil's physical and chemical properties, such as its structure (stability of aggregates) and permeability, are highly sensitive to the type of potentially exchangeable ions present in irrigation waters **(Bauchamp, 2006)**.

The most important factors in determining the required water quality in agriculture are:

- PH

- Risk of salinity

- Risk of Sodium (DSA)

- Carbonate and bicarbonates in relation to Ca and Mg

- Other traces of elements

- Toxic anions - Food

- Free chlorine

1.5.3. Crops

They influence the way irrigation is done, either by nature, which does not combine with all systems, or by their water requirements which can alter the rotation of waterings **(Zareb, 2002)**

Types of crops Requires an irrigation system. Naturally, the natural conditions must be suitable for both the plant and its watering system. If the environment requires irrigation, the choice of crops is restricted **(Zareb.D, 2002)**

Need for plants Vary with climate and species and the degree of vegetation evolution. Changes due to climatic factors are essentially variable from one year to the next following the regime of temperatures, rainfall, winds, humidity. The requirements vary according to the species, mainly because of the duration of vegetation in summer, some speculations such as vegetable crops, early crops requiring only a few watering's in spring, while others, such as alfalfa, The date palm requires water for most of the year. Some fruit species may be satisfied with watering from far away (apricot, olive), while some require continuous irrigation **(Zareb.D, 2002).**

Chapter 2
Remote sensing
And GIS

2.1. Remote sensing

2.1.1. Introduction

Remote sensing brings together all the techniques related to the analysis and use of satellite data. The main objective of remote sensing is the mapping and monitoring of land resources. Spatial data usually comes in the form of maps describing topography, water availability, soil types, forests and grasslands, climate, geology, population, land ownership, administrative boundaries, infrastructure (main roads, railways, electrical or communication networks).

We distinguish two types of remote sensing, depending on the sources of radiation: passive remote sensing and active remote sensing. The first uses natural sources radiation (Sun). Energy from the Sun is either reflected or absorbed and retransmitted (thermal infrared) by the target. Passive remote sensing devices that measure naturally available energy are passive sensors. The passive sensor can only perceive the energy reflected when the Sun illuminates the Earth. So there is no energy solar reflected at night, while the energy released naturally (thermal infrared) can be seen day or night. The second requires the implementation of an artificial source of radiation (laser and radar) on board the satellite, emitting towards the region observed and which receives the reflected signal. So an active sensor produces its own energy to illuminate the target: it emits electromagnetic radiation which is directed towards the target. THE radiation reflected by the target is then perceived and measured by the sensor.

The active sensor has the advantage of being able to take measurements at any time of the day or season. Active sensors use wavelengths that are not produced in quantity sufficient by the Sun such as microwaves or to better control how a target is illuminated. On the other hand, active sensors must produce huge amount energy to properly illuminate a target. Synthetic Aperture Radar (**SAR**) is an example of active sensors **(ABBAS)**

The definition of technical terms related to passive spatial remote sensing allows us to better then discuss the potential contributions of satellite data for the needs analysis and processing. Their acquisition and use constitute the application framework work in this dissertation.

2.1.2. Definition

Taken in the literal sense of the word, remote sensing means the action of acquiring information from distance to an object or phenomenon without the detector being in contact with the object studied. Despite this very broad etymological meaning, the term remote sensing is currently used to denote the science whose aim is the study of the earth's environment by means of sensors, on board aerial or space platforms, sensitive to radiation electromagnetic radiation reflected or emitted from the earth's surface or atmosphere **(Placeholder1)**

2.1.3. Physical principle of remote sensing

In most cases, remote sensing involves an interaction between incident energy and the targets. The process of remote sensing using imaging systems involves seven steps that we will develop below. Note, however, that remote sensing can also involve emitted energy and use non-imaging sensors **(Tebourbi, 2006)**
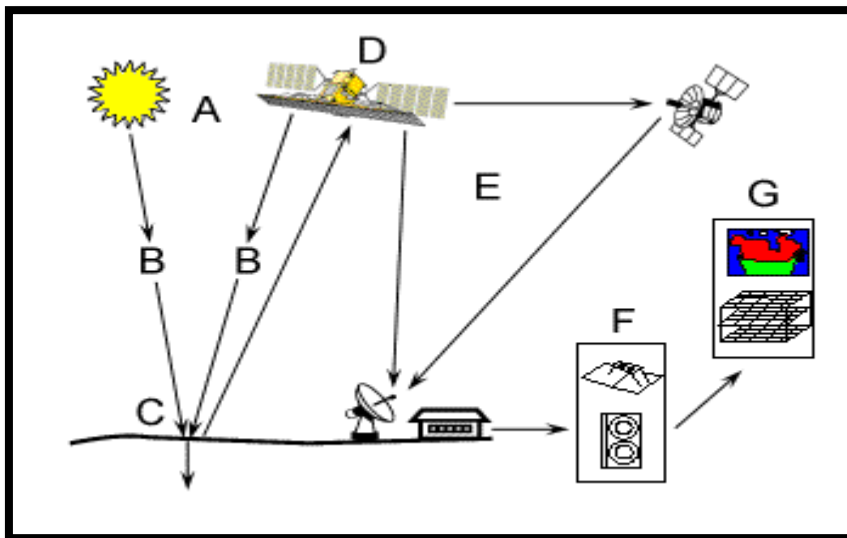
Figure 7: Physical principle of remote sensing **(Tebourbi, 2006).**

2.1.4. Components of the physical principle of remote sensing

2.1.4.1. Source of energy or illumination (A) - At the origin of any process of remote sensing is necessarily finds a source of energy to illuminate the target.

2.1.4.2. Radiation and atmosphere (B) - During its journey between the source of energy and the target, the radiation interacts with the atmosphere. A second interaction occurs when path between the target and the sensor.

2.1.4.3. Interaction with the target (C) - Once it reaches the target, the energy interacts with the surface thereof. The nature of this interaction depends on the characteristics of the radiation and surface properties

2.1.4.4. Recording of the energy by the sensor (D) - The energy diffused or emitted by the target, must be picked up remotely (by a sensor that is not in contact with the target) to be finally recorded.

2.1.4.5. Transmission, reception and processing (E) - The energy recorded by the sensor is

transmitted, often by electronic means, to a receiving station where the information is transformed into images (digital or photographic).

2.1.4.6. Interpretation and Analysis (F) - A visual and/or digital interpretation of the image

processed is then necessary to extract the information that one wishes to obtain on the target.

2.1.4.7. Application (G) - The last step in the process is to use the extracted information of the image to better understand the target, to make us discover new aspects or to help solve a particular problem

Data acquired by remote sensing sensors can allow us to reconstitute a continuous image of the target scene or study the behavior of targets according to a spatial sampling plan. In the first case we are talking about sensors imagers and in the second case non-imaging sensors. The primary function of sensors imagers is to provide us with the appropriate tool to study phenomena whose extent and spatial variations are important parameters that must be taken into account in our analysis.

2.1.5. Radiation and the electromagnetic spectrum

By definition, electromagnetic radiation is a form of energy ubiquitous that surrounds us everywhere, it takes on various patterns such as radio waves, X-rays and gamma rays, as well as sunlight **(COULIBALY.I, 1996)**

The sun is the main source of electromagnetic radiation, and its light is the light source on the planet, so that the brain uses it to construct an image integrated from what a person sees. Indeed, visible light represents a small part of the electromagnetic spectrum and contains a wide range of wavelengths electromagnetic. Also, there are other types of radiation that they are not visible to the naked eye (short microwave, ultraviolet, infrared radiation, etc.) **(Fig. 2)**
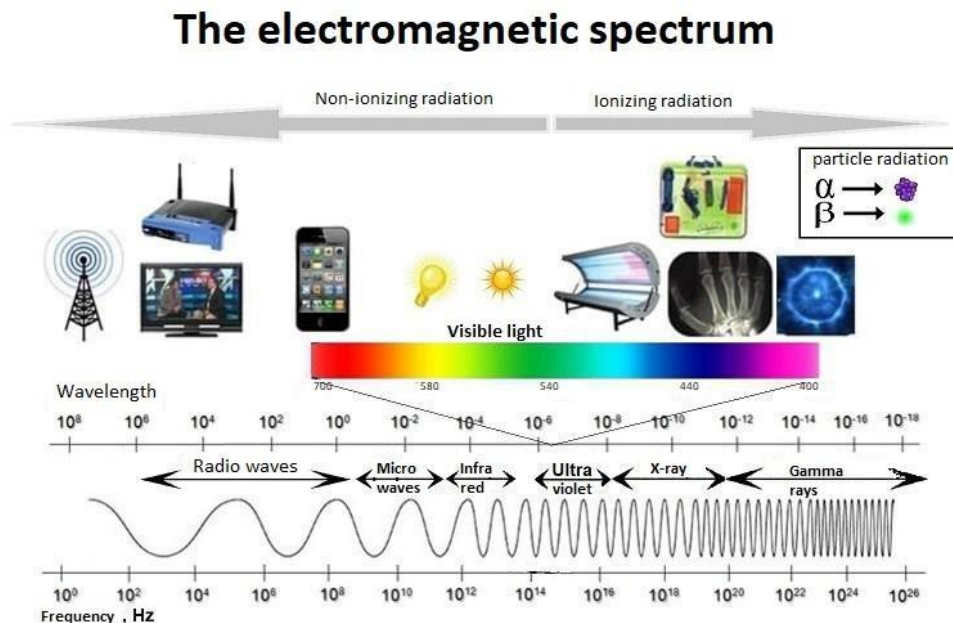
Figure 8: Electromagnetic Radiation and Spectrum

2.1.6. Spectral signature

During the propagation of an electromagnetic wave in a medium, the interactions with matter will depend on its frequency and the nature of the matter. Moreover, these interactions will be mainly by resonant absorption, followed by a re-emission of the radiation by the atoms in the medium. The spectral signature is therefore the response of an object reached by an energy, it is the identity card of the entity **(PEBAY-PEYROULAYE, 2012)**

For example, the amount of energy reflected by water is small compared to plants and the ground. Plants reflect **50%**, soils between **30** and **40%**, while water reflects about **10% (Fig. 3).**

Practically, it is difficult for the spectral signature to be the same in all regions and all seasons of the year.
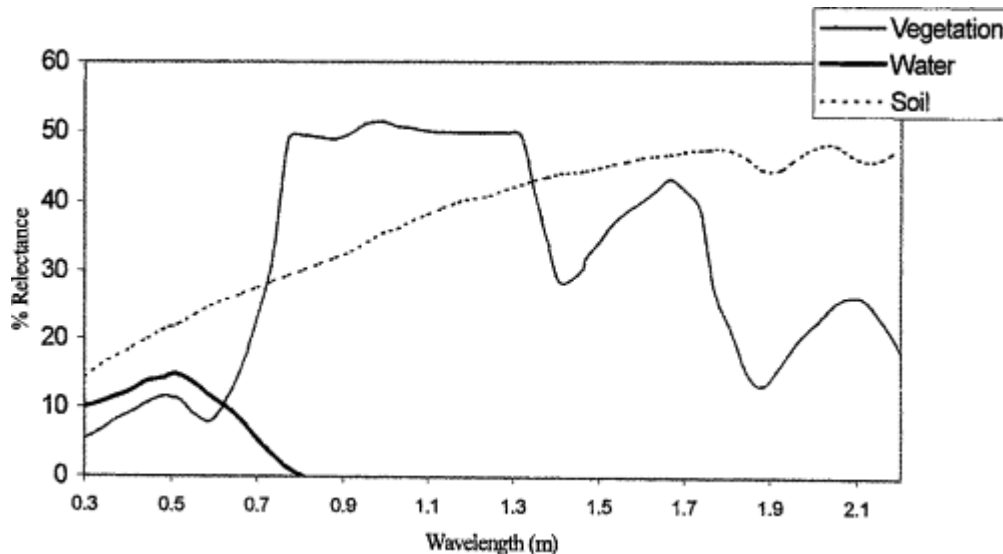
Figure 9: Spectral signature of some elements.

2.1.7. Fields of application of remote sensing

According to **(Kergomard.C, 2004)** three major areas have benefited from remote sensing

• The first major field of application of remote sensing was the study of the atmosphere (meteorology and climatology). The interest of remote sensing in this field is to ensure global and very frequently repeated coverage of the entire planet; on the other hand the spatial resolution is not critical for meteorological applications.
• In oceanography, remote sensing offers the advantage of allowing a synoptic view of vast areas that cannot be reached by traditional means (boats). For some small-scale studies, data from meteorological satellites are largely used in oceanography (ocean surface temperatures).
• Terrestrial applications of remote sensing are extremely varied, and the field of uses continues to expand: cartography, geology and mining prospecting, but also monitoring of crops or forest cover, town planning, development, civil engineering, etc...

• The processing of digital satellite imagery is a discipline in constant development, and the fall in the cost of computer equipment has led to a rapid increase in the number users.

2.1.8. Advantage of remote sensing

   * Currently the application of remote sensing in the study of ecosystems allows according to **Labreque and Letourneau (2003):**

- Carry out rapid surveys over large areas at low cost.
- Gain access to information not obtainable by other methods.
- to follow the evolution of biological phenomena thanks to the possibility of using data multi-temporal data, provided in particular by earth observation satellites with orbits sun-synchronous
- The development of methods for monitoring phytoplankton is one of the actions of the partnership between Onema and Ifremer (2009):
- The "water color" sensors are able to detect the biomass of the phytoplankton from the concentration of chlorophyll pigment in surface waters.
- Satellite observation makes it possible to identify eutrophication phenomena, i.e.
- The abnormal proliferation of certain algae that can lead to asphyxiation of the environment. A another application aims to track toxic phytoplankton species with a signature in surface. Satellite observation will therefore contribute to the monitoring of these risks and thus facilitating the work of the surveillance networks at sea.

2.1.9. Passive and active detection

2.1.9.1. Passive detection

The Sun's energy (a practical source of energy or radiation for remote sensing), is either reflected (the visible portion) or absorbed and retransmitted (thermal infrared) by the target. Remote sensing devices that measure naturally available energy are passive sensors. The passive sensor can only perceive the energy reflected when the Sun illuminates the Earth **(Fig. 27).** There is therefore no reflected solar energy in the evening, whereas energy (thermal infrared) can be perceived during the day or at night. day or night. An active sensor produces its own energy to illuminate the target. electromagnetic radiation which is directed towards the target. The radiation reflected by then perceived and measured by the sensor **(Köhl, 2006).**

2.1.9.2. Active detection

The active sensor has the advantage of being able to take measurements at any time of day or season. Active sensors use wavelengths that are not produced in sufficient quantity by the Sun, such as microwaves, or to better control the way a control the way in which a target is illuminated

(Fig. 10). Active sensors, on the other hand, have to produce an enormous amount of energy to illuminate a target properly. Laser fluorometers and synthetic aperture radar (SAR) are examples of active sensors **(Köhl, 2006).**
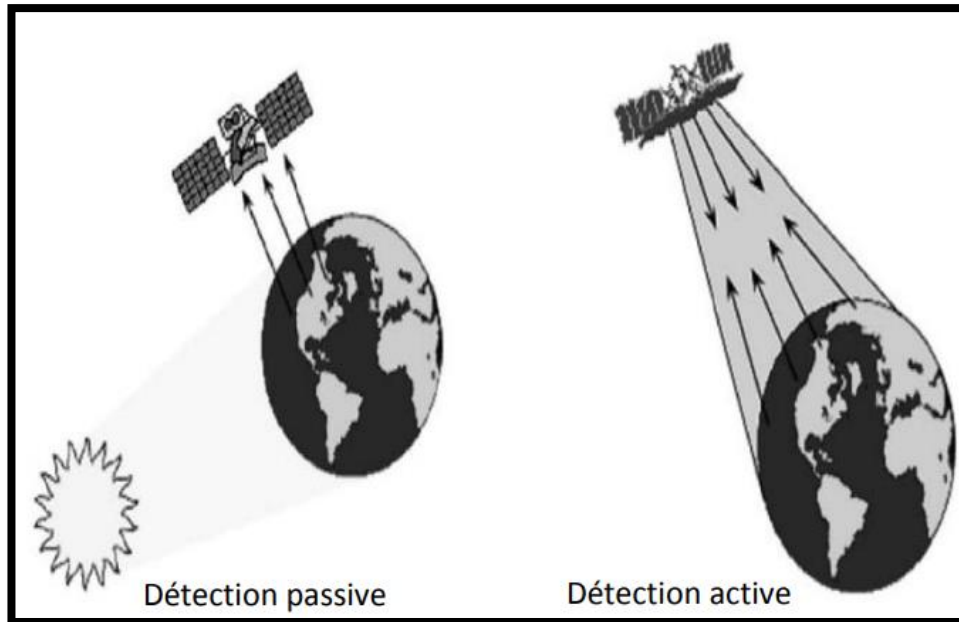
Figure 10: Passive and active detection **(Köhl, 2006).**

2.1.10. Electromagnetic waves

An electromagnetic wave is the simultaneous vibration in space of an electric field electric field and a magnetic field **(Fig. 11).** An electromagnetic wave is a transverse wave. The direction of variation of the fields is perpendicular to the direction of propagation **(Kergomard, 2009)**.
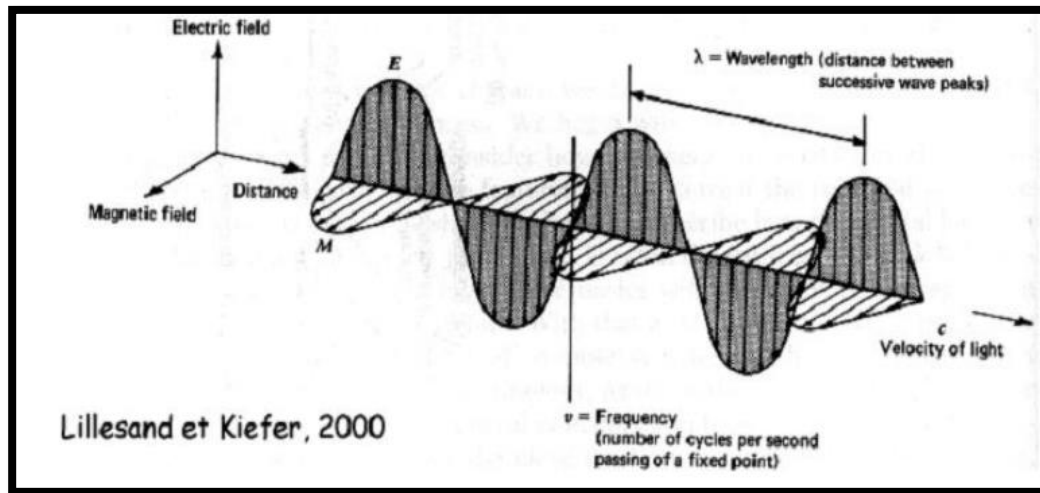
Figure 11: The simple electromagnetic wave (monochromatic, plane) **(Kergomard, 2009)**.

2.1.11. The notion of image in remote sensing

In remote sensing, it is important to distinguish between the terms "image" and "photograph". An image is a graphical representation, regardless of the wavelength or remote sensing device used to capture and record electromagnetic energy **(Fig. 12)**. A photograph refers specifically to any image captured and recorded on photographic film. With these definitions, we can see that every photograph is an image, but that not all images are photographs **(CTC, 2005)**. A photograph can be presented and displayed in digital format by dividing the image into small pieces of equal size and size and shape, which we call pixels. The brightness of each pixel is represented by a digital value **(CTC, 2005).**
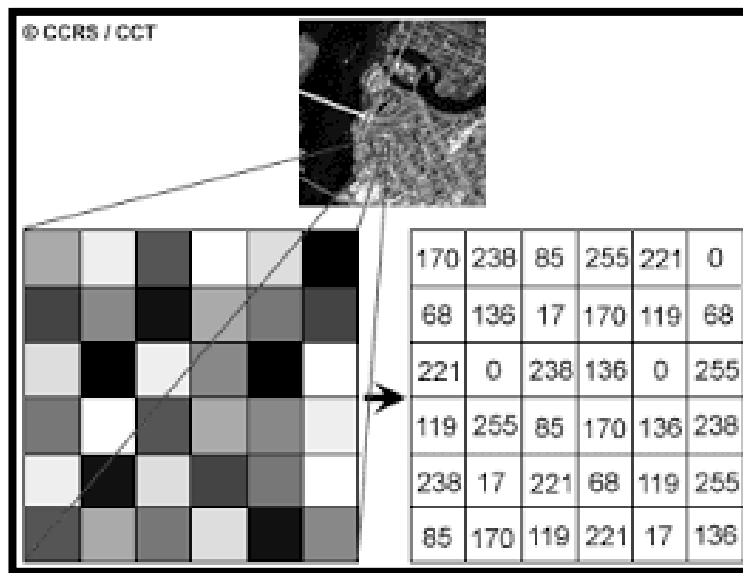
Figure 12: The remote sensing image **(CCT. 2005)**

2.2. Geographic information system (GIS)

2.2.1. Definition

GIS is a spatially referenced information processing environment **(Claude, 2004)**According to **(Berry, 1999),** it is an information system (**IS**) whose objective is to describe a territory in such a way as to improve its knowledge and to allow the description and analysis of the natural or human phenomena that occur there **(Fig.13).**
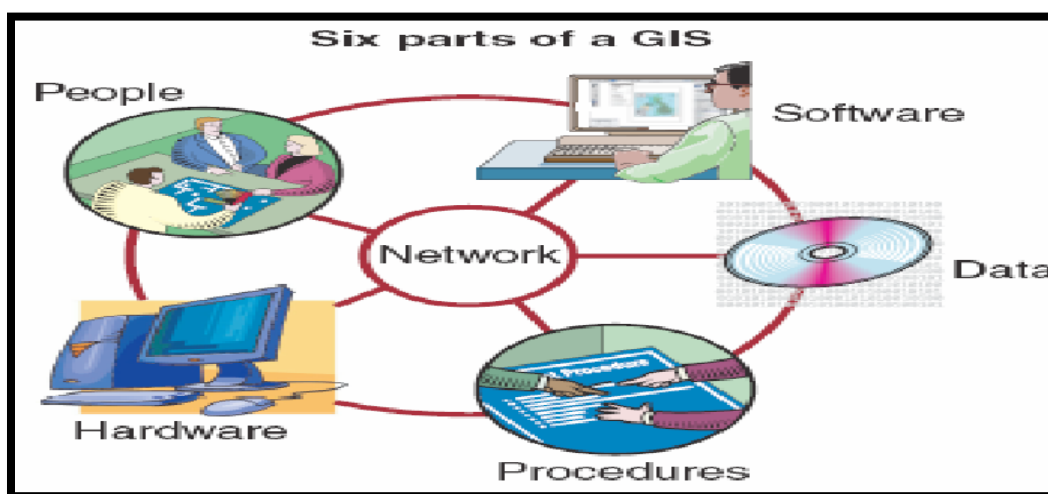
Figure 13: GIS design **(Longley, 2005).**

2.2.2. Geographic data

2.2.2.1. Earth coordinates

The earth is a sphere, but an imperfect sphere: The geoid is the theoretical shape that closest to the actual surface of the earth, Mean sea level **(Fig.14)**. It serves as a reference to determine altitudes **(Lu, 2014) .**
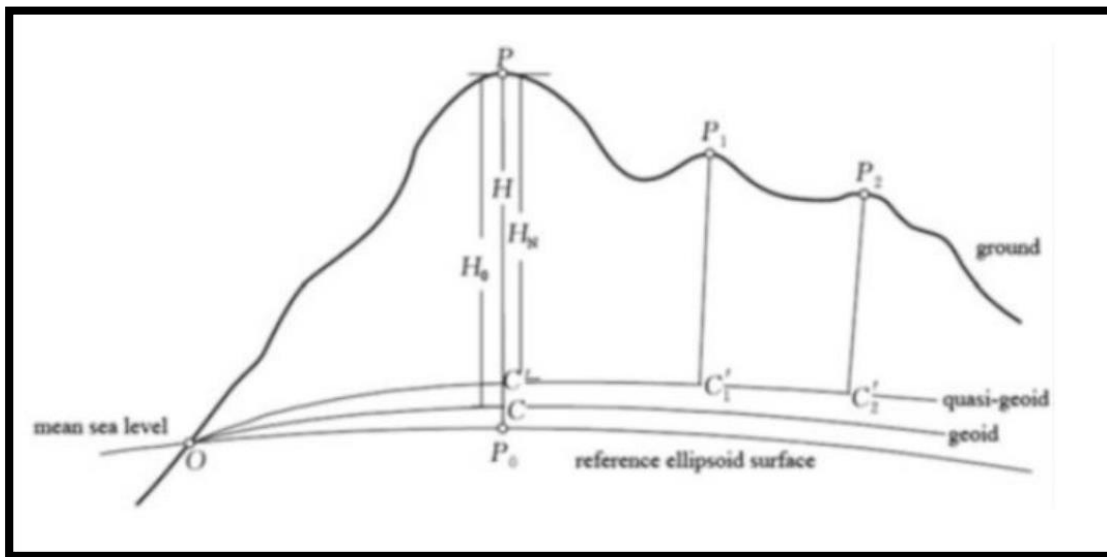
Figure 14: The geoid is the theoretical shape of the earth **(Lu, 2014) .**

The ellipsoid is the mathematical surface that most closely approximates the shape of the geoid **(Fig. 15)** and thanks to the latter, the geographic coordinates of longitude and latitude can be easily calculated **(Lu, 2014) .**
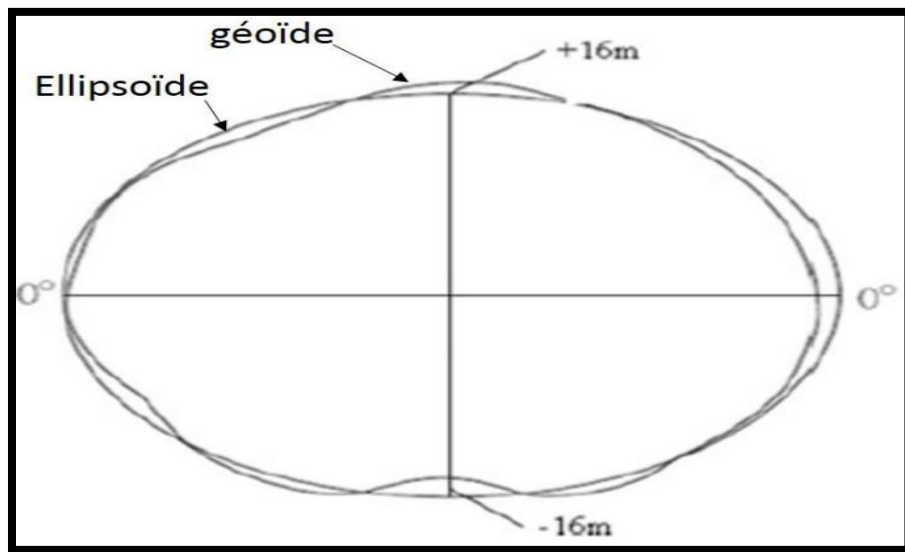
Figure 15: The ellipsoid **(Lu, 2014) .**

The mathematical process used to convert the ellipsoid into a plane is called: planar representation system or projection system or projection A Daum (local ellipsoid) is ellipsoid) is created on the selected ellipsoid and can incorporate local variations in variations in altitude. The datum and the underlying ellipsoid to which the coordinates of a dataset are referenced dataset are referenced can change the coordinate values.

