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THEME

The Use of Geographic Information Systems (GIS) As Decision Support Tool for Agricultural Irrigation

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Abstract

Use of Geographic Information Systems (GIS) as Decision support tool for agricultural irrigation

This work is to show how the Geographic Information System can be used to analyze data about water used for irrigation to understand the reality and impact of the increase in exploiting underground water and eventually finding adequate solutions.

The water resources of the Northern Sahara are mostly fossil resources. The aquifers are certainly fed on the borders, from the Saharan Atlas, from the Tassili, and probably by the wadis, which descend from the reliefs, but this supply is not controlled, and remains negligible with regard to the quantities, which are withdrawn knowing the volumes intended for agriculture represent about two-thirds of the total withdrawals from it.

The big expansion of crop and pastures has increased the drilling of new wells and so an increase in the rate of the over exploitation and draining of the aquifers in certain region

The objective is to use the GIS to represent necessary information and zones of concentration of drilling, agricultural perimeters and the exploited volumes of water to easily define saturated areas and establish a database for future management of water in agricultural field.

Key word: GIS, Irrigation, Drillings, Agriclture, Data Analysing

Résumé

Utilisation des Systèmes d'Information Géographique (SIG) comme outil d'aide à la décision pour l'irrigation agricole

Ce travail consiste à montrer comment le Système d'Information Géographique peut être utilisé pour analyser les données sur l'eau utilisée pour l'irrigation afin de comprendre la réalité et l'impact de l'augmentation de l'exploitation des eaux souterraines et éventuellement trouver des solutions adéquates.

Les ressources en eau du Sahara septentrional sont essentiellement des ressources fossiles. Les aquifères sont certes alimentés sur les bordures, de l'Atlas saharien, du Tassili, et probablement par les oueds, qui descendent des reliefs, mais cet apport n'est pas maîtrisé, et reste négligeable au regard des quantités, qui sont prélevées sachant les volumes destinés à l'agriculture représentent environ les deux tiers des prélèvements totaux de celle-ci.

La grande expansion des cultures et des pâturages a augmenté le forage de nouveaux puits et donc une augmentation du taux de surexploitation et de vidange des aquifères dans certaines régions.

L'objectif est d'utiliser le SIG pour représenter les informations nécessaires et les zones de concentration de forage, les périmètres agricoles et les volumes d'eau exploités pour définir facilement les zones saturées et établir une base de données pour la gestion future de l'eau dans le domaine agricole.

Mots clés : SIG, irrigation, forages, agriculture, analyse des données

ملخص

استخدام نظم المعلومات الجغرافية كأداة لدعم القرار للري الزراعي

يهدف هذا العمل إلى إظهار كيف يمكن استخدام نظام المعلومات الجغرافية لتحليل البيانات حول المياه المستخدمة للري لفهم حقيقة وتأثير الزيادة في استغلال المياه الجوفية وإيجاد الحلول المناسبة في نهاية المطاف.

موارد المياه في الصحراء الشمالية هي في الغالب موارد أحفورية. تتغذى طبقات المياه الجوفية بالتأكيد على الحدود ، من الأطلس الصحراوي ، ومن الطاسيلي ، وربما من الوديان التي تنحدر من التضاريس ، ولكن هذا الإمداد لا يتم التحكم فيه ، ويبقى ضئيلاً من حيث الكميات التي يتم سحبها مع العلم أن الأحجام المخصصة للزراعة تمثل حوالي ثلثي إجمالي المسحوبات منها.

أدى التوسع الكبير في المحاصيل والمراعي إلى زيادة حفر آبار جديدة وبالتالي زيادة معدل الاستغلال المفرط وتصريف طبقات المياه الجوفية في منطقة معينة

الهدف هو استخدام نظم المعلومات الجغرافية لتمثيل المعلومات الضرورية ومناطق تمركز الحفر ، والمحيطات الزراعية وأحجام المياه المستغلة لتحديد المناطق المشبعة بسهولة وإنشاء قاعدة بيانات للإدارة المستقبلية للمياه في المجال الزراعي

كلمات رئيسية, نظم المعلومات الجغرافية, سقي, فلاحة, ابار, تحليل بيانات

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PMH	Périmètre moyen Hydrique	Average Hydric Perimeter
GPI	Grand Périmètre Irriguée	Big Irrigated perimeter
PNDA	Plan National Développement Agricole	National Plan of Agricultural Development
GIS	/	Geographic Information System
DBMS	/	Database Management System

INTRODUCTION

Introduction

When it comes to most important natural resource Water is no doubt the most precious ever, in the Northern Sahara this resource although important it is mostly fossil resources, which mean its renewability is very slow to negligible.

In recent years the agriculture becoming one of important investment both by government and private investors, it leads to big expansion of crop pastures and high increase in drillings mainly for CT water table.

This fast evolution needed fast processing to avoid water scarcity crisis but also over flooding that would be caused by over use of water irrigation.

In this work we show how the Geographic Information System can be used to process data about water used for irrigation and the actual expansion or agriculture parcels and planned expansion, those with help of satellite image that can show not just actual situation but also in past years to see its evolution.

To understand the reality and impact of the increase in exploiting underground water and eventually finding adequate solutions, it is also possible to handle the results by smaller zones and adding more details and information.

The objective here as first step is to use the GIS to represent necessary information and zones of concentration of drilling, agricultural perimeters and the exploited volumes of water to easily define saturated areas and establish a database that can be a base for future management of water in agricultural field.

To reach that objective the work was partitioned on three chapters:

First chapter is a collection of bibliographic database on the Geographic Information System: the different definitions, the history of it, the different areas where the GIS is used, classifications of the GIS and the main components of it.

In the second chapter we presented the area that was the example of study, its geographical situation and its climate.

In Chapter three the project is detailed step by step from introducing basic data, to creating new layers, define zones of agriculture from satellite images, to finally have one product that show all necessary data.

CHAPTER I

Generalities

I-1- Introduction

A Geographic Information System (GIS) is a system of computer software, hardware and data, personnel that make it possible to enter, analyze, manipulate and present data and the information that was tied to a location on the earth's surface.

Stages of GIS Development (Evolution of GIS) were the result of several technologies. Databases, computer mapping, remote sensing, programming, geography, mathematics, computer aided design and computer science, all each factor played the key role in the development of GIS. We also can group the history of GIS into several stages of development.