It is possible to select a particular ellipsoid for use in a specific geographical area, if it mimics the geoid of that part of the world particularly well **(Lu, 2014) .**

2.2.2.2. The coordinate system

The coordinate system is a fixed reference structure superimposed on the surface of an area to designate the position of a point. of an area to designate the position of a point. The geographical base is given to a system of terrestrial coordinates, generally meridians and parallels, within the framework of a given map projection.

 Cartographic projection - this is georeferencing; any point on the base, and therefore any object and therefore any object integrated into the DBMS are identified spatially in X and Y with precision precisely. The Cartesian coordinate system and the geographic coordinate system used on the earth's surface are common examples of coordinate systems coordinate systems **(Steinberg, 2002).**

2.2.2.3. Map projection

A map projection shows a three-dimensional object, such as the globe of the earth, in two-dimensional format. The map projection is quite simply the most intriguing component of the intriguing component of the referenced coordinate system because it offers a high level of flexibility **(Galatia, 2006).**The mathematical procedure that enables the transition from the ellipsoid to the plane is called the projection system. This is impossible without causing deformations (or alterations) of lengths, angles and surfaces, the task assigned to the task assigned to projections is to reduce these alterations as far as possible. The smaller the scale, the greater the alterations **(Steinberg, 2002).**

2.2.2.3.1. The classification of systems according to the projection surface

The three most common projection surfaces are flat, conical and cylindrical **(Fig. 16).** It can be tangent or secant, direct, transverse or oblique **(Andrew, 2017).**

a) Cylyndrical Projection   a) Secant Planar Projection   a) Secant Conic Projection
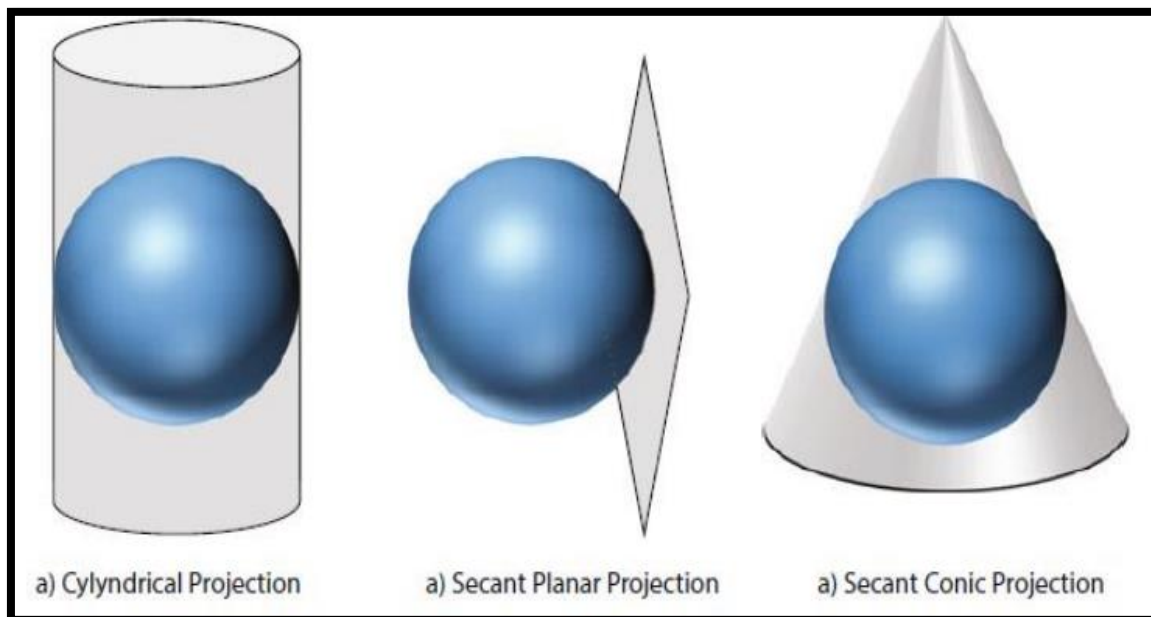
Figure 16: Projection types **(Andrew, 2017).**

2.2.2.3.2. Types of projections in Algeria

2.2.2.3.2.1. Lambert Conformal Conic projection

For the United States, the Lambert Conformal Conic uses the standard parallels of **33 N** and **45 N**. This keeps scale distortion relatively low, even at the edges of the map **(~ 3%)**. This projection is best for countries and states that show a decidedly east-west trend in their geographical extent **(Andrew, 2017).**

2.2.2.3.2.2. Universal Transverse Mercator (UTM) projection

UTM is one of the most commonly used projection systems with national and global coverage. It is based on the Mercator projection, which is equatorial, but has been moved transversely (wrapping the cylinder around the poles, rather than the equator). In total, there are **60 UTM** zones, and the main advantage of this organisational structure is that, for a given zone, the projected north-south bands (also known as "gores") are not also known as "gores") have virtually no shape distortion and very little surface distortion. surface distortion. As a result, spatial analysis within a UTM zone is quite accurate. For example, the distance between points can be calculated with no error greater than **0,04% (Andrew, 2017).**

2.2.2.4. The scale

By definition, scale is the ratio between a distance measured on the map and the same distance measured on the ground, in the same units. distance measured on the ground, in the same units **(Legrois, 1996).** This notion of scale is the same in GIS when elements of the geographic space are represented graphically either on screen or on paper **(Caloz, 2011).**A large scale is a scale with a high 1/x ratio, which means that x is small. Large scale is only of interest to small areas. Conversely, a small scale generally corresponds to considerable areas **(Legrois, 1996).**

2.2.2.5. Data storage models

There are two different models for storing, managing and structuring geographical data determine the type of geographic information system **(Fig. 17):** "raster" GIS and "vector" GIS. raster" GIS and "vector" GIS, both of which store and manage data integrating integrating raster or vector data. Each of the two systems geographic information storage systems, produces,

presents and manages digitised data in the form of pixels (picture elements), the "raster" mode, or in the form of geometric shapes geometric shapes (line segments, points, etc.) related to a vector plane (x, y) (x, y, z)when the third dimension is included **(Yeung, 2007)**. Spatial information in GIS can be used to switch from vector to raster mode and vice versa **(Verbyla, 2003).**
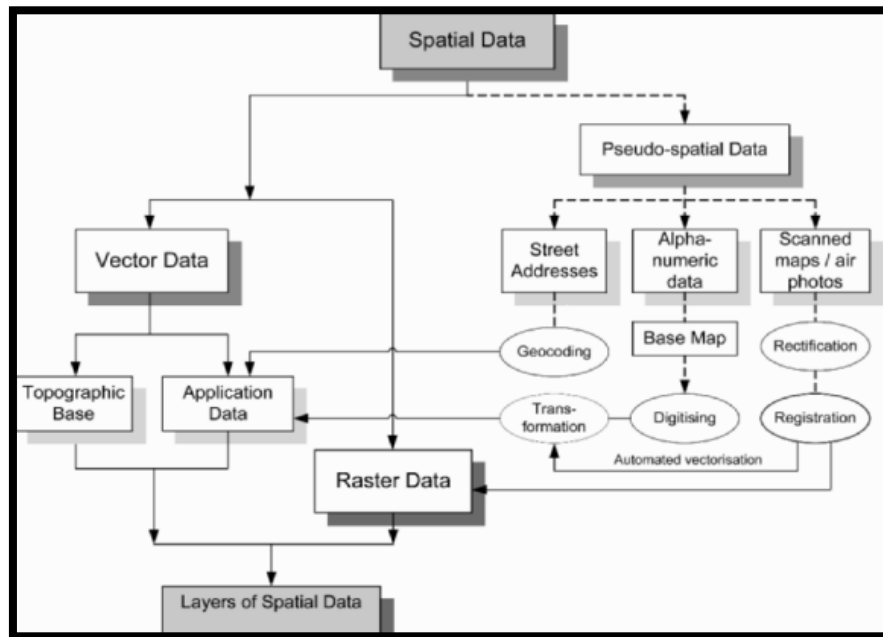
Figure 17: Spatial data types **(Yeung, 2007).**

2.2.2.5.1. Raster data

One type of geospatial data is referred to as raster data, or more commonly a (raster). The most easily recognisable forms of raster data are digital satellite images or aerial photographs. are digital satellite images or aerial photographs **(Figs. 18 and 19).** Slope shading or digital terrain models are also represented in raster. Any type of cartographic data can be represented as raster data, but there are a number of ways in which this can be done. Limitations A raster is a regular grid made up of cells, or in the case of imagery, pixels. pixels, there is a set number of rows and columns where each cell has a numerical value and a certain has a numerical value and a certain geographical size **(Athan, 2010).**
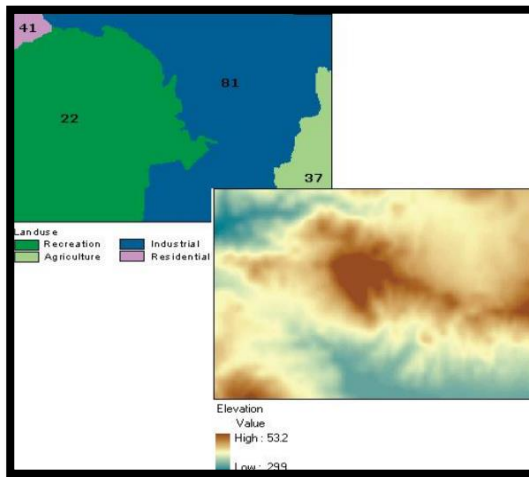
Figure 18: Elevation Map **(Skidmore, 2003).**
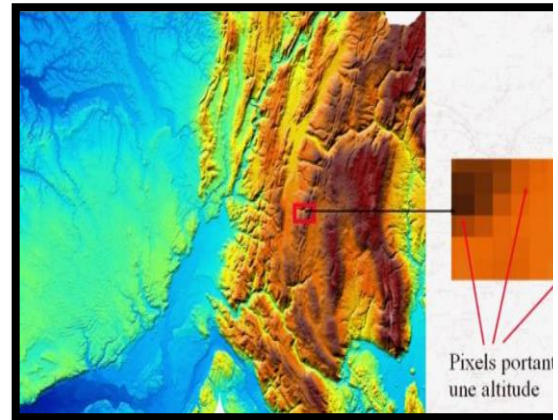
Figure 19: Data where space is evenly divided **(Skidmore, 2003).**

2.2.2.5.2. Vector data

According to **(Denegre, 2005)**, to represent objects on the surface of the globe, GIS use three geometric objects: the point, the line and the surface **(Fig 20).**

*The point

The simplest object can represent trees, fire hydrants; refuse collectors, etc. on a large scale. Fire hydrants, refuse collectors, etc. But at smaller scales, such as a road map at a scale of 1/1 000 000 it represents a regional capital.

*The line

The line represents communication, energy, water and sewage networks etc. . . It can be fictitious, representing the axis of a road, or virtual, modeling information and money flows. Modeling flows of information and money.

*The surface (polygons)

It can represent an abstract entity such as the surface area of a municipality, or entities that entities that exist geographically, such as a forest, a lake, a built-up area, etc.
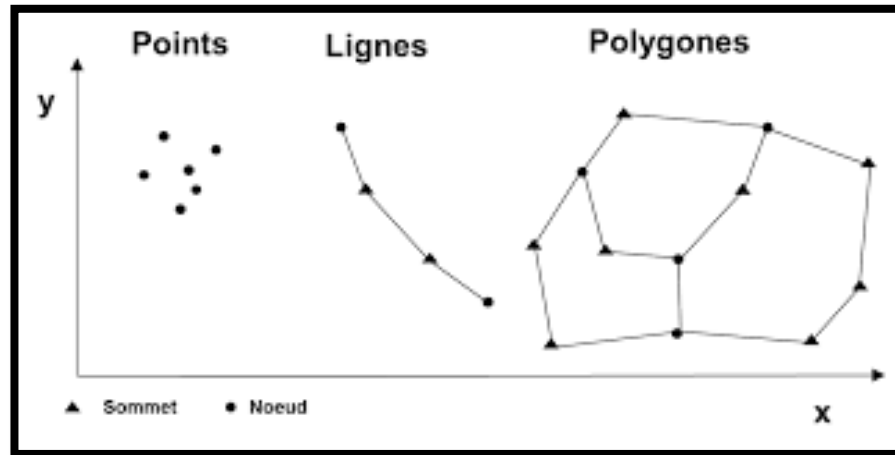
Figure 20: Vector data types **(Skidmore, 2003).**

Part

Experimental

Chapter 03
Presentation of the study area

3.1. Geographical location

Located 340 km from the capital Algiers in the northwest of the country, the wilaya of Tiaret presents itself as a contact zone between North and South. The territory of the wilaya is farid in South. It extends over a space delimited between 0.34° to 2.5° East longitude and 34.05° to 35.30° North latitude **(Official website of the wilaya of TIARET, 2019)**

Tiaret occupies an area of 208793 km^2, it covers part of the Tell Atlas in the North and the high plateaus in the center and in the South. It is bounded to the north by the wilayas of Reliant, Cheleff and Tissemsilt, to the west by the wilayas of Mascara and Saida, to the east by the wilaya of Djelfa, in the South and South-East by Laghouat and El Bayd. **(Official website of the wilaya of TIARET, 2019)**
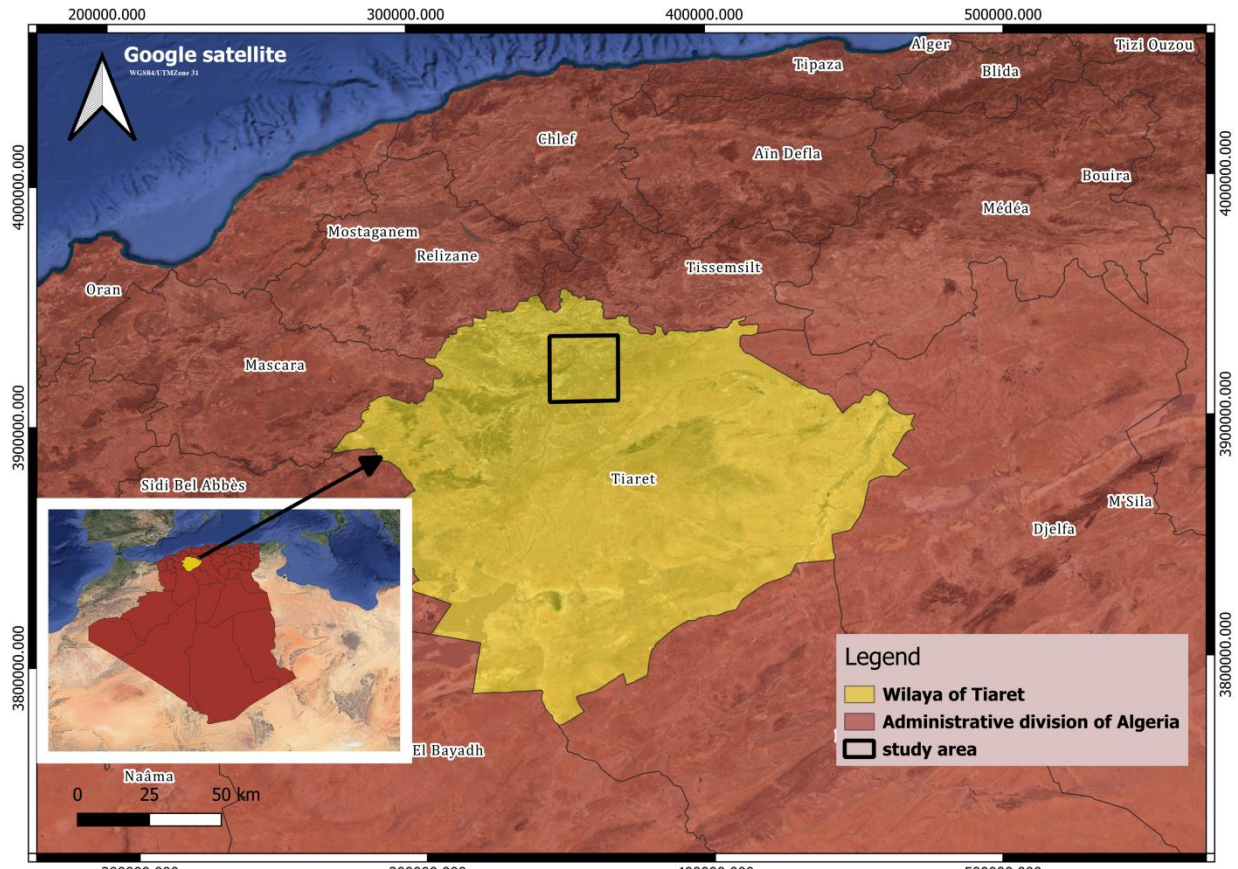
Figure 21: Geographical position of the Tiaret region **(QGIS-personal work)**

3.2. Geographical limits of the DAHMOUNI commune

The commune of DAHMOUNI belongs to the wilaya of Tiaret; it is limited to the north by the commune of Sidi Hosni, to the south by Nahr Ouassel and the commune of Bouchakif, to the east by the commune of Sabaïne, to the west by the commune of Oued Lili and Tiaret (**fig 22**). So the municipality covers an area of approximately 164.25 km^2

It is a commune with an agricultural vocation where the land occupies a total of 13670 ha. They are mainly occupied by the practice of cereal growing in association with fallowing.
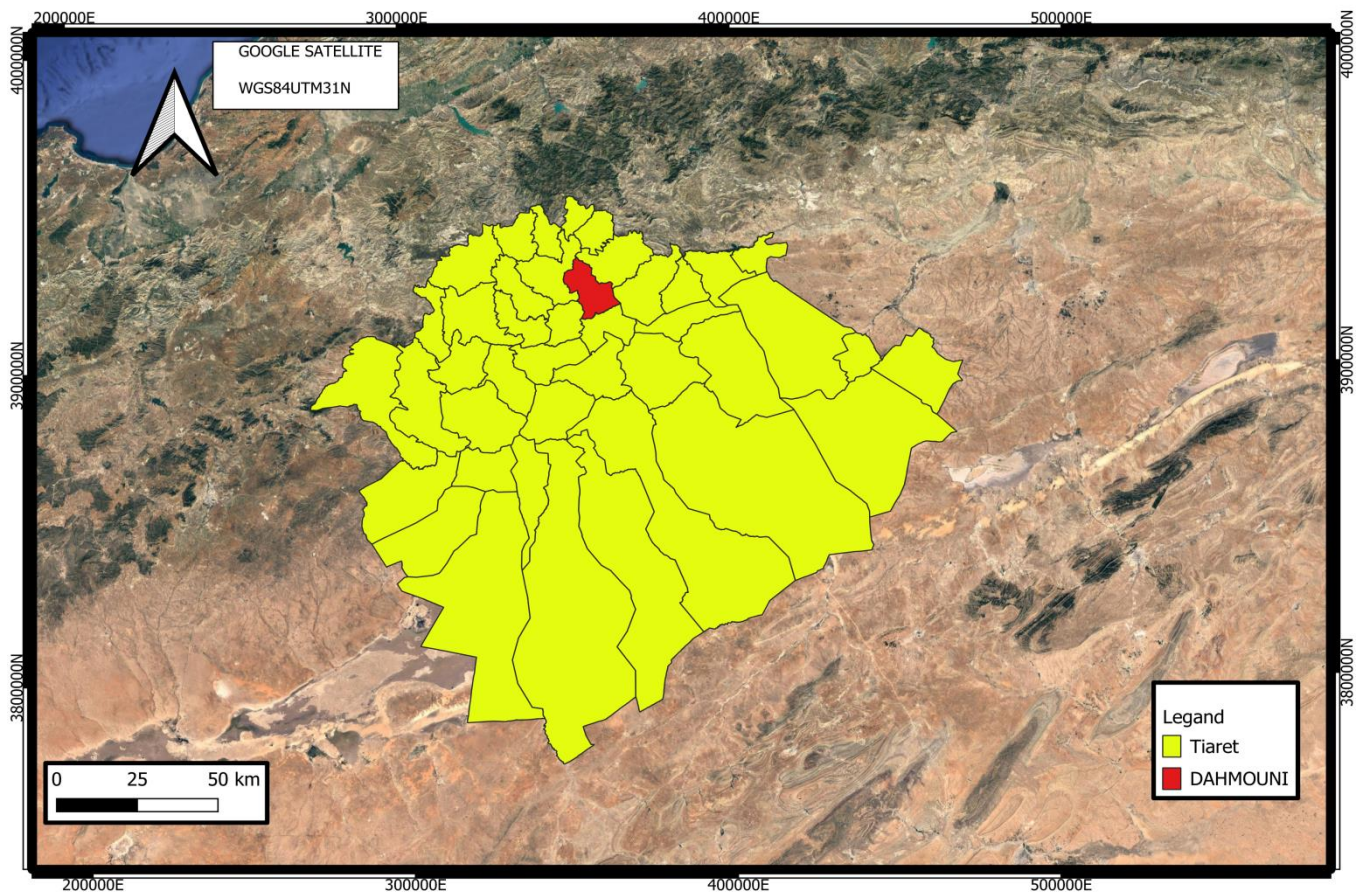
Figure 22: Local situation of the study area (**QGIS-personal work**)