- **GIS History:**

• Paper Mapping Analysis with Cholera Clusters:

The work of british physician Dr. John Snow demonstrates that GIS is a problem-solving tool. In the history of GIS all started in 1854. Cholera hit the city of London, England. John Snow began mapping outbreak locations, roads, property boundaries and water lines. When he added these features to a map, there was happened something interesting: He saw that Cholera cases were commonly found along the water line. Dr. John Snow’s Cholera map was a major event connecting geography and public health safety was the beginning of spatial analysis. He put geographic layers on a paper map and made a life-saving discovery;

• Before 1960 (The GIS Dark Ages of GIS): Dark Ages GIS Computer mapping was in the dark. It was not developed. All mapping was done on paper or sieve mapping. The technology was not here for GIS to become known. In the 1950s, maps were simple. They had their place in vehicle routing, new development planning and locating points of interest. However, none of this was done on computers. Imagine a world without computer mapping. With all the issues that came with paper maps, it was no surprise that cartographers and spatial users wanted to explore computing options for handling geographic data.

• 1960 to 1970 (Pioneering time of GIS): in the history of GIS, this was the main incentive to shift from paper to computer mapping. The early 1960 to 1970s was really the period of GIS pioneering.

The pieces were coming together with advancements in technology:

- Map graphics as outputs using line printers.

- Advances in data storage with mainframe computers.

- Recording coordinates as data input.

- These initial developments in the world of computing are what propelled GIS its next step forward. However, what GIS really needed was a brilliant mind to put the puzzle pieces together;

• 1970 to 1980 (The period of state initiatives): State support for GIS stimulated the development of experimental work in the field of GIS based on the use of databases on street networks:

- Automated navigation systems.

- Systems for the removal of urban waste and garbage.

- Movement of vehicles in emergency situations, etc;

• Early 1980s to present time (Period of commercial development):

A wide market for various software tools, the development of desktop GIS, the expansion of their scope through integration with non-spatial databases, the emergence of network applications, the emergence of a significant number of non-professional users, systems that support individual data sets on individual computers, open the way for systems that support corporate and distributed geodatabases;

• Late 1980s to present time (Users period):

Increased competition among commercial producers of geoinformation technology services gives advantages to GIS users, the availability and "openness" of software tools allows you to use and even modify programs, the emergence of user "clubs", teleconferences, geographically dispersed, but connected by a single theme of user groups, an increased need for geodata, the beginning of the formation of the global geoinformation infrastructure.

- **Progenitors of modern GIS**

What software systems that are the progenitors of modern GIS? Well, several decades ago, several types of systems working with spatially coordinated information were presented on the information systems market:

• Computer-aided design systems - CAD (CAD - computer-aided design);

• Automated mapping systems (AM - Automated Mapping Management);

• Infrastructure management systems or engineering networks (FM - Facilities Management).

CAD AM and FM-systems, along with the systems of small-scale spatial analysis discussed above and database management systems (DBMS), are considered the progenitors of GIS. For example, Intergraph's systems are based on a CAD system, while ArcInfo developed on the basis of a fine-scale spatial analysis system. In modern versions of GIS, there is an integration of ideas and approaches underlying various types of IS.

I-2- Definitions (GIS)

There are many definitions for Geographic Information System (GIS) and defining it can be done by either explaining what it can do (Functions) or by looking at the components. Both are important to really understand a GIS and use it optimally.

First analyzing the three letters of the acronym GIS gives a clear picture of what GIS is all about:

G: (Geographic) Implies ain interest in the spatial identity or locality of certain entities on, under or above the surface of the earth.

I: (Information) Implies the need to be informed in order to make decisions. Data or raw facts are interpreted to create information that is useful for decision-making.

S: (System) Implies the need for staff, computer hardware and procedures, which can produce the information required for decision-making that is data collection, processing, and presentation[2].

1. According to Environmental Systems Research Institute (ESRI) a geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps(3) .

GIS is defined as a computerized system for capture, storage, retrieval, analysis and display of spatial data describing the land attributes and environmental features for a given geographic region, by using modem information technology(4);

2. GIS is a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems(5);

3. GIS is defined as a decision support system involving the integration of spatially referenced data in a problem-solving environment(6);

4. GIS is defined as a powerful set of tools for collecting, storing, retrieving, at will, transforming and displaying spatial data from the real world)(7);

5. GIS is any manual or computer based set of procedures used to store and manipulate geographically referenced data(8);

6. GIS is an institutional entity, reflecting an organizational structure that integrates technology with a database, expertise, and continuing financial support over time(9);

7. In the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations. Practitioners also regard the total GIS as including operating personnel and the data that go into the system(10);

8. GIS is an integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced(11).

9. In current works, attention is most often drawn to the relationship between geoinformatics and cartography. The problem of duality is usually shown, on the one hand, the geoinformation support of cartography, and on the other hand, the cartographic support of geoinformatics. The relationship between cartography and geoinformatics is manifested in the following aspects:

- thematic and topographic maps are the main source of spatiotemporal data for GIS;
- systems of geographic and rectangular coordinates and cartographic layout serve as the basis for coordinate referencing (geographic localization) of all information received and stored in the GIS;
- maps are the main means of geographic interpretation and organization of Earth remote sensing data and other information used in GIS (statistical, analytical, etc.);
- maps are one of the most important sources of mass data for the formation of the positional and content part of GIS databases in the form of digital maps, and the layered representation of spatial objects has direct analogies with the element-by-element division of the thematic content of maps.

I-3- Classification of GIS

Any GIS can be attributed by one or more features to a particular class. Consider the main classes of modern GIS.

I-3-1- Classification of GIS according to the architectural principle of construction:

The GIS, presented at the present stage, are divided into two classes according to the types of architectures: closed and open.

a- **Closed systems** are characterized by a low price, they are presented (determined) in advance by the class of tasks solved by the system. They are characterized by the simplicity of the interface and the rapid development of these systems by users. The set of functions they perform cannot be changed, which largely determines the short life cycle of these systems.

b- Open systems have a specific set of functions and are equipped with a special apparatus for creating and embedding special applications by users, thereby expanding the functionality of basic GIS. Open systems are more expensive, but have a longer life cycle and can be adapted to a wide range of tasks.