3.3. Location of the experimental site

* GPS coordinates:

- Latitude: 35° 25′ N

- Longitude: 01° 29′ E

The hydro-agricultural perimeter of DAHMOUNI is located in the North-West region of Algeria, in the Serous highlands, within the wilaya of Tiaret

The DAHMOUNI dam, built in 1987, is located on the Oued Ouassel, a tributary of Oued Chelef, about 8 Km North-East of the city of DAHMOUNI and 20 Km East of Tiaret **(fig 23)**
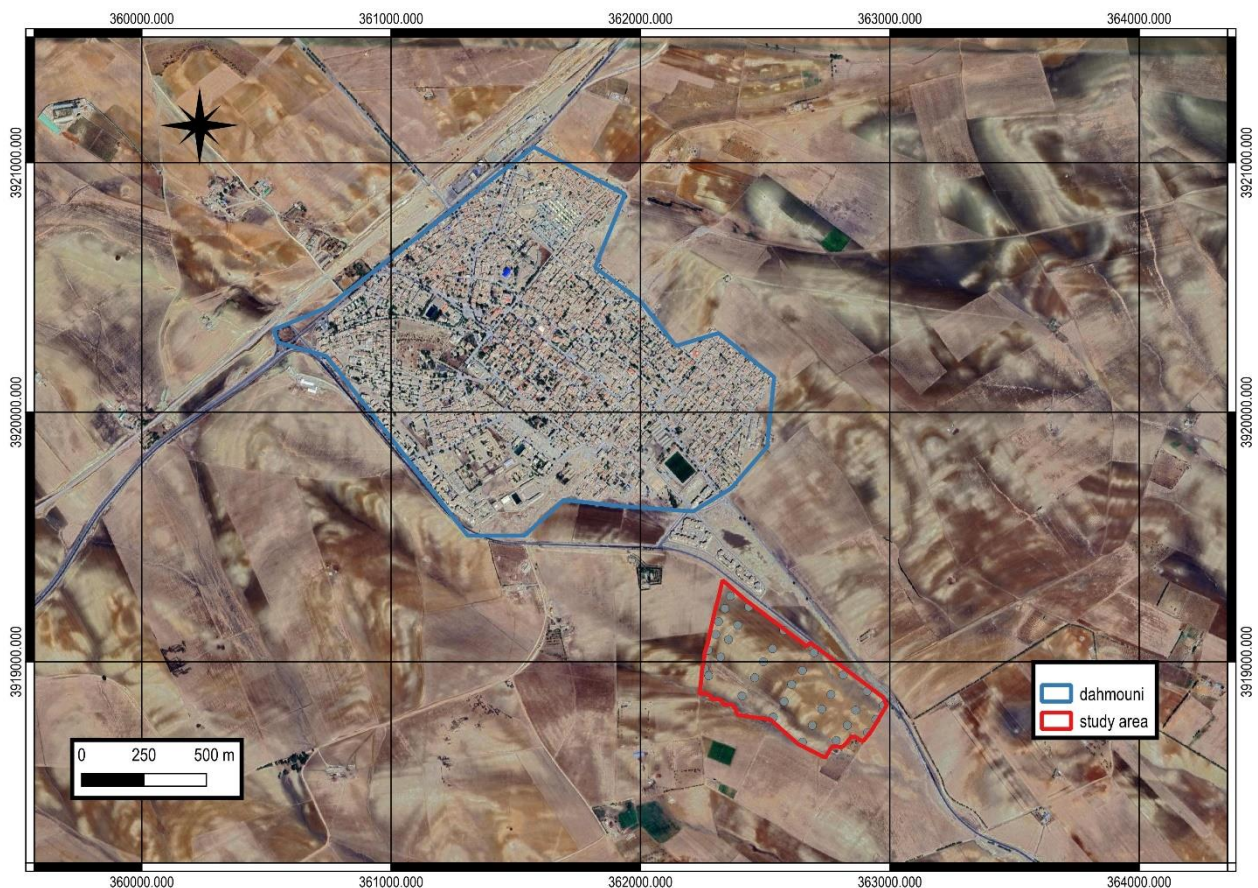
Figure 23: Local situation of the study area **(QGIS-personal work)**

The waters of this work are intended for the irrigation of 4000 hectares downstream and in upstream of the following crop dam:

. Vegetable grower

. Arboriculture

. Cereal farming

The scope is split into three parts which are:

Part 1: irrigation of 1214 ha upstream of the dam, left bank.

Part 2: irrigation of 1326 ha upstream of the dam, right bank.

Part 3: irrigation of 1684 ha of the downstream part of the Oued.

3.4. Soil overview

According to the water resources department (e.g. hydraulics) of the Wilaya of Tiaret (**DRET, 2005)** the soils of the future irrigated perimeter of DAHMOUNI are moderately permeable (permeability between 2 and 6 cm.h-1), porous (porosity varying between 42.74 and **47.14%** with a distribution approximately **50%** for macro-porosity and **50%** for micro-porosity), with an apparent density oscillating between **1.39** and **1.44 g/cm3** and they have good internal drainage. **(AHMED, 2006)**

3.5. Climatological overview

The Tiaret region is located between isohyets 350 mm in the south and 470mm in the north. She is characterized mainly by a continental climate with cold wet winters and has been hot and dry. **(Soudani, 2011)**

3.5.1. Precipitation

The study of the rainfall factor, its repair over the whole year and its intensity is very important since it represents an abiotic factor of significant importance on the evolution and distribution of species in the natural environment. **(Sbihi, 2016)**
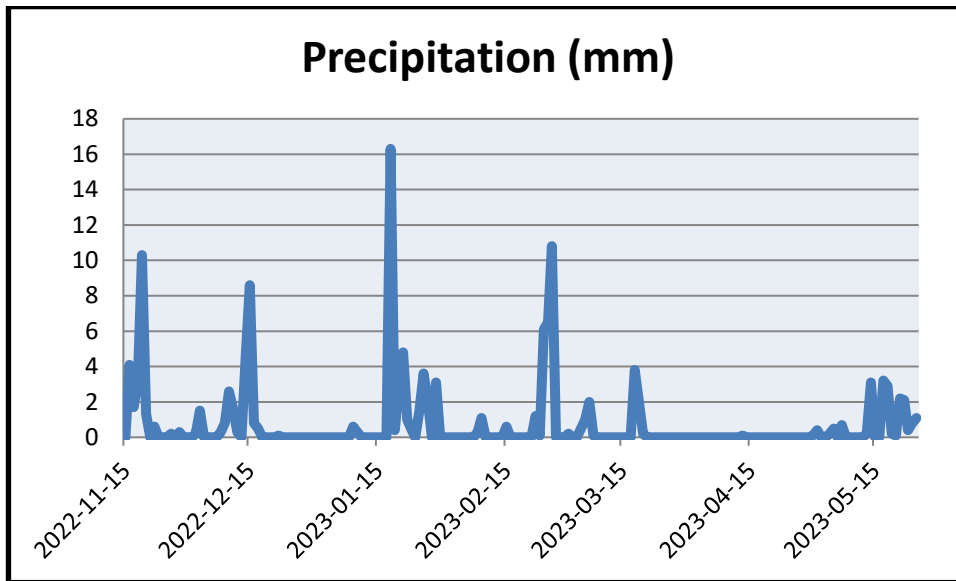
Figure 24: The curve represents the precipitation graph for the years 2022 and 2023 for Tiaret

3.5.2. Temperature

Temperature is one of the most important elements to characterize the type climate and determine its humidity regime. Temperature conditions vary during the day and according to the intensity of the insolation. **(Sbihi, 2016)**
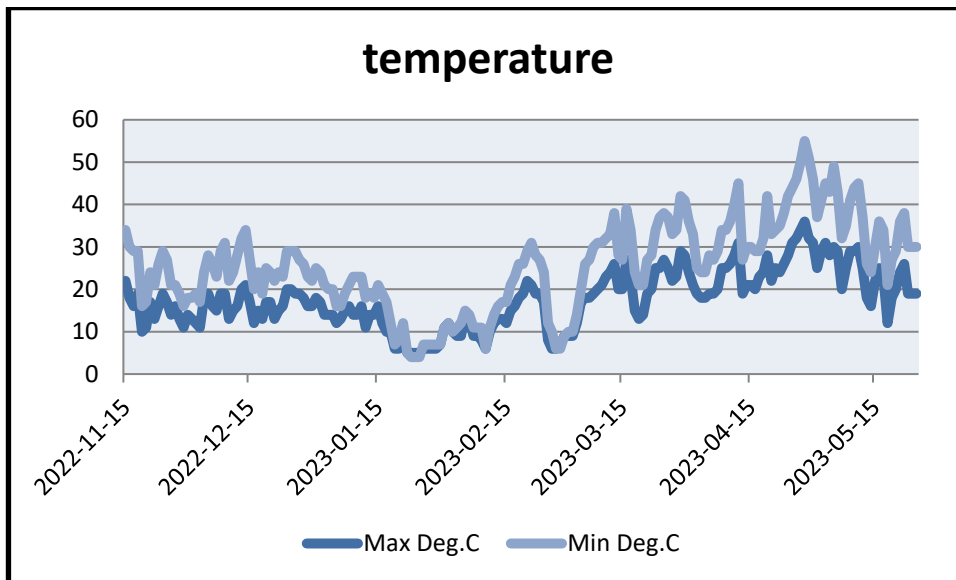
Figure 25: The curve represents the temperature graph for the years 2022 and 2023 for Tiaret

3.5.3. Wind

The wind is one of the most characteristic factors of the climate, and the knowledge of its strength and its direction is also necessary because it accelerates evaporation.It has a variable displacement regime depending on the altitude. Pressure atmosphere and the seasons. It is a climatic factor which also leads to variations temperature and humidity, and exerts a mechanical and physiological action on the forest trees and agriculture. The prevailing winds for the Tiaret region are those from a direction northwest, winds from a southeasterly direction are less frequent and can reach a varying speed of 13.2 to 14.9 m/s.
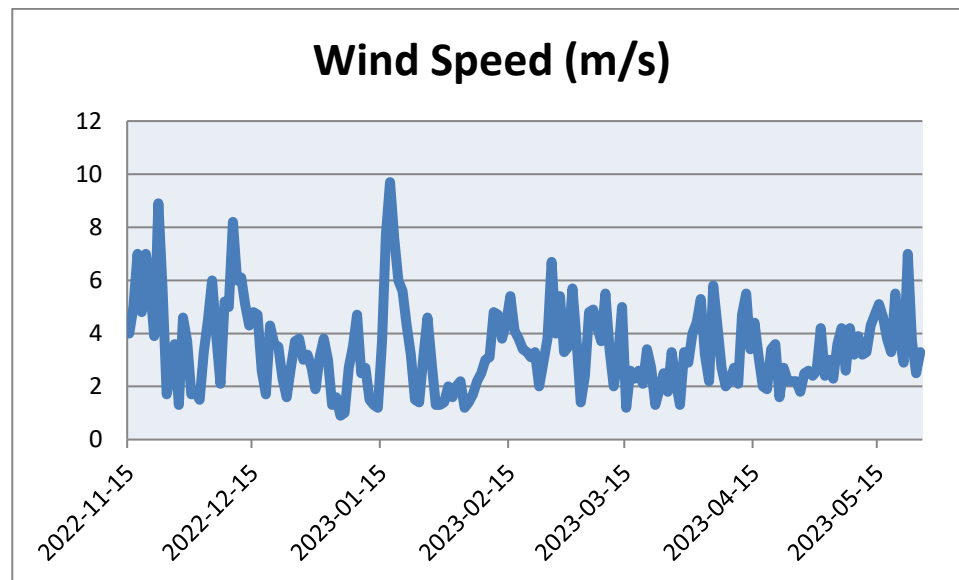
Figure 26: The curve represents the Wind graph for the years 2022 and 2023 for Tiaret

3.6. Agriculture

Agriculture is the main activity practiced by the entire population. distribution of the agricultural area is presented herewith. We can point out the dominance of cereals (59.28%) and fallow land (39; 26%). the analysis of useful agricultural area highlights two production systems.

- A dry production system; including cereal growing; legumes ;rustic arboriculture; the vineyard   and the fallow land
- An irrigated production system; including market garden crops and
pome arboriculture (pear tree, apple tree). **(OUMAROU.M, 2012)**

CHAPTER 4
Materials and methods

4. Material and Methods

4.1. Sampling and choice of sample

4.1.1. Soil

   A preliminary work was done to analyze the satellite image, which is to take a soil sample, where 33 systematic samples were taken. The figure 27 shows the points from which we took samples of soil to examine it and study its characteristics .The following figure shows the points.
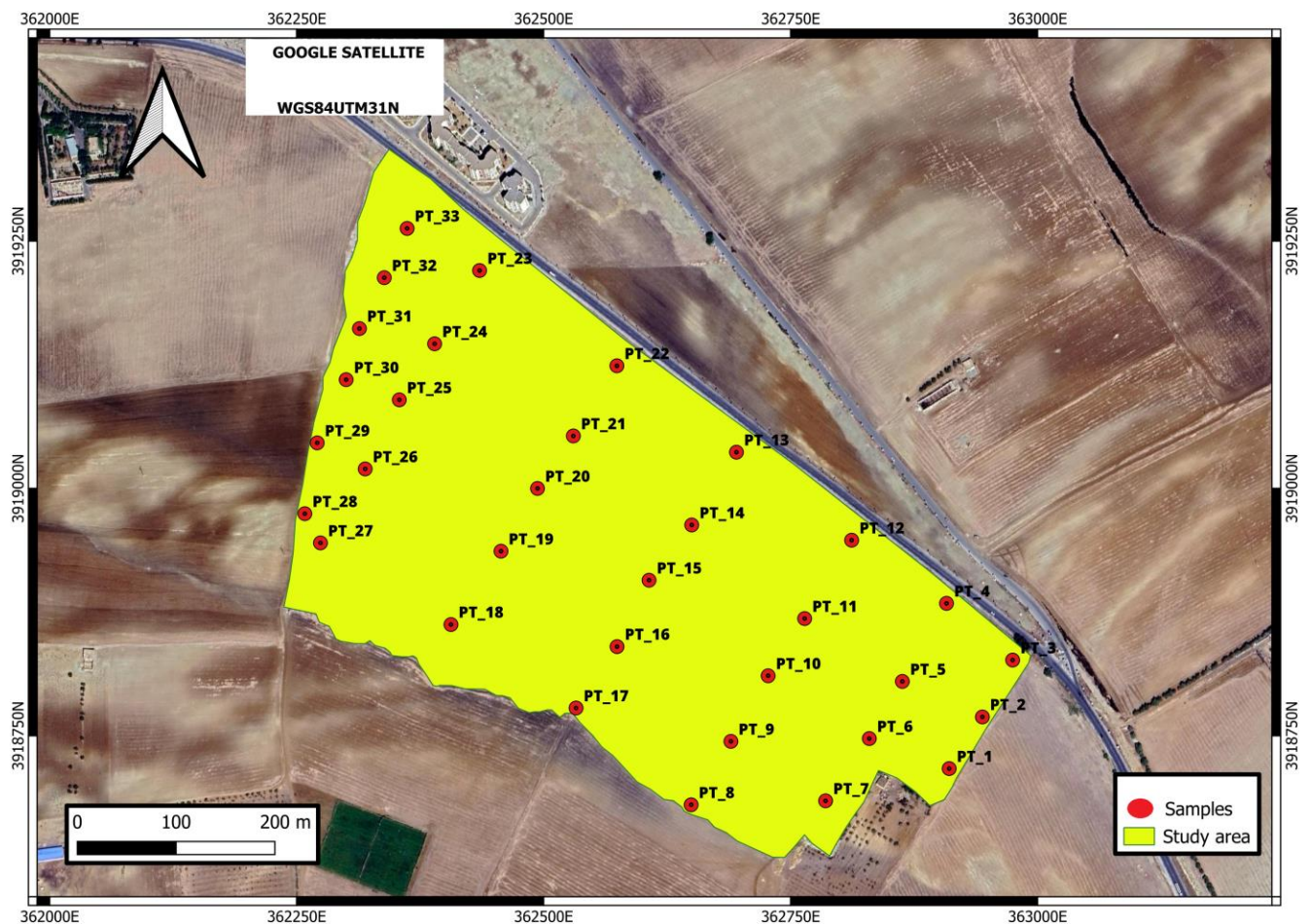
Figure 27: A map showing the locations of soil samples **(personal work in QGIS software)**

4.2. Methodes

The experimental protocol for the soil samples is shown in the figure

Plot of land from DAHMOUNI

33 samples

At depth 30 cm

Humidity calculation

Soil analysis

Physical analysis

Chemical analysis

Granulometry

PH	EC
CaCo$_3$	NPK
Organic material	Active limestone
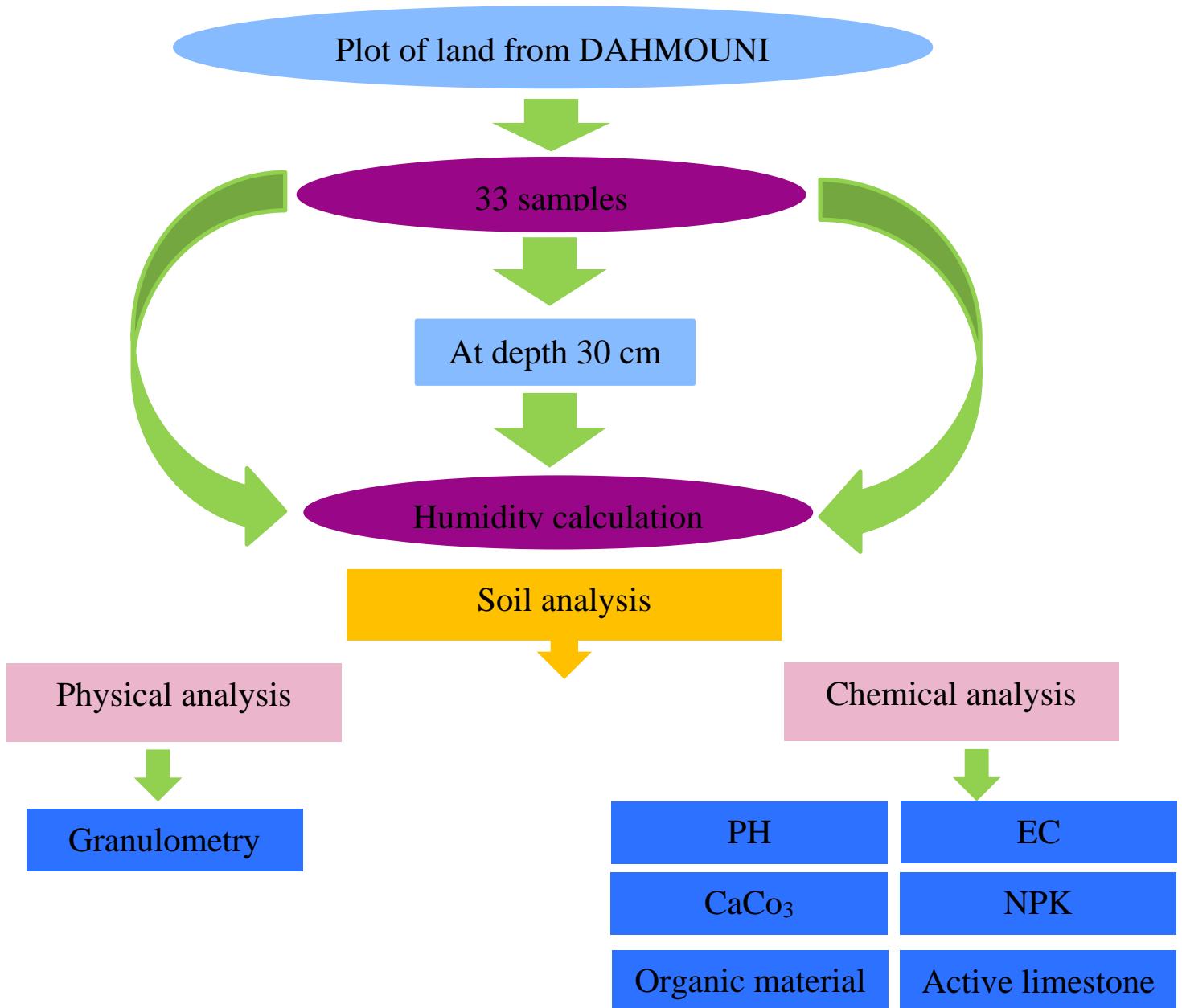
Figure28: Experimental protocol

4.2.1. Soil sample preparation

4.2.1.1. Bring the soil and dry it

After bringing a soil sample to the laboratory, we dry it in the open air over 24 hours to be ready to Work on it.

Figure 29: Bring the soil **(Cliche SENOUCI SOUAD, 2023)**

4.2.1.2. Soil sifting and breaking

The samples were crushed using a pestle and mortar, passed through a sieve with a diameter of 2 mm keeping the fine soil samples in bags in order to be used in various soil analyses.

Figure 30: Soil sifting and breaking **(Cliche SENOUCI SOUAD, 2023)**

4.3. Physical analysis

4.3.1. Humidity calculation

   Soil moisture is defined as the amount of water stored in the soil, and it collects in its pores and voids this water may be in the liquid, solid, or gaseous state, depending on external factors (weather conditions and climate changes). **(Cherlinka, 2023).**

4.3.1.1. Principles of Humidity

   Is the weight loss after drying at 105°C expressed as a percentage (or thousand) relative to the percentage of air-dried soil.

 At the "dew point temperature td" the saturation vapour pressure equals the actual vapour pressure ew (td) =e and the relative humidity reaches its maximum value of Uw=100%. **(Razika, 2013)**

Figure 31: Weighed and oven-dried soil samples **(Cliche SENOUCI SOUAD, 2023)**

*How to work in the laboratory

This analysis does not require the grinding and sieving of the samples. The analysis of the moisture content of the samples must be done on the same day as their collection This is important information for knowing the water status of the soil. The protocol is simple and is done as follows:

• Weigh using a precision scale, a glass capsule empty.

• Tare the weight of the capsule and weigh 20g of soil sample.

• Put in the oven at 105°C for 24 hours.

• Weigh the capsule containing the dried sample, after having allowed it to cool to room temperature in a desiccator.

The equation is

> **H= (Empty capsule+10g) - capsule after 24 hours / empty capsule × 100**

H: humidity in %.

E capsule: Capsule weight before operation.

Capsule after 24 hours: at 105°C.

4.2.3 Granulometry

It is defined as the measurement of the sediment grain size in a granular material as a percentage of the weight of particles of different sizes. The granularity analysis involves sieving the material and subsequent weighing of the individual fractions combined into mainly three groups. The smallest part, the clay, is less than 75 micrometers in diameter. The sand fraction contains all grains with a diameter between 75 μm and 2 mm, and the gravel fraction consists of all grains with a diameter of more than 2 mm.**. (kumar, 2014).**

4.2.3.1. Principles of Granulometry

All types of soil consist of granules of different sizes and shapes. These particles are grouped into volume intervals (fractions). The distribution of fractions forms the granular structure of the soil (Latin granular - small grains).

The granular structure or particle size distribution of soils is one of its basic descriptive criteria, and is used to evaluate the physical and mechanical properties of soils and to classify soils, as well as either an indicator or a factual measure for assessing whether a soil is suitable so that larger fractions are determined by sieving, while smaller fractions are subject to the densimeter method liquids or simply sedimentation, with the aim of knowing the texture of the soil and whether it is suitable for cultivation. **(Geotechnical investigation and testing, 2019)**

***How to work in the laboratory**

• In an erlen, weigh 20g of fine earth.

• Add 50 ml of hydrogen peroxide, and leave to act overnight, so that all the organic matter is destroyed.

• Add 20ml of hydrogen peroxide, and put on a sand bath under the high, until the foam disappears.

• For the dispersion of clay elements, use 25ml of sodium pyrophosphate solution (20g per liter of distilled water) if the soil is not calcareous. If, on the contrary, we have calcareous soil, we use 50ml of the Calga solution (39.2 sodium met phosphate $NaPO_3$ + 10g of sodium carbonates Na_2CO_3 per liter of distilled water).