I-3-2- Classification of GIS by hardware platform:

a- **GIS professional level**. These are fairly powerful systems, originally designed for client-server applications (powerful servers and workstations are used). These systems are built on a modular basis and can be supplied in various configurations. This type includes well-known GIS firms Intergraph - MGE, ESRI - ArcGIS, etc.

b- **Desktop GIS**. GIS of this type are PC-oriented and intended for use by a wide range of users. Such GIS have a smaller set of functions. They have a low price, are more widely used, and work places are organized on their basis in large GIS projects, where the GIS is built as a multi-level system.

c- **Internet/Intranet-GIS**. A distinctive feature of such systems is the use of client-server technology in their construction and Web-technology. In this case, all data is stored on the server and becomes available on the client via the Internet/Intranet. Clients are on the PC and are of two types: "thin" and "thick". "Thin" clients are traditionally based on the use of a standard browser, while "thick" clients are a separate application that interacts with the server with cartographic and other data. It is believed that such GIS has a great future in various fields of human activity.

I-3-3- Classification of GIS by territorial coverage:

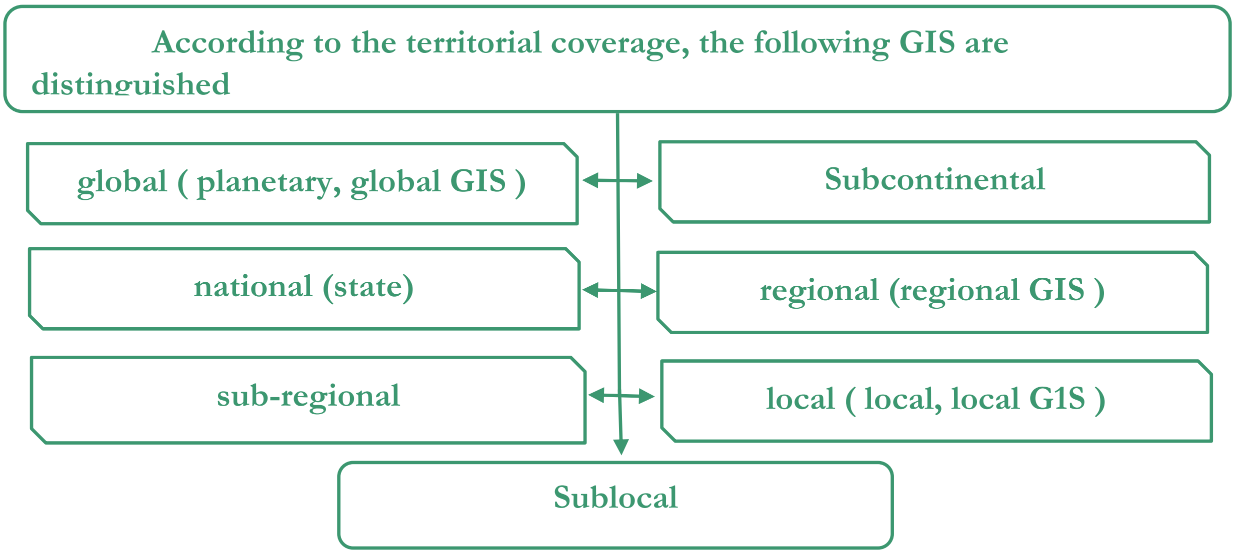


Fig-1 GIS by territorial coverage

I-3-4- Classification of GIS according to the subject area of information modeling:

The problem orientation of a GIS is determined by the tasks it solves (scientific and/or applied), among them such tasks as inventory of natural resources, analysis and assessment of natural phenomena, monitoring of the ecological situation, management and production planning, decision support in various areas of human activity and etc.

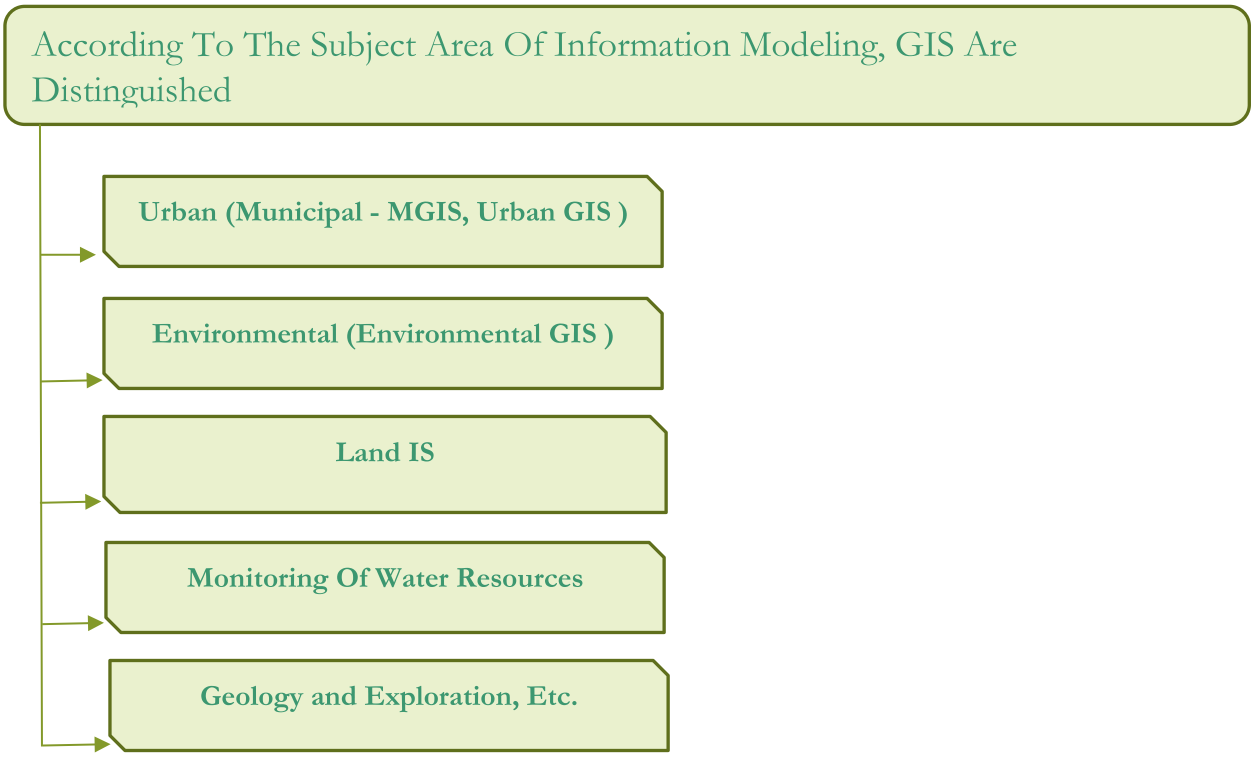


Fig-2 GIS by subject area of information modeling

I-3-5- Classification of GIS by functionality:

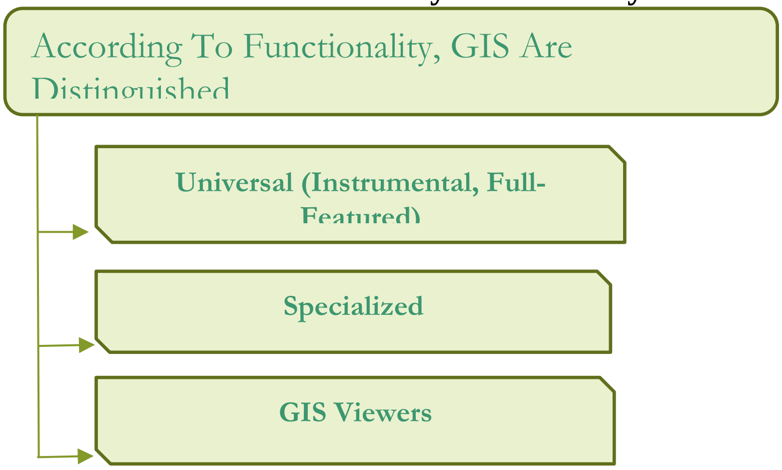


Fig-3 GIS by functionality

Universal GIS are characterized by openness, work with various data formats, have a fairly powerful graphical editor, have tools for developing and implementing various applications (an increase in the set of functions). With the development and creation of new versions, these GIS are supplied with a large number of add-on modules for both general and special purposes (for example, GIS Mapinfo, Arcinfo, etc.).

This is the most widely used class of GIS, since it allows, if necessary, to adapt and solve various problems in many areas of knowledge, to increase the number of built-in specialized modules, with the help of which the apparatus of spatial modeling and analysis of initial data is expanded.

As a rule, these systems have their own built-in languages that work with both attribute and graphic information, and tools for implementing program modules written in high-level languages;

Specialized GIS solve a narrow range of problems on a given set of parameters. Their main task is to control the progress of processes and prevent undesirable situations, automate workflow, etc;

GIS-viewers are designed to visualize spatial information and print it out. These systems are not equipped with a serious apparatus for spatial analysis and modeling.

I-3-6 Classification of GIS according to the data model used:

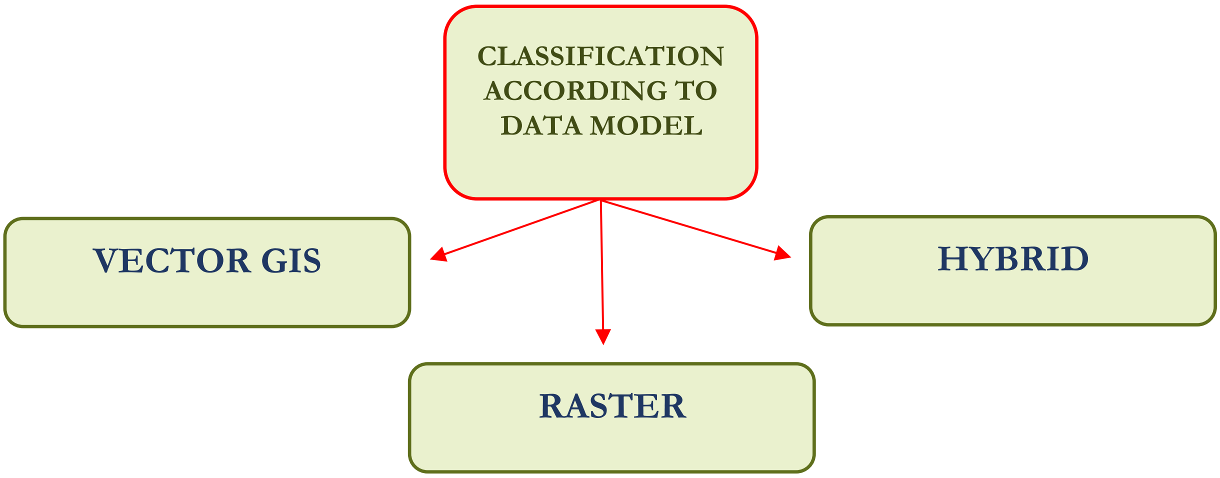


Fig-4 GIS by the data model used

Vector GIS are based on the principles of vector graphics and work with topological or non-stopological vector data models;

Raster GIS are based on the principles of raster graphics and work with raster data models;

Hybrid GIS combine the capabilities of vector and raster GIS.

The vast majority of modern GIS are not strictly vector or strictly raster. Usually in vector GIS there are some tools for working with raster data and, conversely, in raster

GIS there are tools for working with vector data models (this is also observed among graphic editors).

I-3-7 Other types of GIS classification:

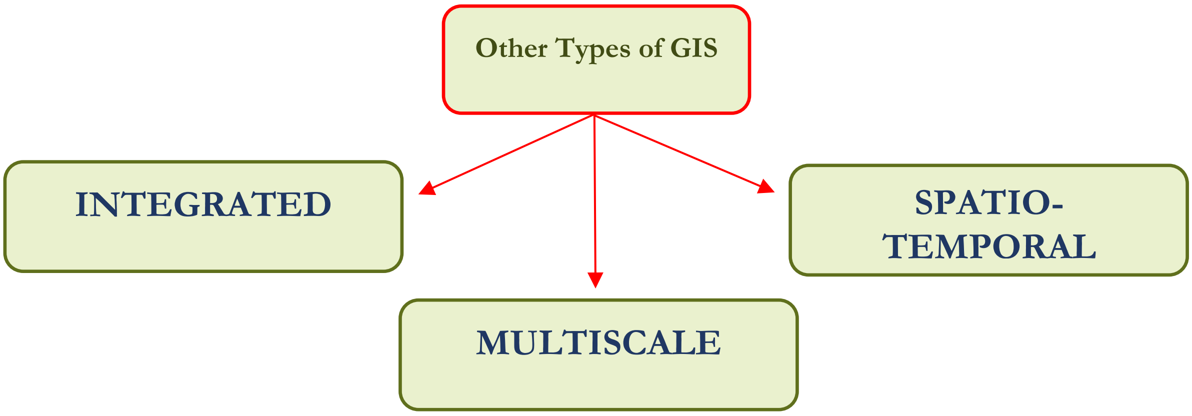


Fig-5 Other types of GIS

Integrated GIS (Integrated GIS, IGIS) combine the functionality of GIS and systems for digital processing and interpretation of images (primarily aerospace) in a single integrated environment;