• Mechanical stirring for 2 hours.

• Pour the suspension into a 0.05mm sieve and rinse with distilled water, and collect the solution in a tank which will then be poured into a cylinder using a funnel.

• Complete the solution poured into the cylinder with distilled water up to the 1 liter mark.

• Put the remaining sand on the 0.05mm sieve in a known weight crucible, and

• Put in the oven at 105°C/ 15 hours.

-• For the fraction < 0.05mm, the cylinder is shaken and the sample is taken in the middle using the Robinson pipette.

• For the fraction of < 0.02 mm, the cylinder is shaken, and allowed to stand for 4min and 40 seconds, then a sample is taken at 10cm using the Robinson pipette

• For the fraction < 0.002mm, the cylinder is shaken, and left to stand for 4 hours and 39 minutes, then a sample is taken at 6cm using the Robinson pipette.

-• The samples are placed in crucibles of known weight, then they are dried in an oven at 105°C/15 hours.

• After removing all the samples from the oven, they are left to cool in a desiccator and weighed. We also weigh the sample of sand, then we sieve it to 0.2 mm, and we weigh the coarse sand which remains in the sieve, and the fine sand which has passed through the meshes of the sieve.

• Make the calculations and determine the texture of the ground thanks to the triangle of textures.

The equation is

(1)= Clays + soluble salts = [(6cm dry soil + tare) - tare].100

(2) = LF + A + soluble salts = [(10cm dry soil + tare) - tare].100

(3) = LG + LF + A + SS = [(middle dry soil + tare) - tare].100

(4) = Sands = (sand + tare) – tare

  Coarse sand = (coarse sand + tare) - tare Fine sand = sand (4) – coarse sand Coarse silt = (3) – (2)

Fine silt = (2) – (1)

Clay = (1) – soluble salts (2.5g Calgon or 0.5g sodium pyrophosphate).

We calculate the sum (S) and check if we find the 20g of soil with which we worked. Calculate percentages by multiplying all results by 100/20.
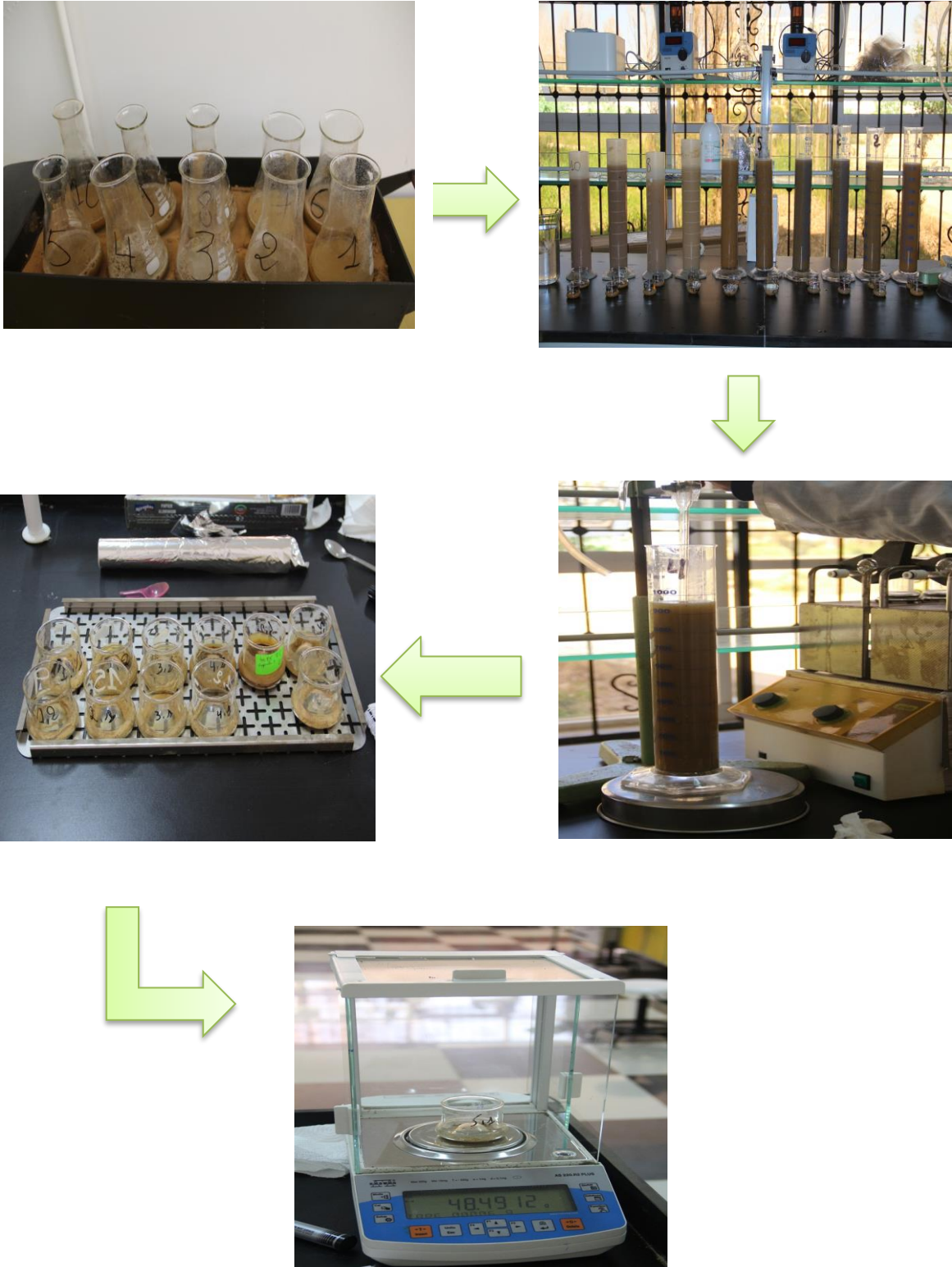
Figure 32: Particle size analysis by the Robinson pipette method**(Cliche SENOUCI SOUAD, 2023)**

4.4. Chemical analysis

4.4.1. PH

Soil pH is one of the most routine and informative measurements performed in standard soil analyses. As a single measurement, pH describes more than relative acidity or alkalinity. It also provides information on nutrient availability, metal dissolution chemistry, and the activity of microorganisms. **(Miller & David E. Kissel, 2010).**

Generally, to measure pH, water is added to the substrate in a certain volume ratio; thus the pH (H_2O) is determined. In practice with KCl or $CaCl_2$ solutions are also used to extract and measure pH (KCl) or pH $(CaCl_2)$.

Since exchange reactions occur between the supplied K^+ or Ca^+ cations and the H^+ ions on the exchange capacity of the substrate, there will be more H^+ ions in the solution at equilibrium and therefore the pH will be lower.

The difference between the pH (H_2O) and pH (KCl) values ranges from 0.5 to 1 pH unit. Therefore it is necessary to follow the pH indicator with H_2O or KCl. Knowing the pH is interesting to perform fertilization and to meet the requirements of the plant. **(Lemaire F, 2003).**

4.4.1.1. Principles of PH

A pH meter will be made up of a probe, which itself is made up of two electrodes. This probe passes electrical signals to a meter which displays the reading in pH units. The glass probe has two electrodes because one is a glass sensor electrode and the other is a reference electrode.

Both electrodes are hollow bulbs containing a potassium chloride solution with a silver chloride wire suspended into it. The glass sensing electrode has a bulb made up of a very special glass coated with silica and metal salts. This glass sensing electrode measures the pH as the concentration of hydrogen ions surrounding the tip of the thin walled glass bulb. The reference electrode has a bulb made up of a non-conductive glass or plastic. (www.slideshare.net, 2015)**.**

Soil pH is measured in a soil/solution ratio = 1/2.5. A first measurement is made with demineralised water. The second is carried out with a molar solution of potassium chloride **(jean, 1993).**

*How to work in the laboratory

• Weigh 20 g of the fine soil into a 250 ml flask

• Add 100 ml of distilled water to the soil.

• Shake for 5 minutes.

• Let's stand for 30 minutes.

• Turn on the pH meter and perform the calibration.

• Place the pH meter electrode in contact with the supernatant and read the value you got.
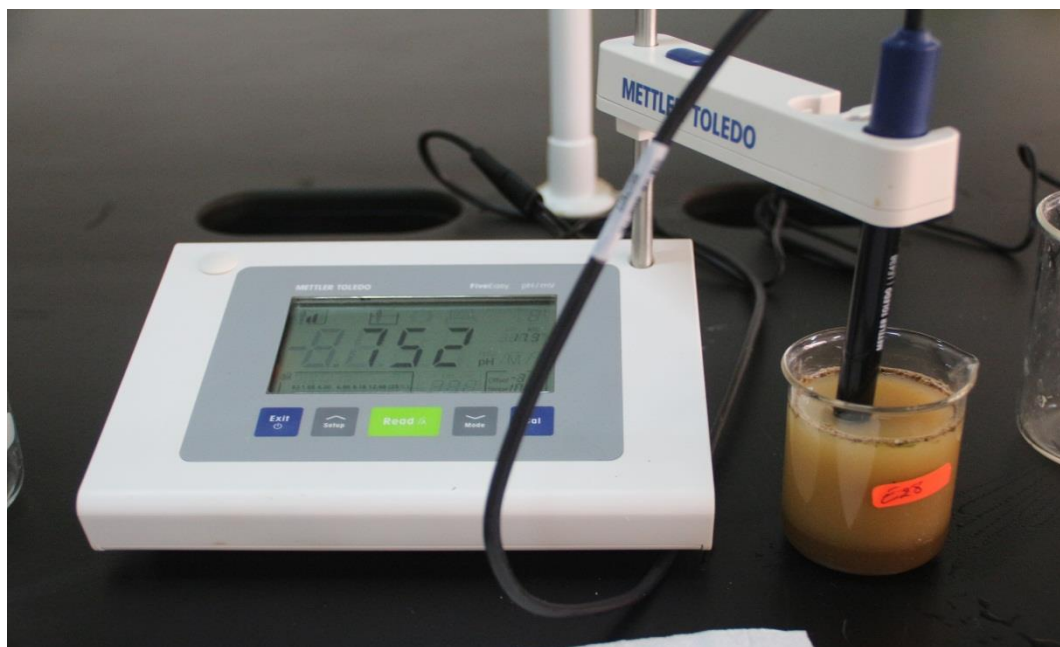
Figure 33: How to calculate the pH by the pH meter **(Cliche SENOUCI SOUAD, 2023)**

4.4.2. PHKcl

• In the same solution as above, add 50 mL of Kcl (0.1 g per liter of distilled water).

Shake for 5 minutes.

• Let it stand for 30 minutes.

Place the pH meter electrode in contact with the supernatant.

• Read the value you got.

• Rinse the pH meter electrode with distilled water before and after each use and dry with Joseph's paper.
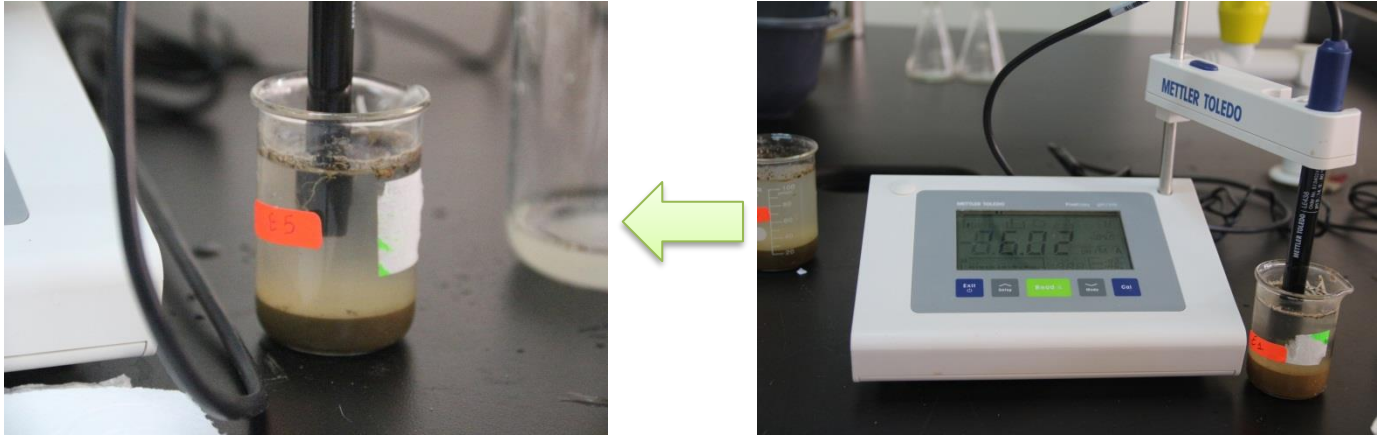
Figure 34: Measuring the pHKcl of a soil sample using a pH meter **(Cliche SENOUCI SOUAD, 2023)**

4.4.3. Electrical conductivity (EC)

Soil electrical conductivity (EC) measures the ability of soil water to carry electrical current. Electrical conductivity is an electrolytic process that takes place principally through water-filled pores.

Cations (Ca^{2+}, Mg^{2+}, K^+, Na^+, and NH_4^+) and anions (SO_4^{2-}, Cl^-, NO_3^-, and HCO_3^-) from

Salts dissolved in soil water carry electrical charges and conduct the electrical current. Consequently, the

Concentration of ions determines the EC of soils.

In agriculture, EC has been used principally as a measure of soil salinity (table 1); however, in non-saline soils, EC can be an estimate of other soil properties, such as soil moisture and soil depth. EC is expressed in DeciSiemens per meter (dS/m). **(Soil Quality Indicators, December 2011)**

4.4.3.1. Principles of Electrical conductivity (EC)

The determination of electrical conductivity (EC) is made with a conductivity cell by measuring the electrical resistance of a 1:5 soil: water suspension. **(SOIL SURVEY STANDARD TEST METHOD)**

*How to work in the laboratory

• Weigh 10g of soil in a 100ml beaker.

• Add 50ml of distilled water.

• Shake for 5min.

• Let stand for 30 minutes.

• Turn on the conductivity meter, and rinse the electrode with distilled water and wipe with Joseph paper.

• Put the electrode in the supernatant of the solution, and read the displayed value.

Figure 35: Measurement of the electrical conductivity of the ground by the conductivity meter

(Cliche SENOUCI SOUAD, 2023)

4.4.4. NPK fertilizer

The letters "NPK" on a fertilizer label stand for nitrogen, phosphorus and potassium, which are the three essential nutrients plants, need to grow.

These fertilizers contain 20% nutrients and 80% are secondary nutrients. Plants need about 16 nutrients. Some he gets from air and water, and others nutrients like iron, calcium and chlorine from the soil.

Nitrogen (N), the first number in the NPK sequence, plays a major role in plant coloration and chlorophyll production, making it an important factor in leaf development. Fertilizers high in nitrogen are often used on lawns or other plants where green leaf development is more important than flowering.

Phosphorus (P), the middle number in the NPK Series Phosphorus plays a key role in root development, flowering and fruiting, which is why it is an essential nutrient for your plants in the spring. It also contributes to many essential plant processes, such as rooting and seed formation.

Potassium (K), The final number on the list of main ingredients shows the percentage of potassium in the product. Potassium contributes to the overall health and vitality of plants. It is known to help strengthen plants' ability to resist disease, and to aid in the movement of water and nutrients in the plant.

(BEAULIEU, MARY MARLOWE LEVERETTE,, & ELIZABETH MACLENNAN, 2023)

4.4.4.1. Principles of NPK fertilizer

Measuring the soil contents of N (nitrogen), P (phosphorous), and K (potassium) is essential for the nutrients that must be added in the soil to increase crop fertility.

This improves Soil quality which in turn yields a good crop. In the present work, color sensors based on optical fibers were developed to determine the values of N, P and K in the soil sample. **(Deepa V. Ramane1, 13-14 February 2015)**

*How to work in the laboratory

The electro-chemical method and the method of ionization reduction were adopted and the tester is for field use, to quickly test instant nitrogen, instant phosphorus and instant potassium content in soil.

1/- Take off the protective cap from metal probe.

2/- Press off/on button tester displays 0.

3/- Quick testing water the soil with distilled water before testing make are the water can go 10 cm deep the least. Best humidity is 70%-80% insert the metal probe into sol vertically and clock wisely, to about 6-8 am deep and make sure the soil has thorough contact with metal probe.

4/- After about 6 seconds, the tester will display the measured value.

5/-Tightness of soil will affect measuring result, multiple tests at the same and different points should be performed and take the average as final result. Accurate testing.

6/- Use a 200ml beaker container mix dried soil with distilled water at the stir and make it into a mud form.

7/-Put the metal probe into the mud about 6-bcm deep. About 6 seconds, the tester will display the measured value.

8/- wipe the metal probe with towel or tissue paper after each test make it clean and dry, till the display shows 0 . (Measuring units: 1mg/kg=1mg/1=lug/ml=1ppm)

How to calculate NPK content

To convert mg/kg to kg/ha we need (i) area (ii) bulk density and (iii) layer depth if area is 1 ha, bulk density is 1.2 t/m3 and soil depth is 30 cm (0.3m) volume of soil layer is:

10000 x 0.3=3000 m3 mass of soil layer is 3000 m3 x 1.2 t/m3 = 3600 or 3600000 kg if NO3 content per kg soil is 10 mg 3600000 x10 = 36 kg no3 /ha at a layer depth of 30 cm.
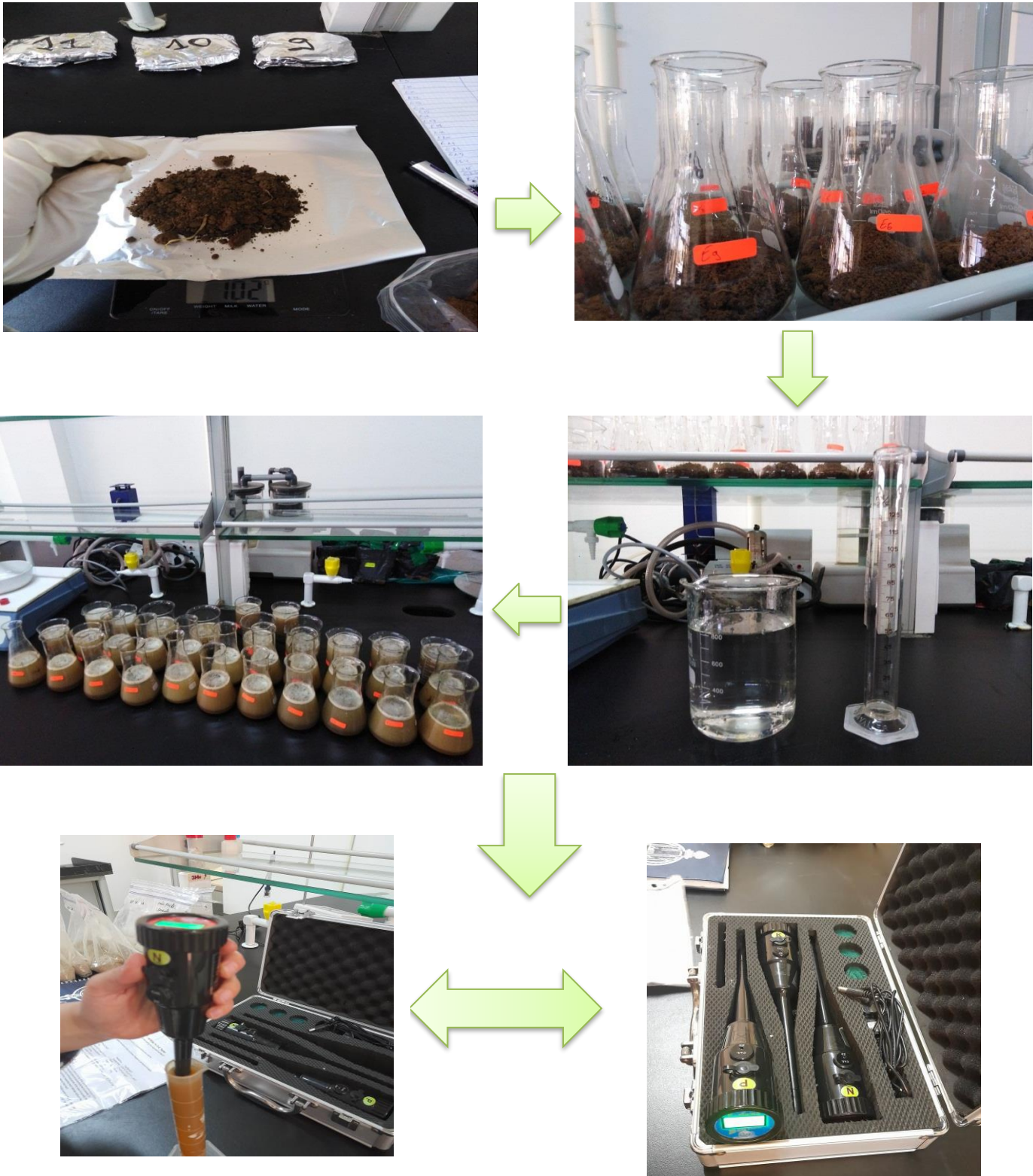
Figure 36: Measurement of NPK values by NPK sensors **(Cliche SENOUCI SOUAD, 2023)**

4.4.5. Total limestone

  Total limestone is one of the components inherited from the soil, possibly slightly modifiable by massive and repeated contributions of basic amendments.

  The analysis of total limestone is necessary to refine the characterization of soil constituents and improve strategic choices in terms of liming. **(Mimoune, 2020) .**

4.4.5.1. Principles of total limestone

  The total limestone defined as being the totality of the limestone dosed by destruction with HCl. It is carried out using the BERNARD calcimeter method.

 Its principle is based on the decomposition of calcium carbonate by hydrochloric acid and the measurement of the volume of CO_2 obtained. **(ELHACHMI, 2001).**

***How to work in the laboratory**

• Weigh 1g of fine earth in a 250ml Erlen.

• Hold the lateral appendix using metal forceps, and fill it with HCl to 37% at 3/4.

• Dry the walls of the Erlen with joseph paper to avoid HCl-soil contact

• Open the bulb of the calcimeter and adjust the level of the calcimeter to zero.

• Connect the Erlen to the calcimeter, taking care to close the opening properly.

• Read the volume of CO_2 released (V0).

• Spread the acid on the earth, and read the level of the volume of CO_2 released on the calcimeter (V1).

• For the witness, we replace the earth with 0.3g of $CaCO_3$ and we read the volume V0 when we connect the Erlen with the calcimeter and the V1 after the contact of the HCl with the $CaCO_3$.