Multiscale GIS (scale-independent GIS, multiscale GIS) are based on multiple or multi-scale representations of spatial objects (multiple representation), providing graphical or cartographic reproduction of data at any of the selected scale levels based on a single data set with the highest spatial resolution;

Spatio-temporal GIS (spatio-temporal GIS) operate with spatio-temporal data.

It is possible to classify GIS, which is based on two, and sometimes three features.

I-4- Why and Where to use GIS

- Considering the spatial character of parameters and precipitation controlling hydrologic processes, it is not surprising that Geographic Information Systems (GIS) have become an integral part of hydrologic studies [(12)].

- GIS benefits organizations of all sizes and in almost every industry. There is a growing interest in and awareness of the economic and strategic value of GIS, in part because of more standards-based technology and greater awareness of the benefits demonstrated by GIS users. The number of GIS enterprise solutions and IT strategies that include GIS are growing rapidly. The benefits of GIS generally fall into five basic categories:

- Cost savings resulting from greater efficiency. These are associated either with carrying out the mission (i.e., labor savings from automating or improving a workflow) or improvements in the mission itself. A good case for both of these is Sears, which implemented GIS in its logistics operations and has seen dramatic improvements. Sears considerably reduced the time it takes for dispatchers to create routes for their home delivery trucks (by about 75%). It also benefited enormously in reducing the costs of carrying out the mission (i.e., 12% - 15% less drive time by optimizing routes). Sears also improved customer service, reduced the number of return visits to the same site, and scheduled appointments more efficiently.

- Better decision making. This typically has to do with making better decisions about location. Common examples include real estate site selection, route/corridor selection, zoning, planning, conservation, natural resource extraction, etc. People are beginning to realize that making the correct decision about a location is strategic to the success of an organization.

- Improved communication. GIS-based maps and visualizations greatly assist in understanding situations and storytelling. They are a new language that improves communication between different teams, departments, disciplines, professional fields, organizations, and the public.

- Better geographic information recordkeeping. Many organizations have a primary responsibility of maintaining authoritative records about the status and change of geography (geographic accounting). Cultural geography examples are zoning, population census, land ownership, and administrative boundaries. Physical geography examples include forest inventories, biological inventories, environmental measurements, water flows, and a whole host of geographic accountings. GIS provides a strong framework for managing these types of systems with full transaction support and reporting tools. These systems are conceptually similar to other information systems in that they deal with data management and transactions, as well as standardized reporting (e.g., maps) of changing information. However, they are fundamentally different because of the unique data models and hundreds of specialized tools used in supporting GIS applications and workflows.

- Managing geographically. In government and many large corporations, GIS is becoming essential to understand what is going on. Senior administrators and executives at the highest levels of government use GIS information products to communicate. These products provide a visual framework for conceptualizing, understanding, and prescribing action. Examples include briefings about various geographic patterns and relationships including land use, crime, the environment, and defense/security situations.

- GIS is increasingly being implemented as enterprise information systems. This goes far beyond simply spatially enabling business tables in a DBMS. Geography is emerging as a new way to organize and manage organizations. Just like enterprise-wide financial systems transformed the way organizations were managed in the ‘60s, ‘70s, and ‘80s, GIS is transforming the way that organizations manage their assets, serve their customers/citizens, make decisions, and communicate. Examples in the private sector include most utilities, forestry and oil companies, and most commercial/retail businesses. Their assets and resources are now being maintained as an enterprise information system to support day-to-day work management tasks and provide a broader context for assets and resource management(13).

- GIS can be used to map locations. It allows the creation of maps through automated mapping, data capture, and surveying analysis tools.

- GIS can be used to map quantities, like where the most and least are, to find places that meet their criteria and take action, or to see the relationship between places, this gives an additional level of information beyond simply mapping the locations of features.

- Mapping densities: While you can see concentrations by simply mapping the locations of features, in areas with many features it may be difficult to see which areas have a higher concentration than others. A density map lets you measure the number of features using a uniform areal unit, such as acres or square miles, so you can clearly see the distribution.

- GIS can be used to find out what's occurring within a set distance of a feature.

- GIS can be used to map the change in an area to anticipate future conditions, decide on a course of action, or to evaluate the results of an action or policy(14).

- Ultimately, the GIS combines the traditional database operations of query and statistical analysis with the rich visualization and geographic (spatial) analysis benefits that a map provides. This feature provides unique opportunities for using GIS in solving a wide range of problems related to the analysis of phenomena and events, forecasting their likely consequences and planning strategic decisions.

Data in GI System is stored as a set of thematica layers, which are combined based on their geographical location. This flexible approach and ability of GIS to work with both vector and raster models is effective in solving any problems related to spatial information.

I-5- Components and Tasks of GIS

I-5-a Components

A working GIS integrates five key components: hardware, software, data, people, and methods.

- Hardware is the computer on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.
- Software: GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are:

· Tools for the input and manipulation of geographic information

· A database management system (DBMS)

· Tools that support geographic query, analysis, and visualization

· A graphical user interface (GUI) for easy access to tools

- Data: Possibly the most important component of a GIS is the data. Geographic data and related tabular, data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to organize and maintain their data, to manage spatial data;
- People: GIS technology is of limited value without the people who manage the system and develop plans for applying it to real world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work;
- Methods: A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

How GIS Works: a GIS stores information about the world as a collection of thematic layers that can be linked together by geography. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems from tracking delivery vehicles, to recording details of planning applications, to modeling global atmospheric circulation. Geographic References: Geographic information contains either an explicit geographic reference such as a latitude and longitude or national grid coordinate, or an implicit reference such as an address, postal code, census tract name, forest stand identifier, or road name. An automated process called geocoding.