The equation is

$$CaCO_3 \% = \frac{Vs \; x \; mCaCO_3}{Vt \; x \; msoil} \; x100$$

msoil = 1g

mCaCO3 = 0.3g

Vs = V1 ground –V0 ground

Vt = V1 sample –V0 sample V0 = Initial volume

V1 = Volume read
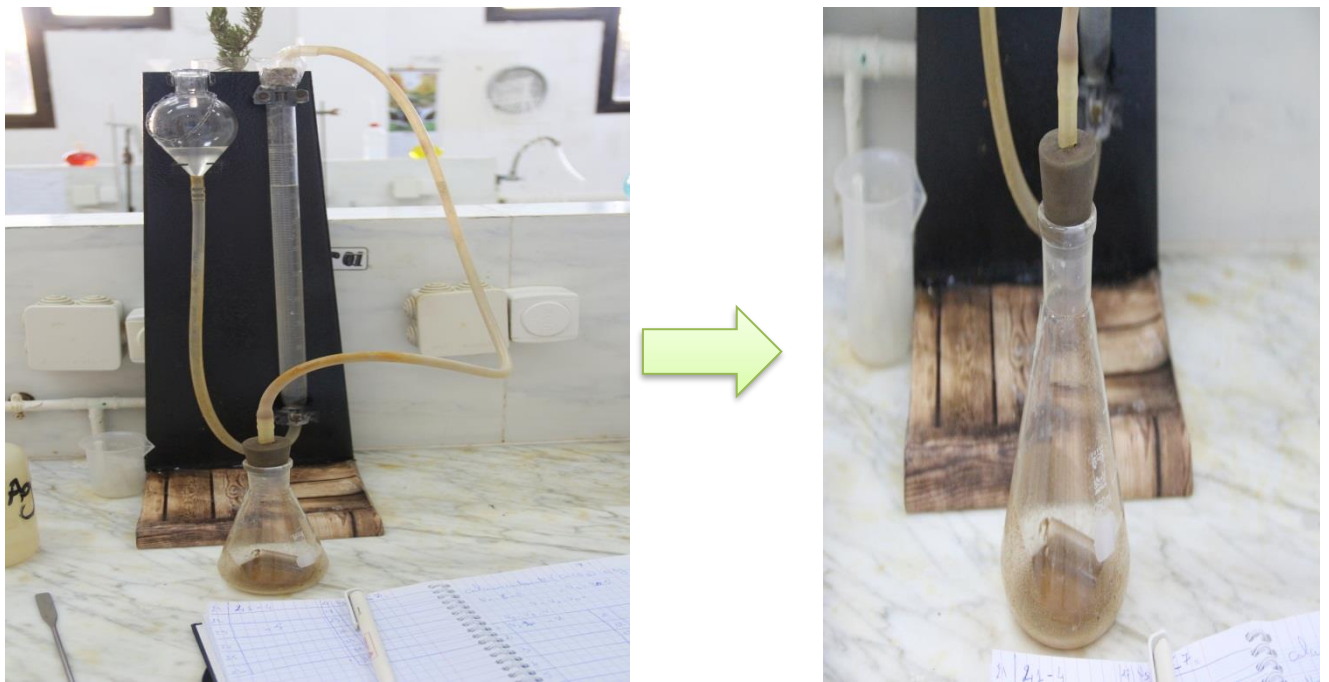
Figure 37 : measurement of total limestone by Bernard's calcimeter

(Cliche SENOUCI SOUAD, 2023)

4.4.6. Active limestone

Active limestone is the fraction of total limestone likely to dissolve easily and quickly in the soil solution. It more or less corresponds to the fine fraction in terms of particle size (size of the clays, i.e. less than 2 µm).

The presence of active limestone can induce, in certain soils poor in free iron, a risk of ferric chlorosis, to which certain productions are sensitive. This is the case in horticulture (strawberry for example), in arboriculture or in viticulture. **(Mimoune, 2020).**

4.4.6.1. Principles of active limestone

The principle consists in titrating the excess of the oxsalate, by the manganimetry and by the difference with the result obtained by the oxsalata of ammonium departure (witness) one estimates the number of gram ion of oxsalate precipitated and by the following the number of moles of active limestone extracted. **(ELHACHMI, 2001).**

*How to work in the laboratory

The determination of active limestone is only carried out for samples with 5% or more of total limestone.

• Weigh 1g of fine earth in a 250ml Erlen.

• Add 100ml of ammonium oxalate solution (14.2g per liter of distilled water).

• Mechanical agitation for 2 hours.

• Filter twice using filter papers.

• Collect 20ml of the filtered, and put in a 250ml beaker.

• Add 100ml of distilled water.

• Add 5ml of sulfuric acid.

• Heat the solution to 60°C.

• Titrate with the KMnO4 potassium permanganate solution (6.32g per liter of distilled water), until a persistent pink color.

• For the control, follow the same steps but without adding the soil sample.

The equation is

$$CaCO_3\ active\ \% = 5.\ (N - n)$$

N: number of ml of KMnO4 used for the control.

n: number of ml of KMnO4 Used for the fine earth sample.
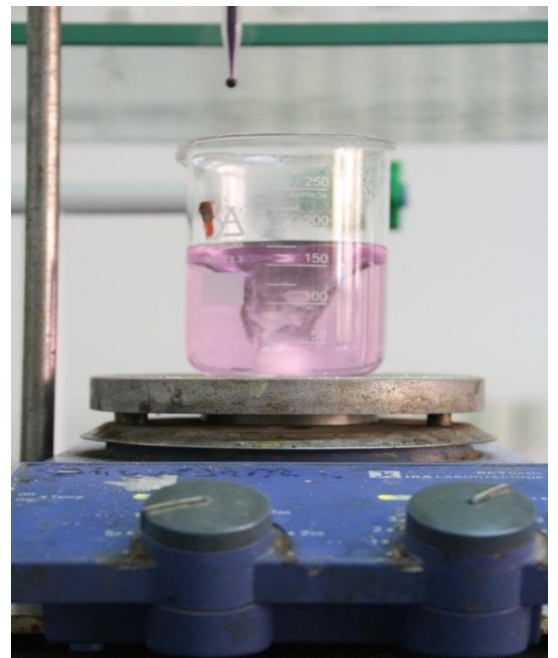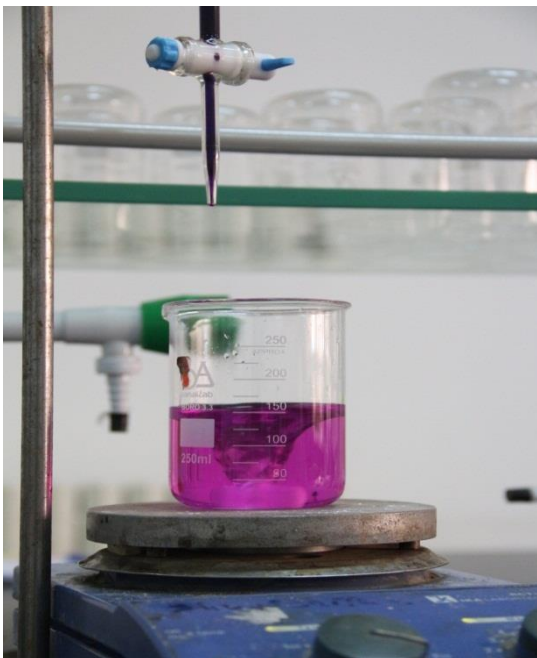
Figure 38 : active limestone dosing **(Cliche SENOUCI SOUAD, 2023)**

4.4.7. Organic carbon dosage (Organic material)

Soil organic carbon is a measurable component of soil organic matter. So that it makes up only 2-10% of most soil mass.

Organic matter contributes to nutrient retention and turnover, soil structure, moisture retention and availability, pollutant degradation, carbon sequestration and has an important role in the physical, chemical and biological function of agricultural soils. **(Edwards, 4 May 2023).**

4.4.7.1. Principles of Organic carbon dosage

Organic carbon in organic matter is oxidized by known but excess of chromic acid. The excess chromic not reduced acid by organic matter is determined by back titration with standard ferrous sulphate solution, using diphenylamine or ferroin indicator. The organic carbon content in soil is calculated from the chromic acid utilized (reduced) by it. **(Vidyapeeth, Mar. 1, 2021).**

*How to work in the laboratory

• In an Erlen with a ground neck, weigh 1g of fine earth.

• Add 10ml of potassium dichromate solution (8g per 100ml of distilled water).

• Add 15ml of sulfuric acid.

• Connect the opening of the Erlen to the condenser, making sure to close it properly

• Turn on the device.

• Heat using a heating stirrer

• When the solution begins to boil, count 5 minutes, then turn off the device and the heating stirrer and allow the Erlen to cool.

• Detach the erlen from the condenser.

• Put the solution in a 100 ml volumetric flask, and top up with distilled water up to the 100 ml line.

• Shake the vial 10 times and Leave to stand for 30min.

• With a graduated pipette, take 20 ml of the supernatant, and put in a beaker of 500ml.

• Add 1.5g Naf, and 3 drops of diphenylamine barium sulphonates color indicator (0.5g in 100ml sulfuric acid +20ml distilled water and keep in a brown bottle).

• Titrate with Mohr's salt solution 78.4278g in 20ml sulfuric acid H2SO4 and complete to 1 liter with distilled water), the brown solution at the start will become dark blue, then there will be a rapid color change at the dark green.

• Read the number of ml of Mohr's salt solution used.

• For the control, follow the same steps, without adding the fine soil sample.

The equation is

 The calculation is done by the following equation:

$$C\% = (V'\text{-}V) \times 0{,}3$$

V': quantity in ml of the Mohr salt solution used for the control.

V: quantity in ml of the Mohr salt solution used for the soil samples.

To calculate the organic matter content of the soil (OM%, or g/100 g of dry soil), the carbon content of the soil (C%, or g/100 g of dry soil) is multiplied by a coefficient of value 1, 72 (**VAN DE KERCHOVE et al., 2006).**

$$Organic\ matter\ \% = C\ \%\ x\ 1{,}72$$
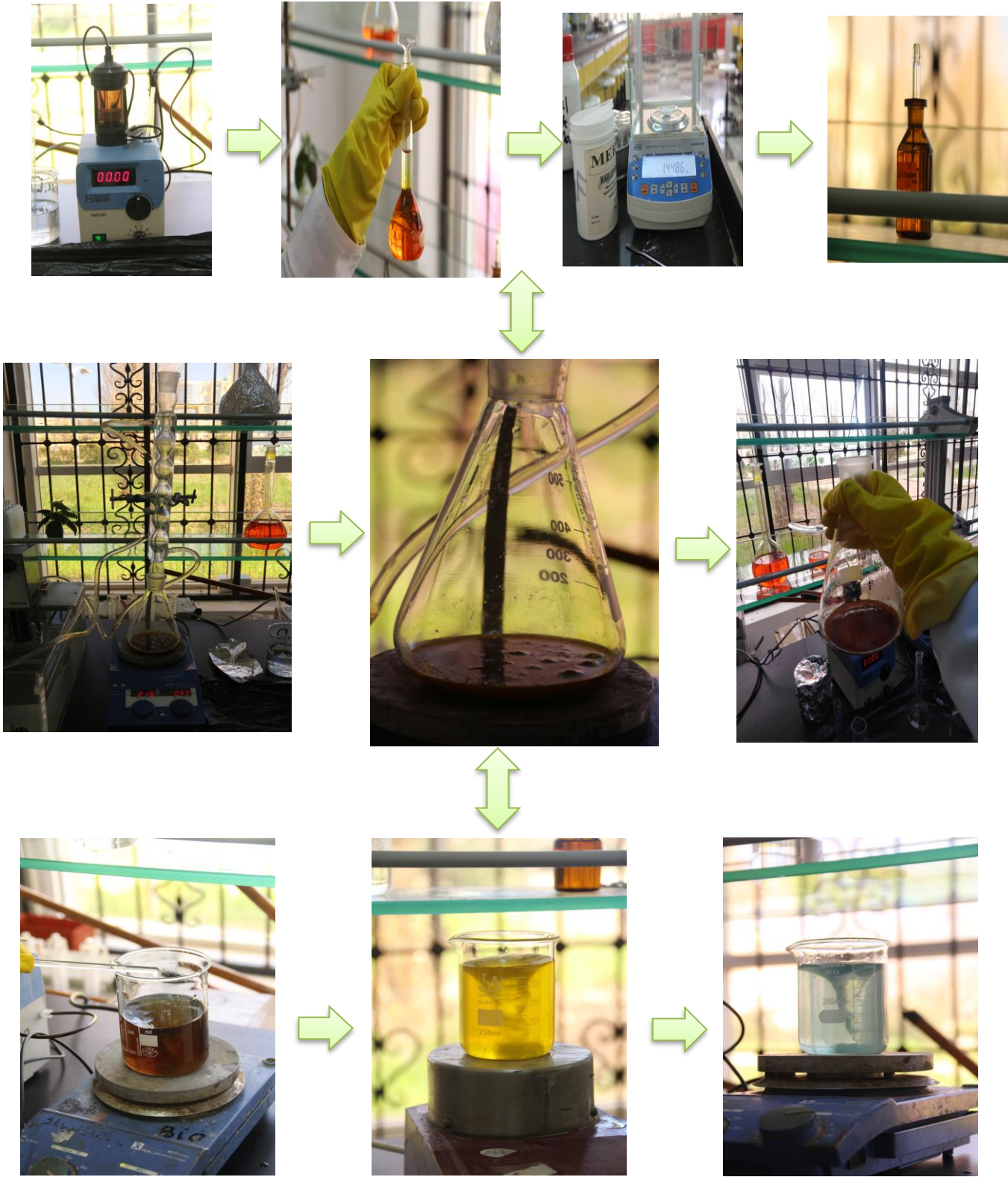
Figure 39: Organic carbon dosage (**Cliche SENOUCI SOUAD, 2023**)

Since the topic of the note deals with remote sensing technology and geographic information system, we took satellite images that helped us understand and explain the results accurately (Sentinel 2 images).

4.4.8. Satellite images

Satellite images are images obtained using cameras placed in satellites orbiting the Earth (the file comprises several images, i.e. a matrix of **pixels**).

 Images are useful in many fields, such as cartography, geology, agriculture, forestry, etc. Satellite images enable scientists and researchers to monitor and study the Earth's environment more effectively and on a larger scale than ever before. **(Surna, 2001-2022).**

These images were processed by the Sentinel 2 satellite.

Sentinel-2 includes a suite of technologies, such as multispectral imaging instruments for observations of the Earth's oceans and atmosphere, and provides high-resolution optical images for Earth observation, emergency response and security services.

The hyper spectral satellite imager provides a variety of 13 spectral bands ranging from visible and near-infrared to short-wave infrared.

Objectives: To monitor changes in vegetation, land use and the impact of global warming with a high degree of accuracy, using repeated observations; to monitor changes in forests, land use, agricultural practices and production, etc**. (Sentinel-2 L2A, 2020)**

Used mapping technology for the results obtained:

Map of MO, map of pH, map of humidity, map of total limestone, active limestone map, NPK fertilizer, Electrical conductivity map (EC) , VHI and VCI map

4.4.8.1. Vegetation Condition Index (VCI)

Vegetation indices is a single value calculated by transforming the observations from multiple spectral bands are designed to maximize sensitivity to the vegetation characteristics while minimizing confounding factors such as soil background reflectance, directional, or atmospheric effects.

The most commonly used vegetation indices utilize the information contained in the red and near-infrared (NIR) canopy reflectance's or radiances. They are combined in the form of ratios: ratio vegetation index (RVI) or normalized difference vegetation index (NDVI). **(Vegetation Index, 2008)**

* To calculate VCI the following formula

$$VCI = \frac{(NDVI\,j - NDVI\,min)}{(NDVImax - NDVI\,min)} \times 100$$

NDVI j: represents the current year NDVI.

NDVI max: represents the multiyear maximum NDVI.

NDVI min: represents the multiyear minimum NDVI.

*How to work in the Google Earth engine

1/-First calculate NDVI.

2/- Extract the minimum and the maximum NDVI value.

3/- Using spatial analyst tool.

4/-Finally use the formula NDVI through raster calculation in the spatial analyst tool.

Value	Category
90 - 100 %	No Drought
80 – 90 %	No Drought
70 – 80 %	No Drought
60 – 70 %	No Drought
50 – 60 %	No Drought
40 – 50 %	No Drought
30 – 40 %	Light Drought
20 – 30 %	Moderate Drought
10 – 20 %	Severe Drought
0 – 10 %	Extreme Drought

Figure 40: The values of vegetation condition index **(vegetation condition index, 2020)**

4.4.8.2. Vegetation health Index (VHI)

The Vegetation health Index (VHI) combines both the Vegetation Condition Index (VCI) and the Temperature Condition Index (TCI). It means knowing the health of plants where TCI is calculated using a formula similar to VCI, but relates current temperature to long-term maximums and minimums. **(Vegetation Health Index (VHI) - Monthly Summary (Global - Monthly - 1 Km)).**

High temperatures worsen vegetation conditions. For example, a decrease in the Hygienic Hybrid Index might indicate relatively poor vegetation conditions and warmer temperatures, which would be indicative of stressed vegetation conditions, and over a longer period would be an indication of drought.

(Vegetation Health Index (VHI) - Monthly Summary (Global - Monthly - 1 Km)).

Table N°1 : drought severity classes for the Vegetation Health Index (VHI) **(Vegetation Health Index (VHI) - Monthly Summary (Global - Monthly - 1 Km))**.

Severity Class	Values
Extreme drought	<10
Severe drought	10-20
Moderate drought	20-30
Mild drought	30-40
No drought	>40

* To calculate VHI the following formula

$$\text{VHI} = \alpha\text{VCI} + (1-\alpha)\ \text{TCI}$$

VCI: represents vegetation cover index.

TCI: Temperature Condition Index.

α: weight of 0.5 is assumed(in most published analyses, a has been assigned a value oh 0.5,assuming an even contribution from both elements in the combined index due to the lack of more accurate information about vegetation and temperature). (https://youtu.be/QN2EKRS1sqU, 2021)

To calculate VHI first we calculate TCI (Temperature Condition Index), so the formula of TCI

$$\text{TCI} = \frac{(\ \text{LST max} - \text{LST}\ )}{(\text{LSTmax} - \text{LST min})}$$

LST max: The value of maximum land surface temperature of each pixel.

LST min: The value of minimum land surface temperature of each pixel respectively in same month during the study period.

CHAPTER 5
Results and discussions

Results and discussions

We have worked on 33 soil samples in the precision farming laboratory. From the results, the maximum value, the optimum value and the average of the obtained results have been set.

5. 1. Results of physico-chemical soil analysis

5.1.1. Granulometry

The following table shows the soil texture for 33 samples

Table N°2: The result of the particle size analysis of the studied soil

S	Clay %	Silt %	Sand %	TEXTURE
(1-3)	14,07	83,85	2,08	FINE CLAY SILK
(4-7)	13,13	84,53	2,34	FINE CLAY SILK
(8-12)	23,27	71,89	4,85	FINE CLAY SILK
(13-17)	33,27	64,46	2,26	FINE CLAY SILK
(18-22)	34,91	63,25	1,84	FINE CLAY SILK
(23-27)	31,17	67,47	1,36	FINE CLAY SILK
(28-33)	21,16	77,23	1,61	FINE CLAY SILK

According to Table No., it can be seen that 33 soil samples that were studied have approximately the same proportions of silt and clay, and the proportion of silt ranges between 63.25% and 84.53%, while the proportion of clay ranges between 13.13% And 34, 91%. So, the soil texture is silty clay.

As shown graphically in the relative circle of the percentage of soil texture, where we notice that the percentage of silt is large compared to the percentage of sand and clay.
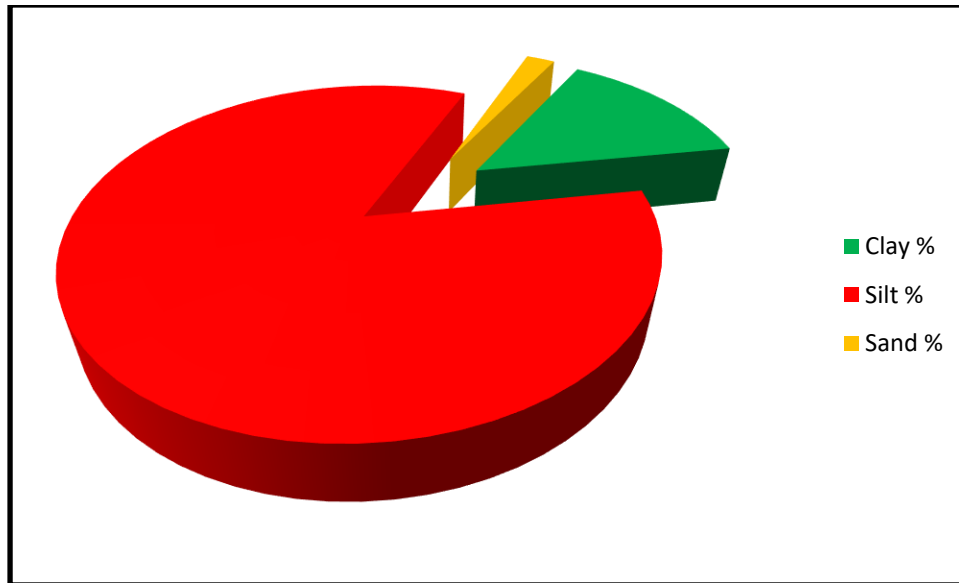
Figure 41: Relative circle representing particle size analysis of soil samples

5.1.2. Soil Moisture

The following table shows the obtained results and their representation of the optimal, minimum and average values

Table N°3: Soil Moisture Analysis Result

	Minimum values	Optimal values	MEAN	MEDIANE	Standard deviation	MODE
Soil moisture(%)	0.77	55.82	1.95	2.91	9.81	2.41

Moisture levels in the soil sample range from 1 to 10%, and these values depend on the climatic conditions (lack of rain, scarcity of irrigated water, high temperature). The values are low and this is due to the organic matter present in it; In addition to the quality and nature of the soil.

Water plays a role in the physical and chemical phenomena that occur in the soil. It can compete with organic molecules for solids adsorption which leads to a decrease in pollutant uptake when the soil moisture rate increases... **(Gholamabbas Sayyad a, 23 April 2009).**
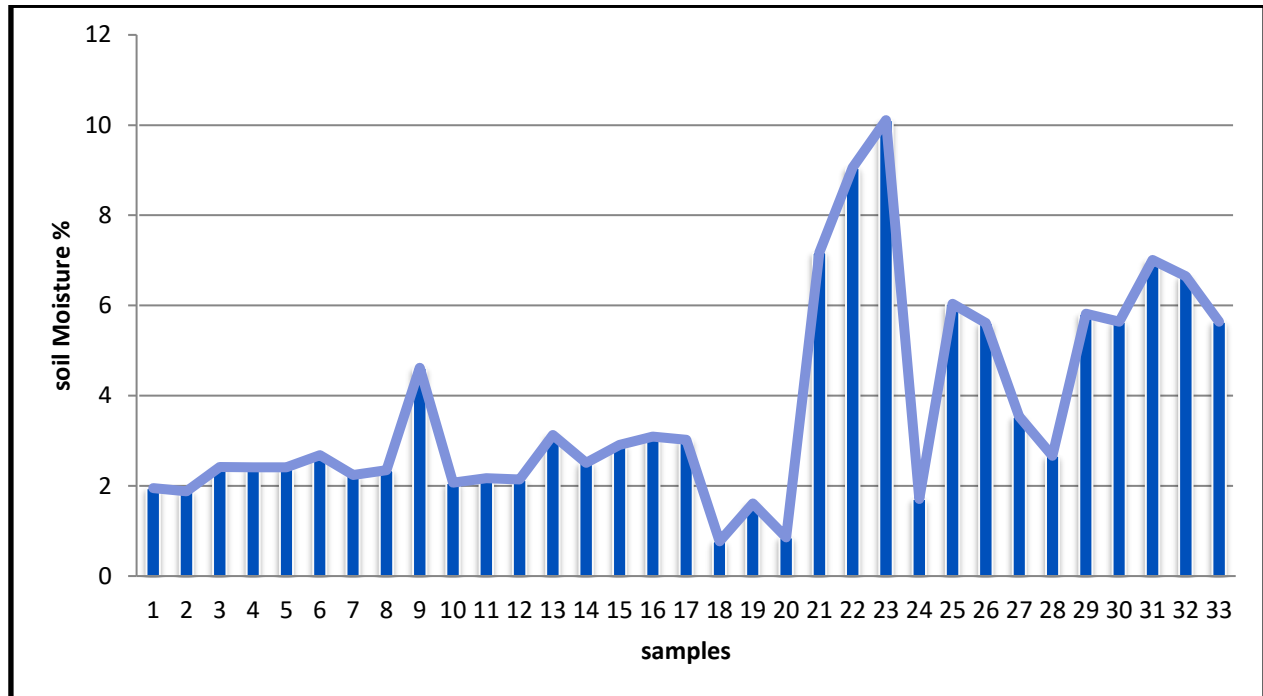
Figure 42: A graphic curve representing the percentage of moisture changes for soil samples

As shown graphically in the graphic curve of the columns, which represents the percentage of moisture in the soil. Therefore, we note that the percentages on the lower side are weak and close compared to the upper side of the plot of land.
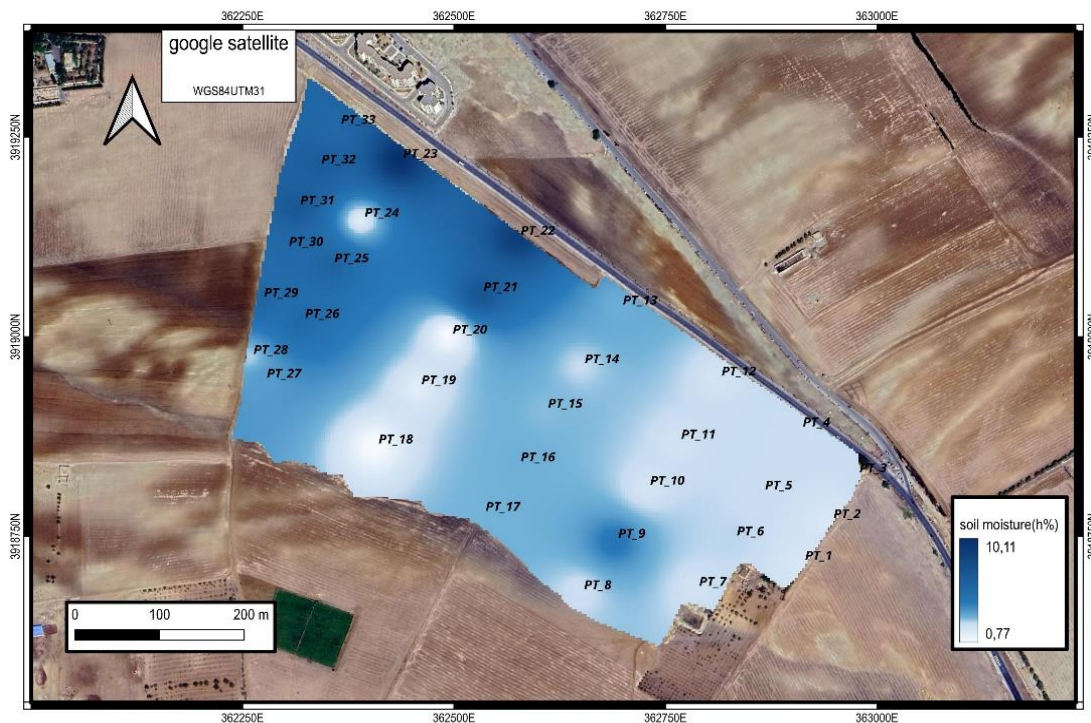
Figure 43: Soil moisture map **(personal work in QGIS software)**

   High soil moisture in the upper part of the field to exceed 10 percent compared to the lower part of the field, where it does not exceed 1 percent.

5.1.3. pH

The following table shows the obtained results and their representation of the optimal, minimum and average values.

Table N°4 : pH Analysis Result

	Minimum values	Optimal values	MEAN	MEDIANE	Standard deviation	MODE
(the values of the pH)	7.54	8.22	8.00	8.05	0.18	8.14

   According to the table that gives the pH values, these values vary between 7.54 and 8.22. So the soil contains an alkaline medium (higher than 7).

Soils with a pH of 4 to 6 are called acidic soils and soils with a pH of 8 to 9 are called alkaline soils. Fertile soil has a pH between 6 and 7. It is suitable for most plants. **(Gerbeaud).**

Some plants are very particular about the type of soil they grow in: some thrive in acidic soil (acid-loving plants), while others prefer neutral or lime-rich soil (calcareous plants). When a plant is in a soil that is too acidic or too calcareous for it, it is likely to suffer. At first, it will flower and grow less well, and then it could even end up dying. **(What is soil pH and what does it do?, 2022).**
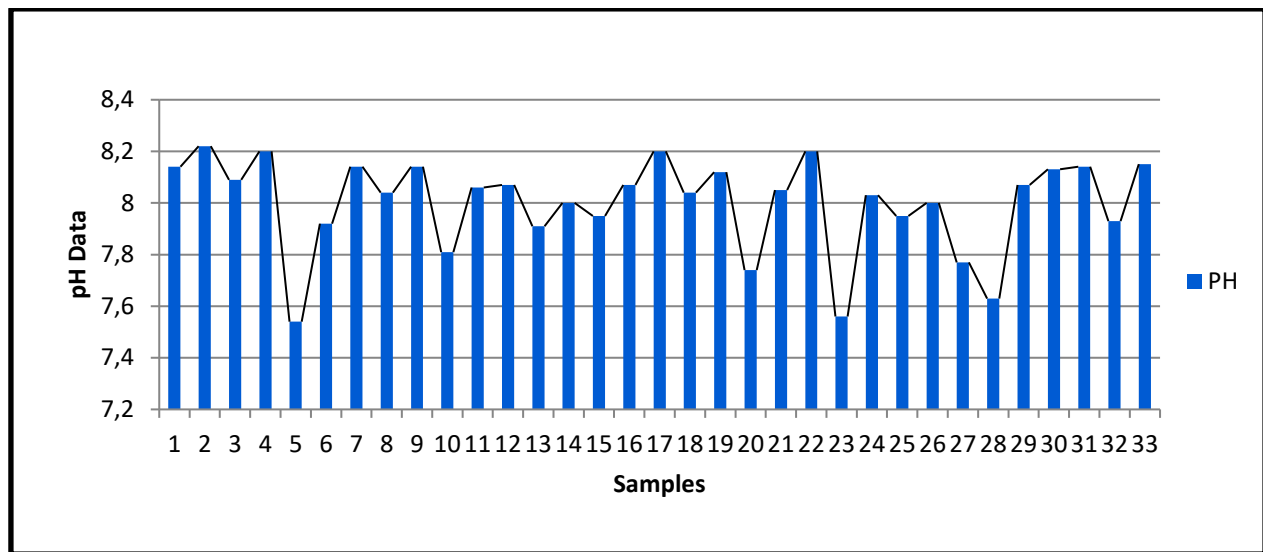
Figure 44: Graphical curve representing the pH values of soil samples

The field concentration is moderate and the ratio was between [7.54, 8.65]. We note that the middle of the field has a basic concentration compared to the average pH (higher than 7), Figure N°43 shows the obtained results.
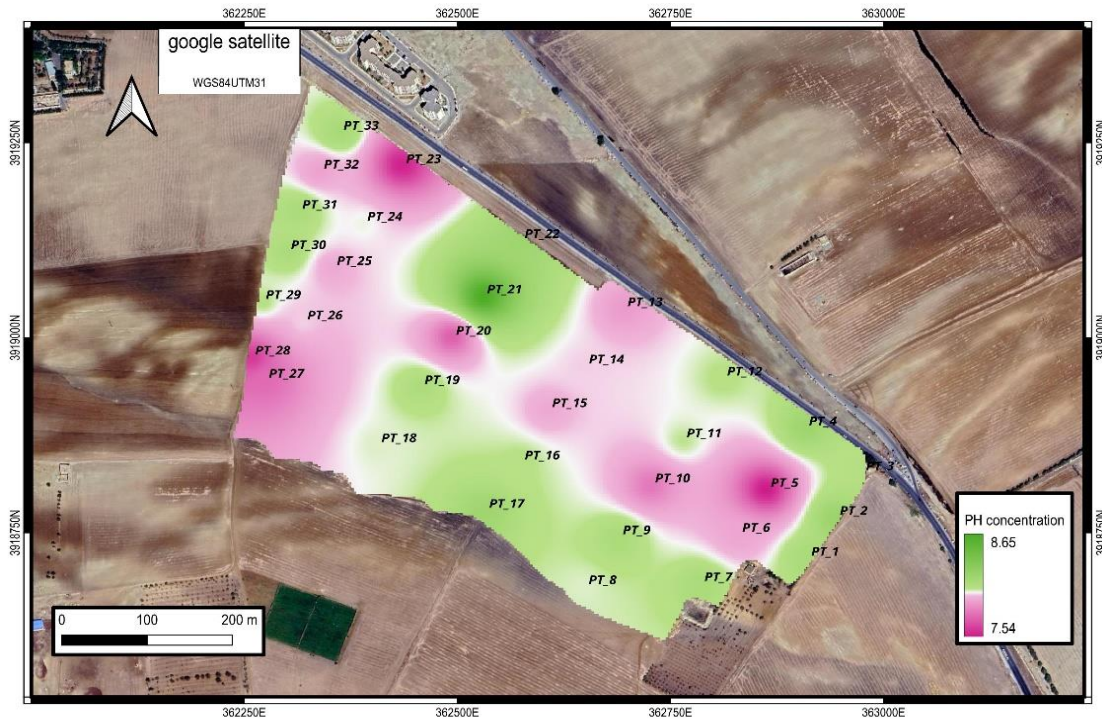
Figure 45: pH map **(personal work in QGIS software)**

5.1.4. pHKCL

The pHKcl values were measured and the following results represented in the table were obtained

Table N°5 : pHKCL Analysis Result

	Minimum values	Optimal values	MEAN	MEDIANE	Standard deviation	MODE
the values of the pHKcl	6.33	6.82	6.58	6.59	0.12	0.12

The pHKcl corresponds to the pH of a suspension of earth in a solution of potassium chloride. It's gives values lower than pHwater by 0.5 to 1 unit.

Lowering the pH in the soil helps to make certain aluminum-containing mineral compounds increasingly soluble. This element becomes toxic when the water pH is less than 5.5. It is therefore this indicator, the PHwater of the soil, which makes it possible to decide whether liming is necessary or not. **(pH water or pH KCl, 2021)**

Pure water is replaced by a Kcl solution. The K+ ions replace the H+ ions, which are released into the solution. The Kcl pH is always lower than the water pH, by 0.5 to 1.5 units. The greater the difference, the more acidity the soil has in reserve, the more easily it can acidify. **(UNDERSTANDING AND KNOWING SOIL PH, 2015).**
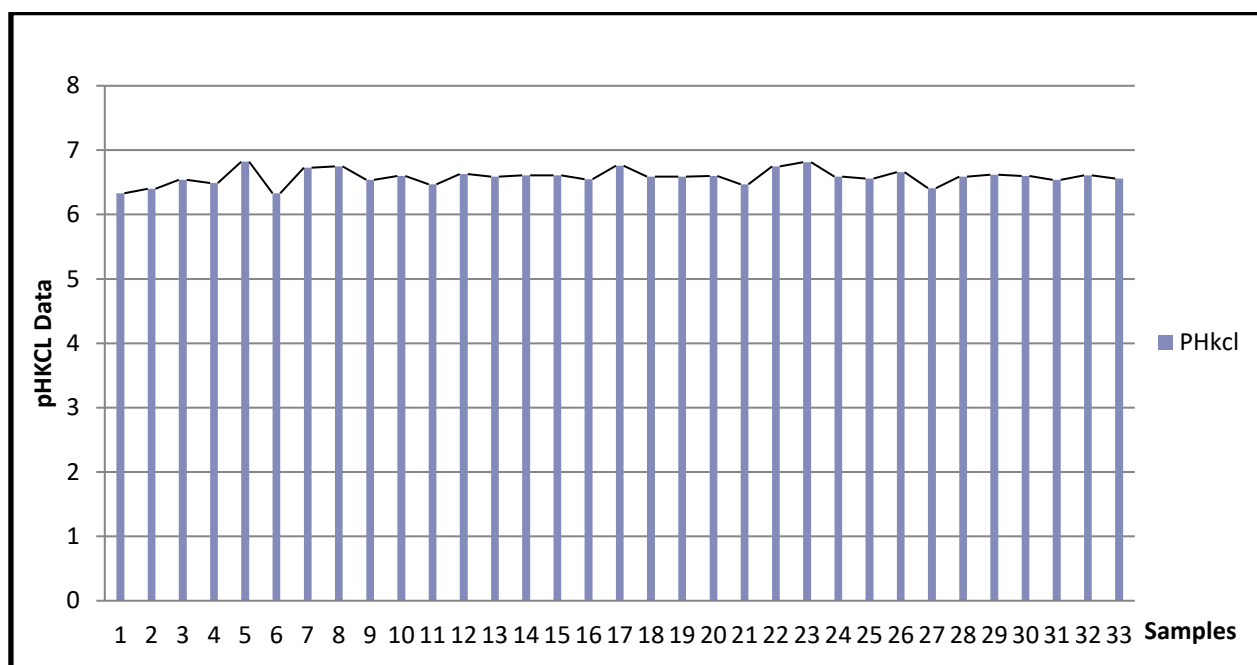
Figure 46: Graphical curve representing the pHKCL values of soil samples

5.1.5. Electrical conductivity (EC)

Electrical conductivity values were measured and the results represented in the table were obtained:

Table N°6: Electrical conductivity Analysis Result

	Minimum values	Optimal values	MEAN	MEDIANE	Standard deviation	MODE
EC(µS/cm)	34.5	346	209.45	165.6	105.68	313

According to the results, the average electrical conductivity is 209.45 µS/cm. This shows the distribution of soil salinity levels, where there is a significant difference for different soil samples. Based on this interpretation, we can say:

Soil electrical conductivity (EC) measures the ability of soil water to electrical current. Electrical conductivity takes place principally through water-filled pores. Cations (Ca^{2+}, Mg^{2+}, K^+, Na^+, and NH_4^+) and anions (SO_4^{2-}, Cl^-, NO_3^-, and HCO_3^-) from salts dissolved in soil water carry electrical charges and conduct the electrical current.

Consequently, the concentration of ions determines the EC of soils. So soil EC is affected by planting, irrigation, land use, fertilizer, manure, and compound fertilizer application. **(Electrical Conductivity and Resistivity, 2022).**
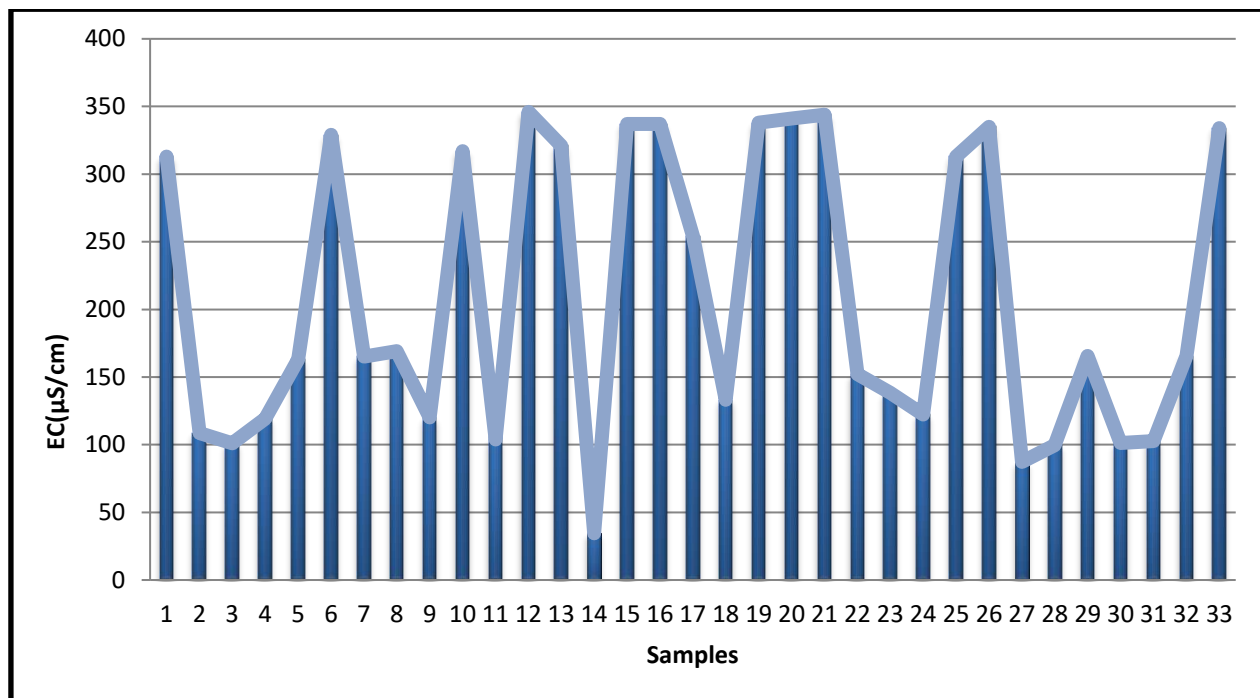
Figure 47: Graphical curve representing the EC values of soil samples

The map represents the concentration of conductivity in the middle of the field, where we notice that the maximum value reached 346 µS/cm, while for the field borders it almost reached 35 µS/cm.
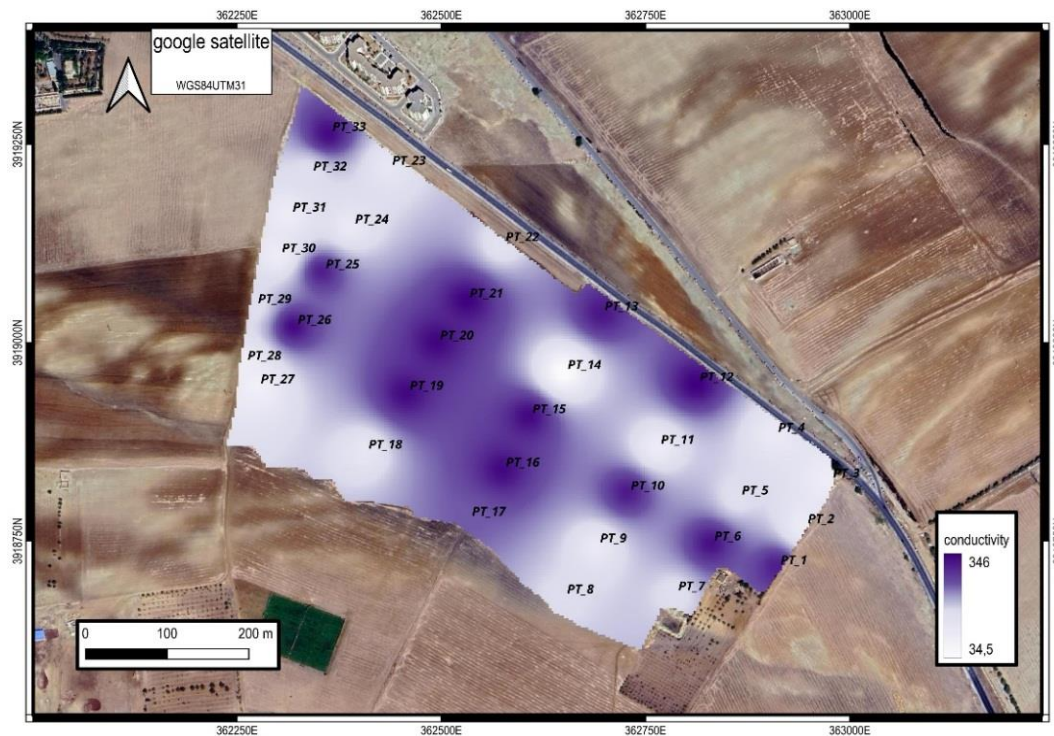
Figure 48: conductivity map **(personal work in QGIS software)**

5.1.6. NPK fertilizer

The values of NPK were measured with NPK sensors and after conversion, the following results were obtained

Table N°7: NPK fertilizer Analysis Result

	Minimum values	Optimal values	MEAN	MEDIANE	Standard deviation	MODE
N(kg/Ha)	18	43.2	28.69	28.80	4.72	28.80
P(Kg/Ha)	18	39.6	27.82	28.80	5.03	28.80
K(Kg/Ha)	61.2	111.6	76.69	75.6	10.24	72

   The value of NPK fertilizer varies from one point to another, and this is evidence of the soil's need for fertilizer, Phosphorous helps produce healthy flowers, buds, roots and fruits. Nitrogen helps leaf growth and potassium keeps plants healthy.

Nitrogen

Nitrogen is an important element for plants as it is used to control the process of photosynthesis, by which sunlight is converted into sugar, water and carbon dioxide.

It is also responsible for amino acids - which are the building blocks of many different types of proteins. Nitrogen goes through a series of transformations to provide these proteins to plants. There are also many organisms found within the soil that can slow down plant growth or even devour the soil.

Nitrogen-rich compounds make sure this is not possible, by immobilizing them which further increases plant growth. Once these organisms are no longer able to feed on the plant, they die and decompose in the soil as inorganic matter. **(Siddharth, 2020).**
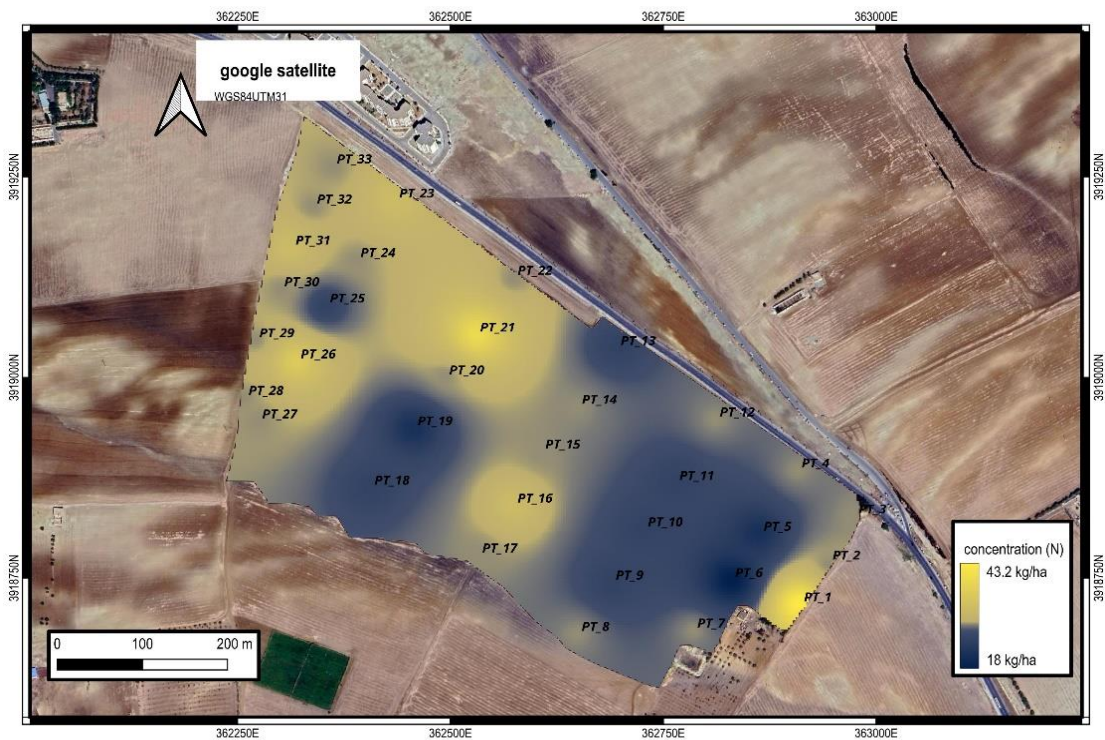
Figure 49: nitrogen percentage map **(personal work in QGIS software)**

 We notice a high percentage of nitrogen in the upper part of the field, except for the point p18, p19 and p25. The nitrogen content is about 43 kg per hectare as for the lower part of the field. We notice a small proportion of nitrogen, up to 18 kilograms per hectare, except for the point p1 and p16.

Phosphorous

Phosphorus is an important component in plants not only because it serves as an energy unit and catalyst for many plant-soil interactions, but mainly for converting sunlight into a useful resource for plants.

It also acts as a memory unit for all living things. The DNA properties of plants are enhanced for the construction of proteins, seed production, and other genetic transfer.