It is used to create explicit geographic references (multiple locations) from implicit references (descriptions such as addresses). These geographic references allow you to locate features such as a business or forest stand and events such as an earthquake on the Earth's surface for analysis. Vector and Raster Models: Geographic information systems work with two fundamentally different types of geographic models--the "vector model" and the "raster model." In the vector model, information about points, lines, and polygons is encoded and stored as a collection of x,y coordinates. The location of a point feature, such as a bore hole, can be described by a single x,y coordinate. Linear features, such as roads and rivers, can be stored as a collection of point coordinates. Polygonal features, such as sales territories and river catchments, can be stored as a closed loop of coordinates. The vector model is extremely useful for describing discrete features, but less useful for describing continuously varying features such as soil type or accessibility costs for hospitals. The raster model has evolved to model such continuous features. A raster image comprises a collection of grid cells rather like a scanned map or picture. Both the vector and raster models for storing geographic data have unique advantages and disadvantages. Modern GISs are able to handle both models.

I-5-b- GIS Tasks: GISs essentially perform five processes or tasks:

Input:

Before geographic data can be used in a GIS, the data must be converted into a suitable digital format. The process of converting data from paper maps into computer files is called digitizing. Modern GIS technology has the capability to automate this process fully for large projects using scanning technology; smaller jobs may require some manual digitizing (using a digitizing table) which drastically reduces the terms of the techological cycle. Today many types of geographic data already exist in GIS-compatible formats. These data can be obtained from data suppliers and loaded directly into a GIS and user-friendly display of spatial data mapping of spatial data including in three dimensions, is the most convenient for perception, that simplifies the construction of queries and their subsequent analysis.

Manipulation:

It is likely that data types required for a particular GIS project will need to be transformed or manipulated in some way to make them compatible with your system. For example, geographic information is available at different scales (street centerline files might be available at a scale of 1:100,000; census boundaries at 1:50,000; and postal codes at 1:10,000). Before this information can be integrated, it must be transformed to the same scale. This could be a temporary transformation for display purposes or a permanent one required for analysis. GIS technology offers many tools for manipulating spatial data and for weeding out unnecessary data.

Management:

For small GIS projects it may be sufficient to store geographic information as simple files. There comes a point, however, when data volumes become large and the number of data users becomes more than a few, that it is best to use a database management system (DBMS) to help store, organize, and manage data. A DBMS is nothing more than computer software for managing a database -an integrated collection of data. There are many different designs of DBMSs, but in GIS the relational design has been the most useful. In the relational design, data are stored conceptually as a collection of tables. Common fields in different tables are used to link them together. This surprisingly simple design has been so widely used primarily because of its flexibility and very wide deployment in applications both within and without GIS.

Query and Analysis:

Once you have a functioning GIS containing your geographic information, you can begin to ask simple questions such as · Who owns the land parcel on the corner? · How far is it between two places? · Where is land zoned for industrial use? And analytical questions such as: · Where are all the sites suitable for building? · What is the dominant soil type for oak forest? · If a new highway is built here, how will traffic be affected? GIS provides both simple point-and-click query capabilities and sophisticated analysis tools to provide timely information to managers and analysts alike. GIS technology really comes into its own when used to analyze geographic data to look for patterns and trends, and to undertake "what if" scenarios. Modern GISs have many powerful analytical tools, but two are especially important.

Visualization:

For many types of geographic operation the end result is best visualized as a map or graph. Maps are very efficient at storing and communicating geographic information. While cartographers have created maps for millennia, GIS provides new and exciting tools to extend the art and science of cartography. Map displays can be integrated with reports, three-dimensional views, photographic images, and other output, such as multimedia.

I-6 Conclusion

The ability of GIS to search databases and perform geographic queries has saved many companies literally millions of dollars. GISs have helped:

· Decrease the time taken to answer customer requests.

· Find land suitable for development.

· **Search for relationships among crops, soils, and climate**.

· Locate the position of breaks in electrical circuits.

"Better information leads to better decisions" is as true for GIS as it is for other information systems. A GIS, however, is not an automated decision making system but a tool to query, analyze, and map data in support of the decision making process. GIS technology has been used to assist in tasks such as presenting information at planning inquiries, helping resolve territorial disputes, and siting pylons in such a way as to minimize visual intrusion.

GIS can be used to help reach a decision about the location of a new housing addition (spatial analysis) that has minimal environmental impact, is located in a low risk area, and is close to a population center. The information can be presented succinctly and clearly in the form of a map and accompanying report, allowing decision makers to focus on the real issues rather than trying to understand the data. Because GIS products can be produced quickly, multiple scenarios can be evaluated efficiently and effectively (for example, if we add a new road).