Phosphorus also helps legume nitrogen fixation and crop quality. It also increases leg and calf strength. Many plant diseases can also be avoided, due to the resistance offered by potassium and Phosphorus is one of the few components that last throughout the entire life cycle of a plant. (Siddharth, 2020)**.**
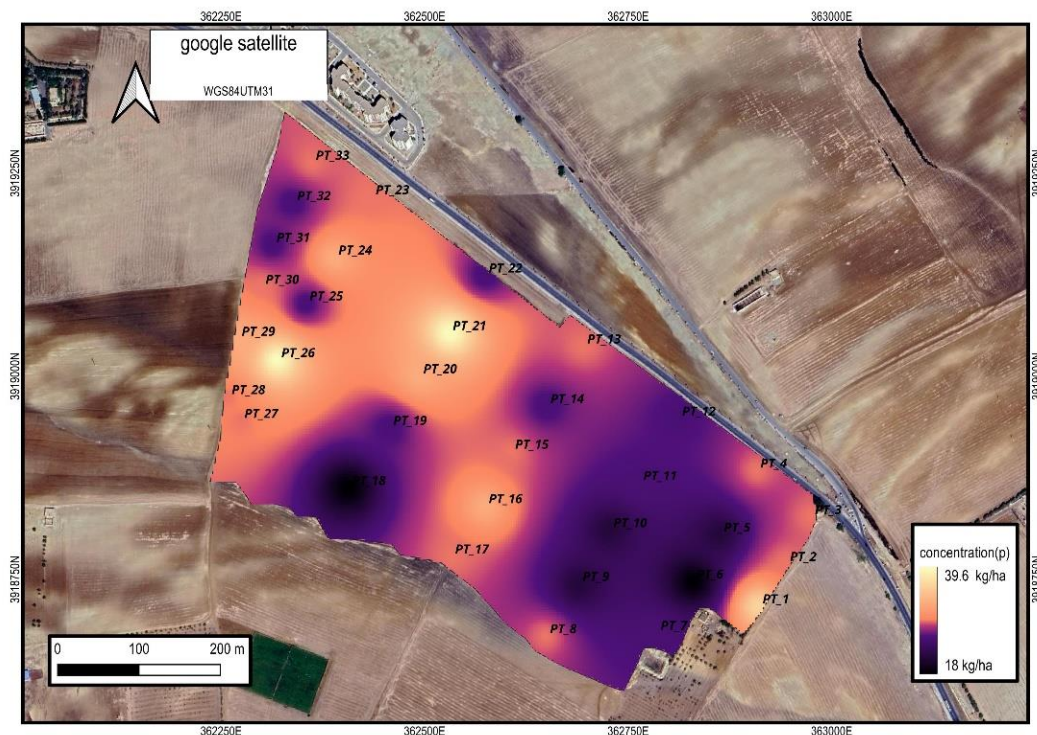
Figure 50: Phosphate percentage map **(personal work in QGIS software)**

We notice a high percentage of phosphorus in the upper part of the field, except for point p18, p19, p25, p31and p32. The phosphate content is about 40 kg per hectare, as for the lower part of the field. We observe a small percentage of phosphate, up to 18 kg/ ha, except for point p1, p16 and p17.

Potassium

It plays a vital role in regulating carbon dioxide intake and also for closing and opening stomata (which are small pores that allow a plant to breathe) and Adenosine Triphosphate (ATP) is an energy source that handles all the chemical processes in the pants. All ATP and other enzymes are activated by the potassium component. Potassium also controls the regulation of water levels in the plant.

Potassium can make plants drought tolerant. They are definitely high quality nutrients for plants **(Siddharth, 2020).**
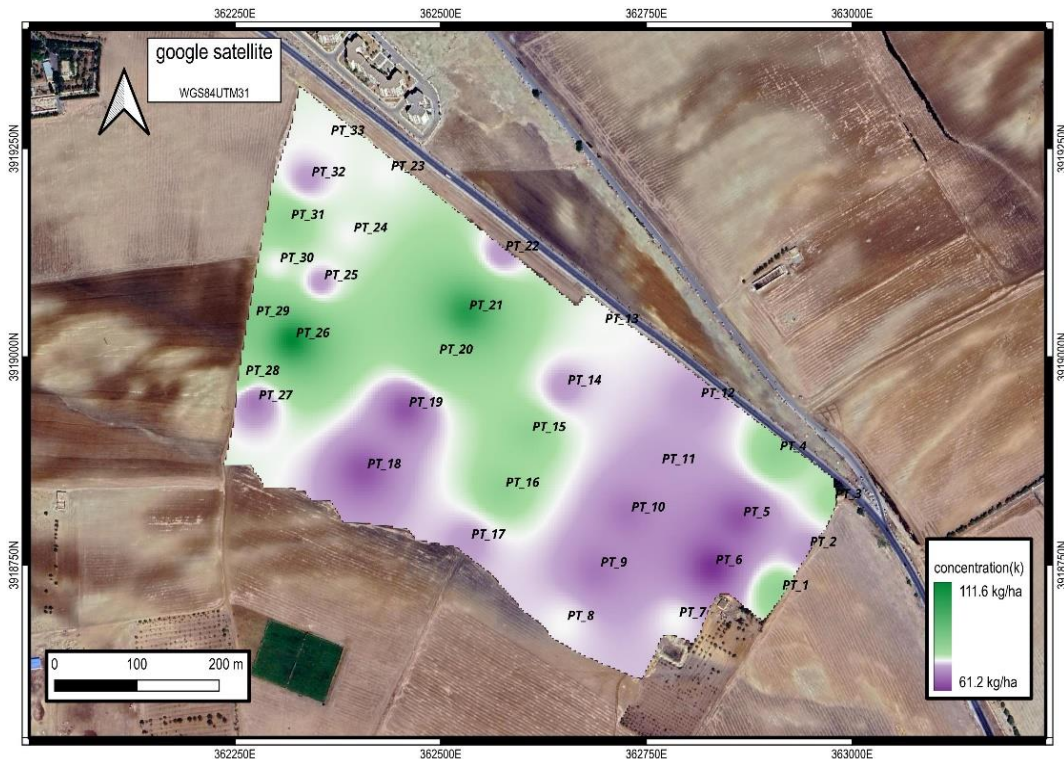
Figure 51: Potassium percentage map **(personal work in QGIS software)**

The percentage of potassium is high in the whole field, between 111 and 81 kg /ha. The same observation showed an increase in the percentage of potassium in the upper part of the field, 111 kg/ha, while the percentage decreased in the lower part, reaching 81 kg/ha.

After analyzing the results, we translate the results into this curve
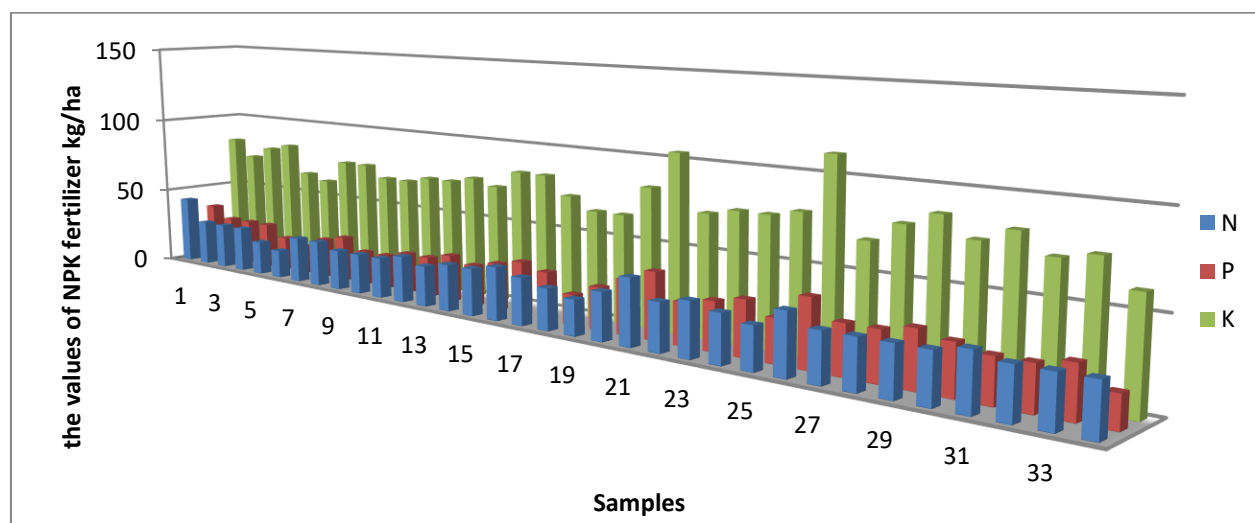
Figure 52: Graphical curve representing the NPK fertilizer values of soil samples

5.1.7. Total limestone

Total Limestone value was measured using calcimeter techniques and after calculation the following results were obtained

Table N°8 : Total limestone Analysis Result

	Minimum values	Optimal values	MEAN	MEDIANE	Standard deviation	MODE
Total CACO3 (%)	0.7	33.68	10.43	9.47	8.72	0.87

According to the results, the average percentage of total lime was 10.43, with values ranging between [0.7; 33.68]. As for the upper side of the land, the amount of lime in the soil was concentrated in the soil, and this is evidence of the presence of a slab of limestone in the depth, and this helps the soil in its fertility.

According to stamfordstone.co agricultural magazine, agricultural lime helps:

* Increasing the pH in acidic soils, decreasing acidity and increasing alkalinity (this confirms the results of the analyzes).

* Improve water penetration into the soil.

* Improve the absorption of essential nutrients (nitrogen, phosphorus and potassium) **(WILSON, 2021).**

After analyzing the results, we translate the results into this curve
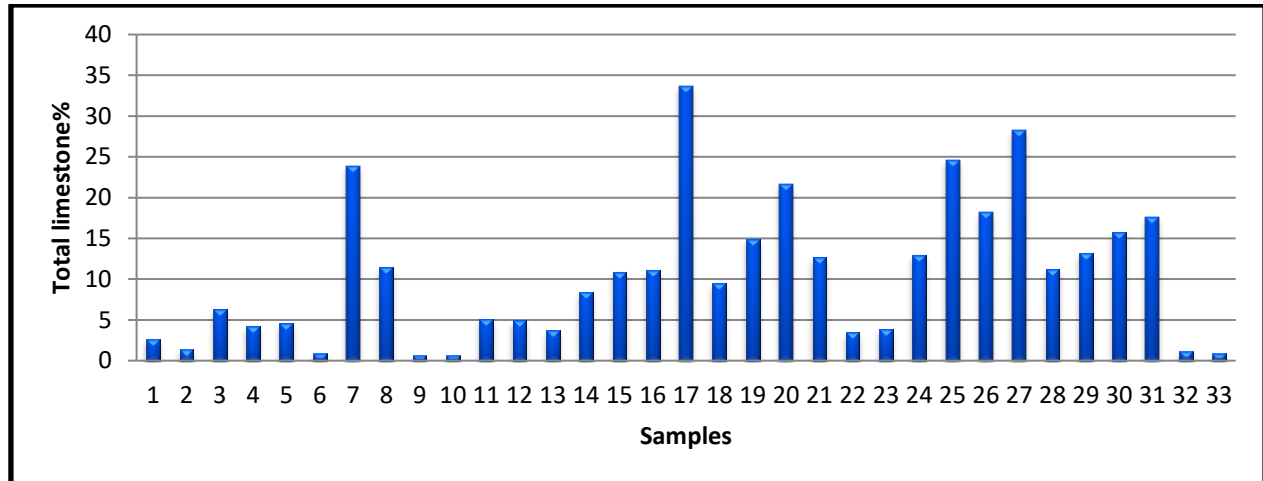
Figure 53: Graphical curve representing the Total limestone values of soil samples

5.1.8. Active limestone

The results obtained of Active limestone in the following table

Table N°9 : Total limestone Analysis Result

	Minimum values	**Optimal values**	**MEAN**	**MEDIANE**	**Standard deviation**	**MODE**
ACTIVE CACO3 (%)	0	21	7.44	8.00	7.08	0

The results of the active limestone analyzes are shown in Table No..... where the active limestone values range between (0% and 21%), while the activity rate reached 7.44, and we note that the high percentage is concentrated in the upper side of the earth.
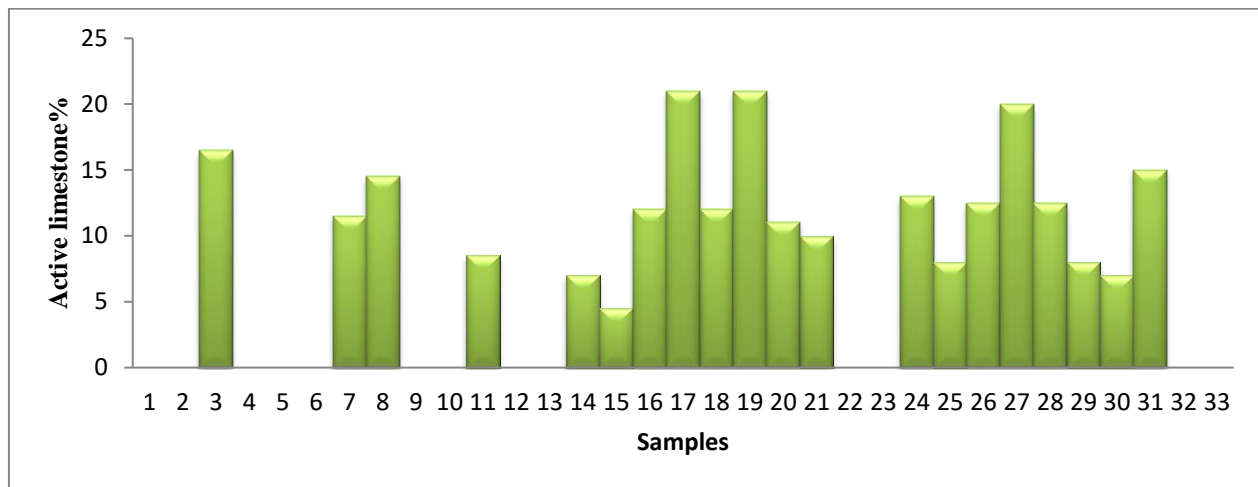
Figure 54: Graphical curve representing the Active limestone values of soil samples

From the graph, we notice the absence of active limestone in the following samples: 1,2,4,5,6,9,10,12,13,22,23,32 and 33 (values are less than 5). As for the other values, they are lime activity

5.1.9 Organic carbon dosage (Organic material)

Organic carbon dosage value after calculation the following results were obtained

Table N°10: Organic carbon dosage Analysis Result

	Minimum values	Optimal values	MEAN	MEDIANE	Standard deviation	MODE
OM (%)	0	2.2	1.3	1.3	0.54	0.82

According to the table…we found that the values of 33 soil samples vary between 0 and 2.2 organic matter, as shown in the classification table, they are Low OM soils.
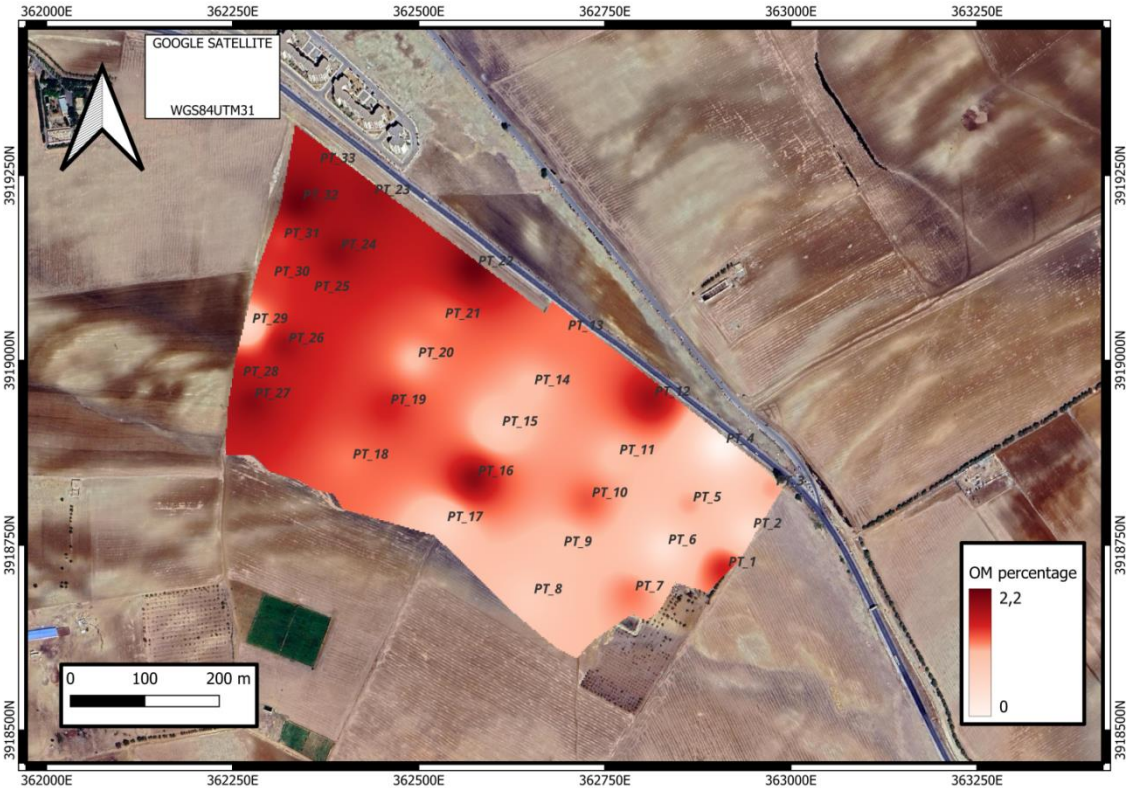
Figure 55: OM map **(personal work in QGIS software)**

We see a decrease in the percentage of organics, there's a slight difference, a slight increase of 2.5 percent at the top of the field. And sometimes there isn't at the bottom
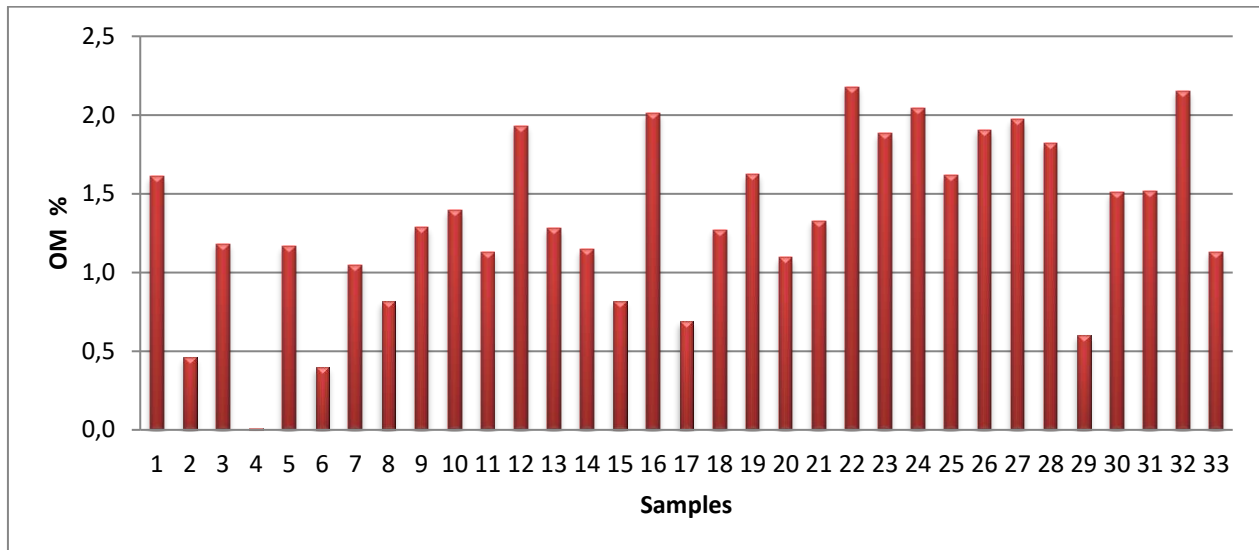
Figure 56: Graphical curve representing the OM values of soil samples

5.1.10. Vegetation Condition Index (VCI)

This map represents the Vegetation Cover Index (VCI) obtained from Sentinel 2 images
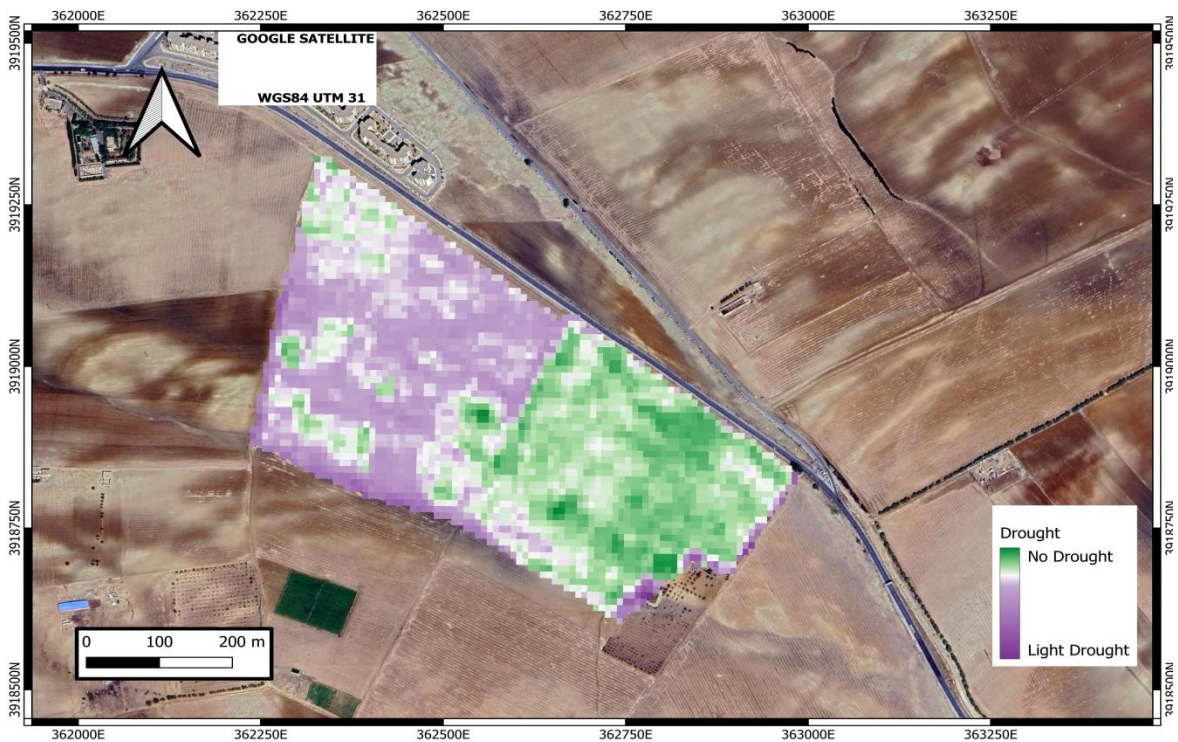
Figure 57: vegetation condition index **(personal work in QGIS software)**

we observe the state of good vegetation in the upper and southern half of the field, reaching 55% without drying, while in the half of the field, we observe a moderate drought of 35 percent.

5.1.11. Vegetation health Index (VHI)

This map represents the Vegetation health Index (VHI) calculated on Sentinel 2 images in the cloud computing Google Earth engine .
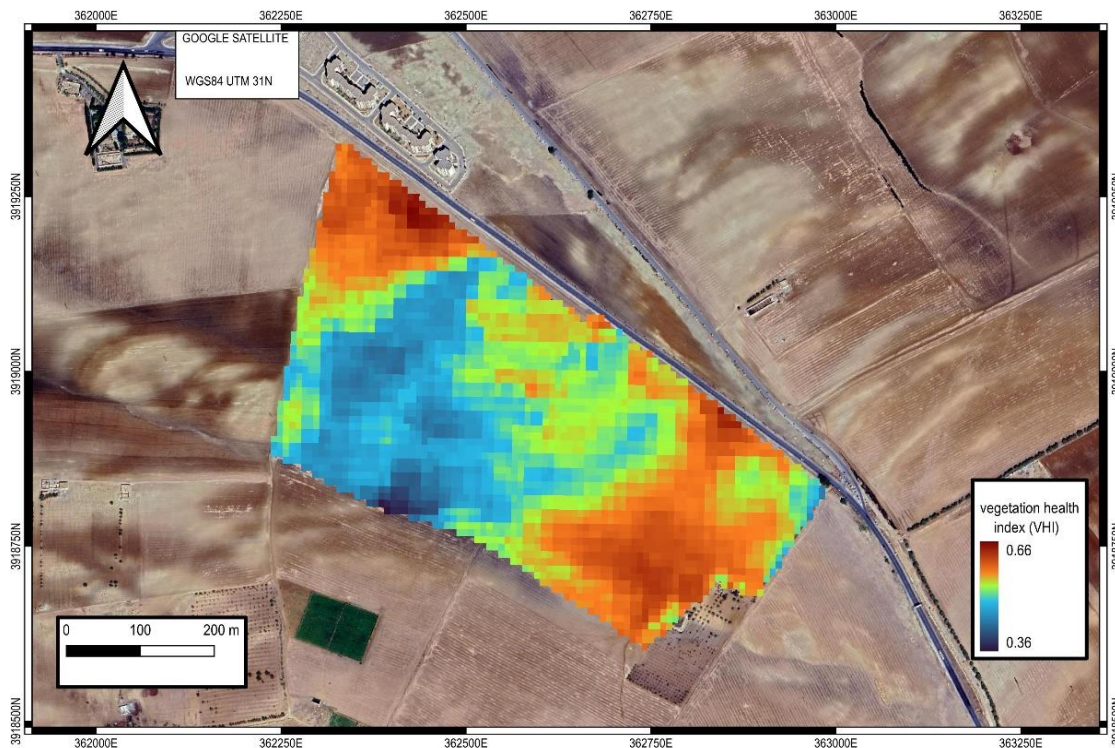
Figure 58: vegetation health index **(personal work in QGIS software)**

we observe the good vegetation health in the upper and southern half of the field, where it reached 66 percent, while in the middle of the field, we observe plant health from medium 55 to as low as 36 percent..

5.1.12. Correlation between the VCI and VHI indices with the results Obtained

the objective was a simple correlation with Phtyon under Google Colab between the VCI and VHI indices with the results obtained are shown in figure56 and 57

- Correlation between the VCI with the soil moisture and NPK fertilizer

So the Python show the results:

The Correlation between VCI and N: weak positive correlation

The Correlation between VCI and P: No correlation

The Correlation between VCI and K: Negative correlation

The Correlation between VCI and soil moisture: weak positive correlation


```
Sélect. fichiers   VCI_Map (5).tif
•  VCI_Map (5).tif(image/tiff) - 15836 bytes, last modified: 12/06/2023 - 100% done
Saving VCI_Map (5).tif to VCI_Map (5) (1).tif
Sélect. fichiers   4 fichiers
•  H%.tif(image/tiff) - 236854 bytes, last modified: 15/06/2023 - 100% done
•  P.tif(image/tiff) - 229452 bytes, last modified: 15/06/2023 - 100% done
•  N.tif(image/tiff) - 59218 bytes, last modified: 15/06/2023 - 100% done
•  K.tif(image/tiff) - 54154 bytes, last modified: 17/05/2023 - 100% done
Saving H%.tif to H% (1).tif
Saving P.tif to P (1).tif
Saving N.tif to N (1).tif
Saving K.tif to K (1).tif
Correlation coefficient with H%.tif: 0.32299078258213
Correlation coefficient with P.tif: -0.116467800513097838
Correlation coefficient with N.tif:  0.24358213678
Correlation coefficient with K.tif: -0.33243008691152
```

Figure 59: Correlation between the VCI with the soil moisture and NPK fertilizer **(Google colab)**

-The results get with the correlation. Says that: correlation between VCI and N: weak positive correlation but according to **(EFFEt of Nitrogen Deficiency on plant stress Response and Tolerance to dought stress , 2018)** when a plant suffers from nitrogen deficiency, it can have a negative impact on its drought resistance and lead to a decrease in the value of vci. this is partly due

to the effect of nitrogen deficiency on the plant's ability to synthesize proteins and other compounds necessary to protect cells and tissues from the negative effects of dehydration.

-The results get with the correlation. Says that: correlation between VCI and P: no correlation but according to **(current Opinion in plant biology, 2015**)phosphorus is an essential nutrient for plant growth and development, and affects the metabolic and energy transfer processes in the plant.

-The results get with the correlation. Says that: correlation between VCI and K: negative correlation but according to **(Huang)**regulating the opening and closing of water capillaries and activating enzymes and energy transfer, can adversely affect the plant's ability to adapt to and resist drought. potassium deficiency can lead to poor growth, damage to leaves, deformation of fruits, and increased plant susceptibility to drought.

-The results get with the correlation. Says that: correlation between VCI and soil moisture: weak negative correlation but according to **(Chaves, 2009)**lack of soil moisture is an important factor affecting the drought-resistant plant index that has a negative impact on the growth and vital activity of the plant.lack of soil moisture affects the processes of absorption of water and nutrients from the soil, which reduces the availability of water to the plant.

 this stimulates the plant's response mechanisms to conserve water and reduce its loss. however, if the lack of soil moisture persists for a long time, the plant can suffer from water stress and become less adaptable to drought which reflects negatively on the value of.

- Correlation between the VHI with the soil moisture and NPK fertilizer

So the Python show the results:

 The Correlation between VHI and N: Average positive correlation

The Correlation between VCI and P: weak Negative correlation

The Correlation between VCI and K: No correlation

The Correlation between VCI and soil moisture: weak positive correlation

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Requirement already satisfied: rasterio in /usr/local/lib/python3.10/dist-packages (1.3.7)
Requirement already satisfied: affine in /usr/local/lib/python3.10/dist-packages (from rasterio) (2.4.0)
Requirement already satisfied: attrs in /usr/local/lib/python3.10/dist-packages (from rasterio) (23.1.0)
Requirement already satisfied: certifi in /usr/local/lib/python3.10/dist-packages (from rasterio) (2022.12.7)
Requirement already satisfied: click>=4.0 in /usr/local/lib/python3.10/dist-packages (from rasterio) (8.1.3)
Requirement already satisfied: cligj>=0.5 in /usr/local/lib/python3.10/dist-packages (from rasterio) (0.7.2)
Requirement already satisfied: numpy>=1.18 in /usr/local/lib/python3.10/dist-packages (from rasterio) (1.22.4)
Requirement already satisfied: snuggs>=1.4.1 in /usr/local/lib/python3.10/dist-packages (from rasterio) (1.4.7)
Requirement already satisfied: click-plugins in /usr/local/lib/python3.10/dist-packages (from rasterio) (1.1.1)
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-packages (from rasterio) (67.7.2)
Requirement already satisfied: pyparsing>=2.1.6 in /usr/local/lib/python3.10/dist-packages (from snuggs>=1.4.1->rasterio) (3.0.9)
Select fichiers  VHI_Map.tif
• VHI_Map.tif(image/tiff) - 34035 bytes, last modified: 12/06/2023 - 100% done
Saving VHI_Map.tif to VHI_Map (4).tif
Select fichiers  4 fichiers
• H%.tif(image/tiff) - 236854 bytes, last modified: 15/06/2023 - 100% done
• P.tif(image/tiff) - 229452 bytes, last modified: 15/06/2023 - 100% done
• N.tif(image/tiff) - 59218 bytes, last modified: 15/06/2023 - 100% done
• K.tif(image/tiff) - 54154 bytes, last modified: 17/05/2023 - 100% done
Saving H%.tif to H%.tif
Saving P.tif to P.tif
Saving N.tif to N.tif
Saving K.tif to K.tif
Saving pH.tif to pH.tif
Correlation coefficient with H%.tif:0.5535110829402784
Correlation coefficient with P.tif: -0.10148434108182287
Correlation coefficient with N.tif: 0.492944108995953
Correlation coefficient with K.tif: 0.023287846363551176
```
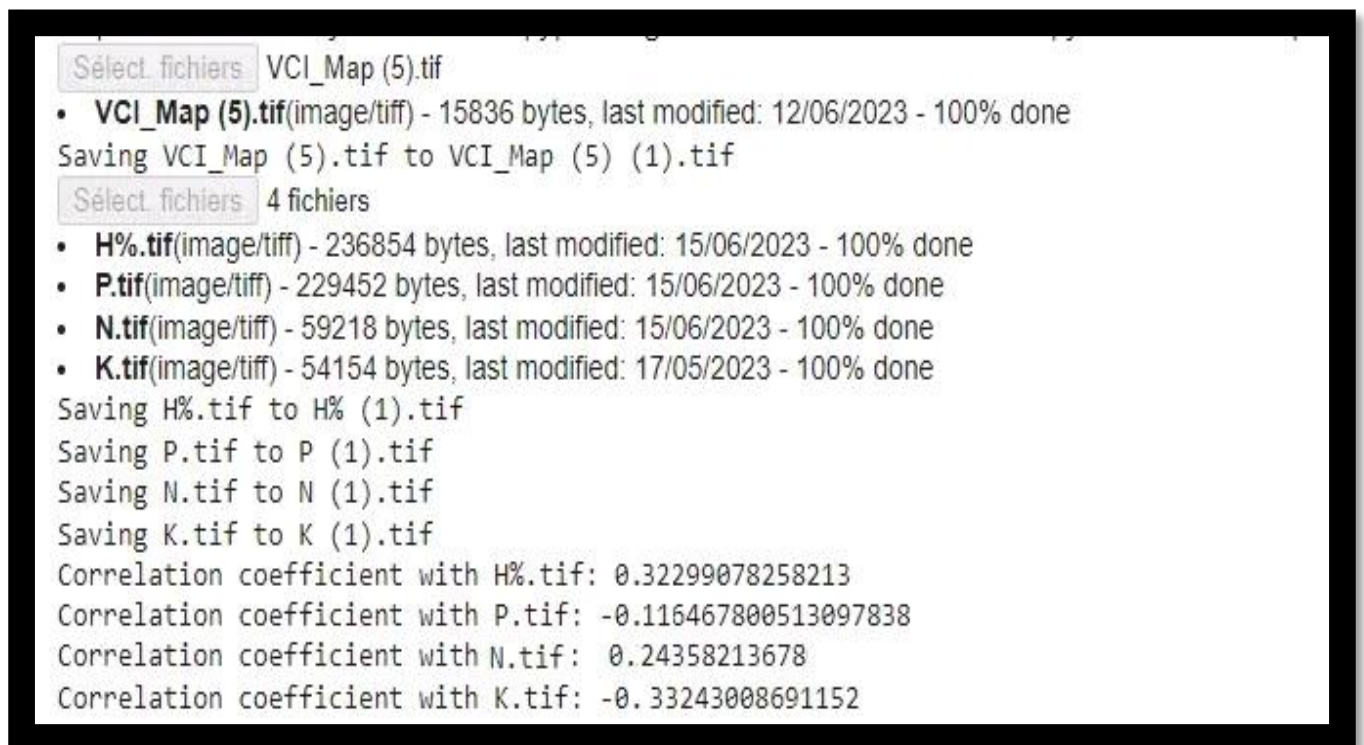
Figure 60: Correlation between the VHI with the soil moisture and NPK fertilizer (**Google colab**)

-The results get with the correlation. Says that: correlation between VHI and N: Average positive correlation but according to (EFFEt of Nitrogen Deficiency on plant stress Response and Tolerance to dought stress , 2018) nitrogen (n) is one of the main components of the formation of proteins in plants and contributes to the development of leaves and stems. the availability of nitrogen improves plant growth, strength and flowering**.**

- The results get with the correlation. Says that: correlation between VHI and P weak Negative correlation but according to (**Plant physiology , 2014**)phosphorus contributes to the growth of roots, the development of new organs and fruit ripening. Availability of phosphorus in appropriate quantities in the soil improves the overall growth of the plant and its root development.

- The results get with the correlation. Says that: correlation between VHI and k: No correlation but according to (**Plant physiology , 2014**) potassium(k) contributes to the regulation of enzymatic activity, water balance and the transport of nutrients in the plant. it also enhances plant strength and resistance to diseases and harsh environmental conditions.the abundance of potassium in appropriate quantities in the soil promotes root growth, development of new organs and plant flowers.

- The results get with the correlation. Says that: correlation between VHI and soil moisture: weak positive correlation but according to (**Plant physiology , 2014**) the effect of soil moisture on plant growth is of great importance. soil moisture affects the availability of water and other nutrients.in the plant. lack of soil moisture may lead to plant dehydration and damage, reduced root growth and a negative impact on the formation of new organs such as flowers and fruits.

Conclusion

Conclusion

Conclusion

The commune of Dahmoni is a semi-arid region that forms part of the cereal-growing areas of the province of Tiaret, in western Algeria and the Hauts Plateaux region.

This study was carried out in a field on the south side of Dahmoni to learn about and study the physical and chemical properties of the soil and the irrigation methods used by the farmer, with the possibility of applying remote sensing and geographical information systems to help understand the problems from which agriculture suffers and find solutions with the development of modern technology in a way called precision agriculture.

Thirty-three soil samples were systematically taken to obtain: soil moisture, total and active lime content, pH, electrical conductivity, organic matter, NPK fertilisers, soil texture, in addition to mapping all soil factors.

Soil and application of the vegetation condition index and vegetation health index. In all the soil samples taken, the soil texture is a soft limino clay with moderate, almost non-existent moisture levels, which confirms that the soil is rich in the alluvial part and an average amount of water, and this is due to the weather conditions. for this year compared with previous years.

The pH of the soil is alkaline, ranging from 7.54 to 8.22. Organic matter is low, ranging from 0 to 2.2%. As for electrical conductivity, its values are low, between 34 and 346µS/cm, so the quality of the soil is low in salt and has little effect on yield.

High levels of limestone were measured, with a total limestone value of 33.68%. As for NPK fertilisers, their values are moderate, and each element has an effect on the soil and the plant.

We have therefore backed up our results with maps that show what was obtained in the previous results, in particular the irrigation factor.

Consequently, we conclude from the study that the practice of irrigation must be carried out in an organised way by carrying out prior studies, in particular with the use of remote sensing and the geographic information system(GIS) ....

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Annexes

Annexes

Annex: Scales for interpreting the results

Annex 01: soil moisture

S	1	2	3	4	5	6	7	8	9	10	11
%	1.95	1.88	2.42	2.41	2.41	2.68	2.24	2.35	4.62	2.07	2.17
S	12	13	14	15	16	17	18	19	20	21	22
%	2.14	3.13	2.51	2.91	3.09	3.02	0.77	1.61	0.86	7.18	9.06
S	23	24	25	26	27	28	29	30	31	32	33
%	10.11	1.71	6.04	5.61	3.54	2.67	5.82	5.64	7.01	6.65	5.64

Annex 02: NPK fertiliser

S	1	2	3	4	5	6	7	8	9	10	11
N	43.2	28.8	28.8	28.8	21.6	18	28.8	28.8	25.2	25.2	25.2
P	36	28.8	28.8	28.8	21.6	18	25.2	28.8	21.6	21.6	25.2
K	82.8	72	79.2	82.8	64.8	61.2	75.6	75.6	68.4	68.4	72
S	12	13	14	15	16	17	18	19	20	21	22
N	28.8	25.2	28.8	28.8	32.4	28.8	25.2	21.6	28.8	39.6	28.8
P	25.2	28.8	25.2	28.8	32.4	28.8	18	25.2	32.4	39.6	25.2
K	72	75.6	72	82.8	82.8	72	64.8	64.8	82.8	104.4	72
S	23	24	25	26	27	28	29	30	31	32	33
N	32.4	28.8	25.2	36	28.8	28.8	28.8	28.8	32.4	28.8	28.8
P	28.8	32.4	25.2	39.6	28.8	28.8	32.4	28.8	25.2	25.2	25.2
K	75.6	75.6	79.2	111.6	68.4	79.2	86.4	75.6	82.8	72	75.6

Annex 03: Total limestone

S	1	2	3	4	5	6	7	8	9	10	11
CaCo3	2.63	1.40	6.31	4.21	4.56	0.87	23.85	11.40	0.70	0.70	5.08
S	12	13	14	15	16	17	18	19	20	21	22
CaCo3	4.91	3.68	8.40	10.87	11.05	33.68	9.47	14.91	21.64	12.98	3.50
S	23	24	25	26	27	28	29	30	31	32	33
CaCo3	3.85	12.98	24.56	18.24	28.24	11.22	13.15	15.76	17.54	1.22	0.87

Annexes

Annex 04: Organic carbon dosage

S	1	2	3	4	5	6	7	8	9	10	11
OM%	1.6	0.5	1.2	0	1.2	0.4	1	0.8	1.3	1.4	1.1
S	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
OM%	1.9	1.3	1.1	0.8	2	0.7	1.3	1.6	1.1	1.3	2.2
S	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
OM%	1.9	2	1.6	1.9	2	1.8	0.6	1.5	1.5	2.2	1.1

Annex 05: ph resualts

S	1	2	3	4	5	6	7	8	9	10	11
ph	8.14	8.22	8.09	8.20	7.54	7.92	8.14	8.04	8.14	7.81	8.06
S	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
ph	8.07	7.91	8	7.95	8.07	8.2	8.04	8.12	7.74	8.05	8.2
S	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Ph	7.56	8.03	7.95	8	7.77	7.63	8.07	8.13	8.14	7.93	8.15

Annexes

Annex 06 : Classification of Ph(**(Soil Science Department, 2021)**

pH range	Appreciations
Less than 4.5	Extremely sour
4,6 – 5,2	Very sour
5,3 – 5,5	Acid
5,6 – 6,0	Moderately acidic
6,1 – 6,6	Slightly acid
6,7 – 7,2	Neutral
7,3 – 7,9	
8,0 – 8,5	Slightly alkaline
Greater than 8.6	Alkaline

Annexes

**Annex 07 :** Classification of soil organic matter **(Soil Science Department, 2021)**

OM%	Class Name
0.5 to 1 %	Very low in OM
1 to 2 %	Low MO
2 to 3 %	Average (or moderate) in OM
3 to 5 %	High in OM
> 5 %	Very high in OM

Annex 08 : Classification of Total limestone **(Soil Science Department, 2021)**

	< 1	Not calcareous
	1 to 5	Little limestone
Total	5 to 25	Moderately calcareous
Caco3	25 to 50	Strongly calcareous
%	50 to 80	Very strongly calcareous
	Over 80	Excessively calcareous

Annexes

Annex 09 : Texture triangle
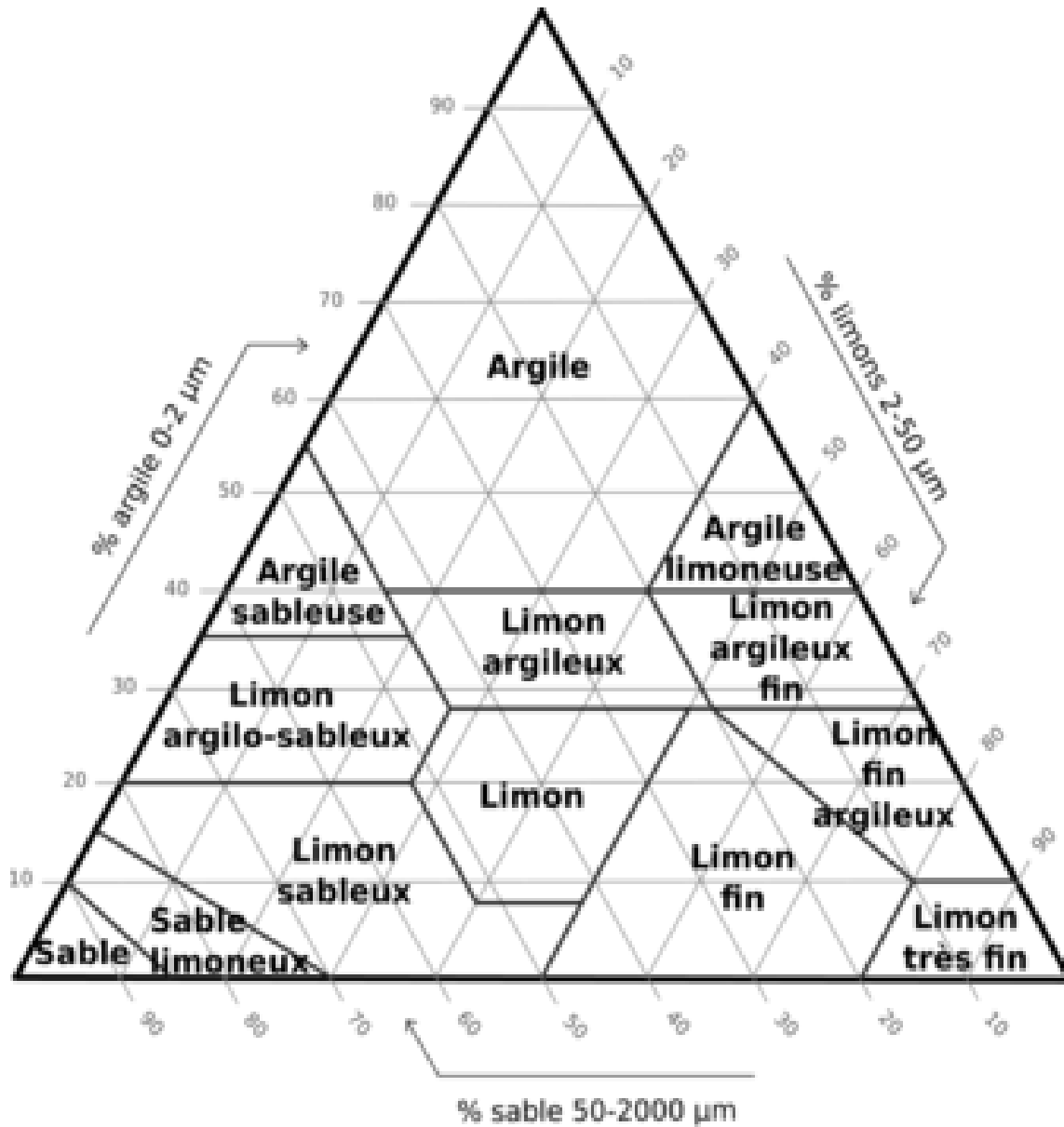
Triangle des textures

Summary

We carried out this study with the aim of knowing the nature of irrigation on **the basis of the physical and chemical properties of the soil** as well as the application of remote sensing technology and **the mapping of agricultural** land in **Dahmuoni** by taking 33 soil samples with a depth of 30 cm and they were examined in the laboratory of **precision agriculture** of the University Ibn Khaldoun of Tiaret to know the following characteristics:
Total and active lime, electrical conductivity, organic matter, exponential pH, soil moisture, NPK fertiliser and soil texture.
We relied on the results obtained in the laboratory and on the use of **geographic information systems(GIS)** and **remote sensing technology** to facilitate the research process on how to irrigate, particularly with the drought that has affected the region.

Key words : the basis of the physical and chemical properties of the soil, Dahmuoni, precision agriculture, geographic information systems(GIS), remote sensing technology, the mapping of agricultural.

Résumé

Nous avons réalisé cette étude dans le but de connaître la nature de l'irrigation sur **la base des propriétés physiques et chimiques du sol** ainsi que l'application de la technologie de télédétection et **la cartographie** des terres agricoles à **Dahmouni** en prélevant 33 échantillons de sol avec une profondeur de 30 cm et ils ont été examinés au laboratoire **d'agriculture de précision** de l'Université Ibn Khaldoun de Tiaret pour connaître les caractéristiques suivantes : Chaux totale et active, conductivité électrique, matière organique, pH exponentiel, humidité du sol, NPK fertiliser et texture du sol.

Nous nous sommes appuyés sur les résultats obtenus en laboratoire et sur l'utilisation du **système d'information géographique (SIG)** et de la technologie de **télédétection** pour faciliter le processus de recherche sur la façon d'irriguer, en particulier avec la sécheresse qui a touché la région.

Mot clé : la base des propriétés physiques et chimiques du sol, la cartographie, Dahmouni, agriculture de précision, système d'information géographique (SIG), télédétection.

ملخص

قمنا بهذه الدراسة بهدف معرفة طبيعة الري هناك بالاعتماد على **الخصائص الفيزيائية والكيميائية للتربة** وكذا تطبيق **تقنية الاستشعار عن بعد** و **رسم الخرائط** للاراضي الزراعية **بالدحموني** بأخذ 33 عينة تربة بعمق يتراوح 30 سنتيمتر وتم فحصها في مخبر **الزراعة الدقيقة** بجامعة إن خلدون تيارت لمعرفة خصائصها التالية

الجير النشط ـالناقلية الكهربائية ـالمادة العضوية ـالرقم الهيدروجيني الاسي ـرطوبة التربة ـالاسمدة (الازوت-الفوسفور-البوتاسيوم) و قوام التربة.

فقد اعتمدنا على النتائج المحصل عليها في المخير واستعمال **نظام المعلومات الجغرافية** و **تقنية الاستشعار عن بعد** لتسهيل عملية البحث عن كيفية الري خاصة مع الجفاف الذي مس المنطقة.

الكلمات الاستدلالية :

ـالخصائص الفيزيائية والكيميائية للتربة.

ـالدحموني.

ـ رسم الخرائط.

ـ الزراعة الدقيقة.

ـ نظام المعلومات الجغرافية و تقنية الاستشعار عن بعد.