CHAPTER II

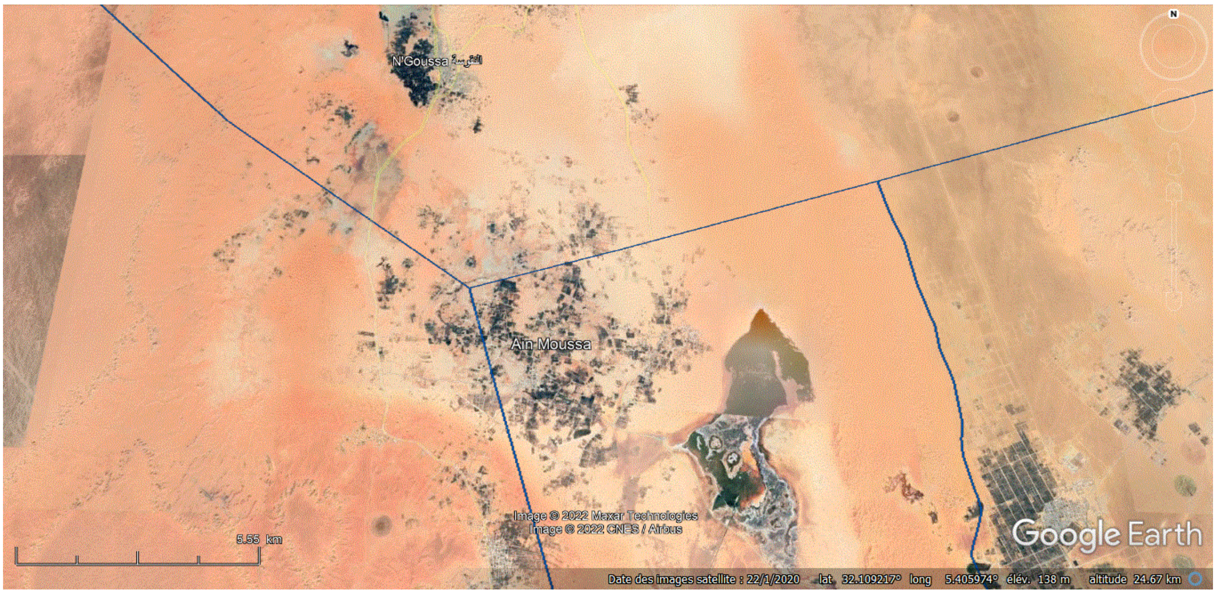
Presentation of the Area of study

II-1 Intro about the region

The commonly held idea is that the groundwater resources of Sahara are known and quantified for the most part, while the degree of knowledge varies according to the aquifers and the regions. If the resources of the main aquifers have been quantified, many others, with certainly modest resources, have not been the subject of detailed hydrogeological studies.

II-2 Geographical location of the study region

The study was conducted in the localities Ain Moussa (Ouargla-Sidi Khouiled-N'Goussa-). This choice was dictated by the geomorphological diversity and an agricultural profile renowned for the significant activity of irrigation via wells and boreholes (drills).



Map.1 : Aerial representative of Ain Moussa.

II-3 Climate

The Algerian Sahara has a hyper-arid climate, characterized by low and irregular rainfall. It is cold and dry in winter, hot and dry in summer with intra and inter-daily temperature differences. The Sahara is also characterized by high luminosity and prevailing seasonal winds. To support climate data namely; precipitation and temperature, we made a synthesis covering a period of 30 years from 1991-2020

Rainfall in the Saharan areas is low and rare. The annual distribution is irregular and in some, it causes torrential rains.

Temperature is the most important climatic factor (Dreux, 1980).

The study region is a part of the Sahara, which has large temperature differences

II-4 Water Resources

The water resources of the Northern Sahara part of which the study region is in, have been the subject of a modeling study within the framework of the SASS project. The simulations carried out show that for the Continental Intercalaire, the withdrawals, which were around 670 Hm3/year in 2000, and very probably more than 1,000

Hm3/year in 2010, are likely to reach 2,300 Hm3/year in 2050, in the case of the weak hypothesis of mobilization of this resource, and 6,100 Hm3/year in the case of the strong hypothesis.

The exploitation of these volumes will obviously lead to significant drawdowns, but which remain admissible in the case of the low hypothesis.

II-5 Land use

Actually irrigated by type of speculation by perimeter.
the importance of areas under arboriculture (65% for the 2008 campaign, against 48% overall in PMH) which by their nature represent "obligatory" areas
in terms of irrigation water demand; the relatively significant development of open-field market gardening, crops cash crop, making more use of irrigation water than industrial crops which do not developed (6%) despite the primary relative vocation of GPIs in this area, and for lack of enhancement of processing sectors;
The very low development of fodder crops, despite a great need for fodder
for the development of the milk and dairy products sector, which is very lacking in terms of national ; The absence of oilseed-protein crops.

The evolution of the PMH was marked by the development of individual irrigation systems (in particular with the recent PNDA) and the regression of collective irrigation systems and related perimeters under the concomitant effect of the scarcity of surface water. Available for irrigation, the disorganization of irrigation syndicates, the dismemberment of estates and socialist cooperatives and the rise of individualism at the level of farmers (traditional, modern private fellahs,..).

A "geographical irrigation area" thus defined includes irrigation systems (see definition below) which can be integrated and contiguous in space (collective hydraulic perimeters and/or geometric parcels in one piece in systems of individual irrigation) or on the contrary fragmented (mosaic units of discontinuous individual irrigated farms on a plain land).

A "geographical area" of irrigation is thus generally made up of several agricultural holdings practicing irrigation, and can correspond to one or more irrigation systems and put involved in irrigated systems, perimeters and plots, of various kinds, such as:

• Modern collective gravity perimeters,

• Irrigated parcel of plain more or less dispersed with individual pumping,

• Plot with individual greenhouses,

• GPI

• Oasis perimeters with more or less developed individual or collective additional pumping (palm groves and group of palm groves)[15]

CHAPTER III
Method and Materials

III-1 Collecting Data

In our work, we did work on the Ain Moussa area, whose part of SASS project launched recently to establish a data record on water resources in general and the irrigation in particular to assess the situation and possible waste.

The first mission was collecting data and for that it was necessary to visit the drillings on field to update the information of already existing data and collect new ones.

One of problem that we encountered was related of old method of localization, where sometimes wasn't easy to recognize the exact drilling due to error of precession of localization especially in concentration areas where few meters error can mix up more than 2 drillings, , the access to parcels and collect exact data was delicate as well for both drillings data and superficies.

Fig.5 drilling photo

III-2 Creation of the project on ArcGIs

In our work, we did work on the Ain Moussa area, whose part of SASS project launched recently to establish a data record on water resources in general and the irrigation in particular to assess the situation and possible waste.

In the decision-making process, we examine the water consumption of parcels and create a map of the existing water drillings and the relative water consumption in each.

ArcCatalog is a tree where data about a city is located. We add these data one by one to the map. They can also be considered separately.

ArcMap is a dock Option to view the query, edit and layout the map. We can use many different symbols to display our data.

a- First step in creating a project is to open through ArcCatalog, new file Geodatabase, in which we create new feature class.
This step is to be able to get the whole project with all shape files in one place and it is created as new geodatabase file the catalog and can be placed in chosen file. (Annex fig.6)

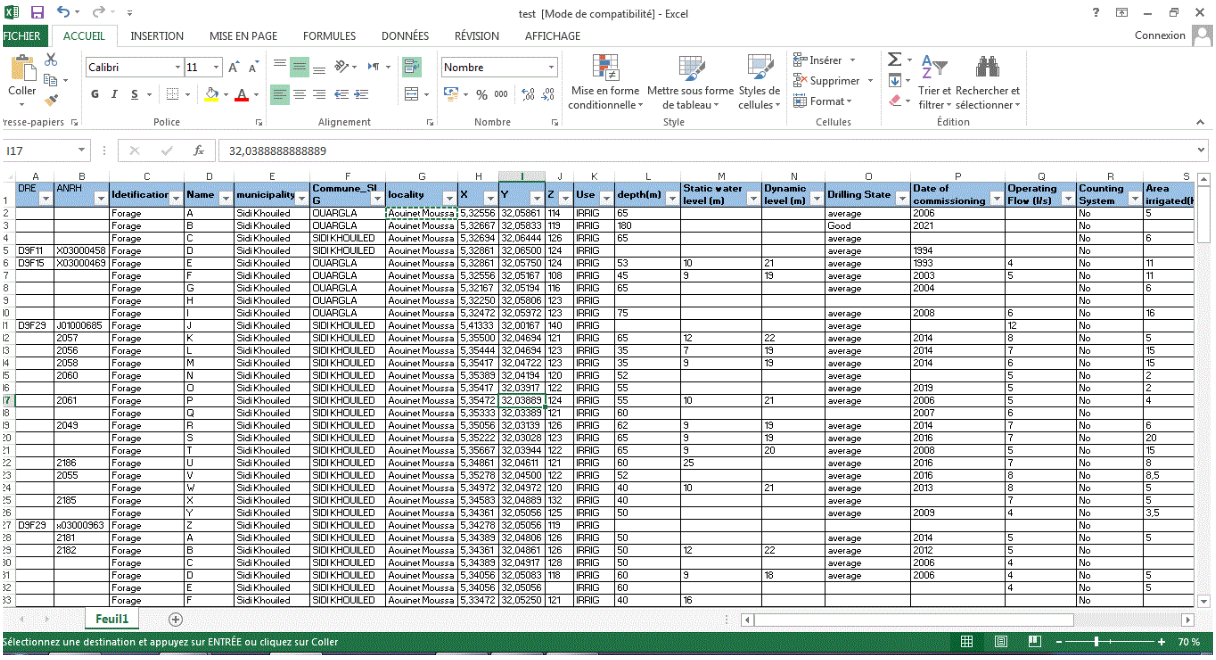
b- In feature class there are different types that can be created; points can be used to positioned objects using their unique geographic coordinates such as drills, water towers or specific landmark..
Lines are used for limitations, roads and tracks..,
The polygons are used for determination and frame zones and areas or any specific body that occupy an important area that can be shown on the map such buildings , agriculture perimeters, wetlands.. (Annex Fig.7)

c- In the ArcGis there are many coordinates system to choose from, thing that can be confusing for first use , the coordinates for project should be selected accordingly to the position (continent, country ..) but also accordingly to the system adopted by for other projects in area to avoid future issues, in our case the WGS1984 was used as it is the system used in previous projects by local companies and studies. (Annex Fig.8)

III-2 Adding the data

a- First step is to add the data; although data can be added straight into the ArcGig table in the feature class we create (Annex fig.9).
In our project the drillings information already collected and organized on an Excel table; the variety of data was at first step brought into Excel from the field investigations forms and completed by existing data and verified multiple times, so this step was necessary.

The simplest step was then to export these tables to the ArcGIS and for that the data on Excel that should include geographic coordinates in correct forma along with other data needed for the study.(Annex fig.9)



DRE	ANRH	Idetification	Name	municipality	Commune_SIG	locality	X	Y	Z	Use	depth(m)	Static water level (m)	Dynamic level (m)	Drilling State	Date of commissioning	Operating Flow (l/s)	Counting System	Area irrigated(
		Forage	A	Sidi Khouiled	OUARGLA	Aouinet Moussa	5,32556	32,05861	114	IRRIG	65			average	2006		No	5
		Forage	B	Sidi Khouiled	OUARGLA	Aouinet Moussa	5,32667	32,05833	119	IRRIG	180			Good	2021		No	
		Forage	C	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,32694	32,06444	126	IRRIG	65			average			No	6
D9F11	X03000458	Forage	D	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,32861	32,06500	124	IRRIG				average	1994		No	
D9F15	X03000469	Forage	E	Sidi Khouiled	OUARGLA	Aouinet Moussa	5,32861	32,05750	124	IRRIG	53	10	21	average	1993	4	No	11
		Forage	F	Sidi Khouiled	OUARGLA	Aouinet Moussa	5,32556	32,05167	108	IRRIG	45	9	19	average	2003	5	No	11
		Forage	G	Sidi Khouiled	OUARGLA	Aouinet Moussa	5,32167	32,05194	116	IRRIG	65			average	2004		No	6
		Forage	H	Sidi Khouiled	OUARGLA	Aouinet Moussa	5,32250	32,05806	123	IRRIG							No	
		Forage	I	Sidi Khouiled	OUARGLA	Aouinet Moussa	5,32472	32,05972	123	IRRIG	75			average	2008	6	No	16
D9F29	J01000685	Forage	J	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,41333	32,00167	140	IRRIG				average		12	No	
	2057	Forage	K	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35500	32,04694	121	IRRIG	65	12	22	average	2014	8	No	5
	2056	Forage	L	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35444	32,04694	123	IRRIG	35	7	19	average	2014	7	No	15
	2058	Forage	M	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35417	32,04722	123	IRRIG	35	9	19	average	2014	6	No	15
	2060	Forage	N	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35389	32,04194	120	IRRIG	52			average		5	No	2
		Forage	O	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35417	32,03917	122	IRRIG	55			average	2019	5	No	2
	2061	Forage	P	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35472	32,03889	124	IRRIG	55	10	21	average	2006	5	No	4
		Forage	Q	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35333	32,03389	121	IRRIG	60				2007	6	No	
	2049	Forage	R	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35056	32,03139	126	IRRIG	62	9	19	average	2014	7	No	6
		Forage	S	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35222	32,03028	123	IRRIG	65	9	19	average	2016	7	No	20
		Forage	T	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35667	32,03944	122	IRRIG	65	9	20	average	2008	5	No	15
	2186	Forage	U	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34861	32,04611	121	IRRIG	60	25		average	2016	7	No	8
	2055	Forage	V	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,35278	32,04500	122	IRRIG	52			average	2016	8	No	8,5
		Forage	W	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34972	32,04972	120	IRRIG	40	10	21	average	2013	8	No	5
	2185	Forage	X	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34583	32,04889	132	IRRIG	40			average		7	No	5
		Forage	Y	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34361	32,05056	125	IRRIG	50			average	2009	4	No	3,5
D9F29	x03000963	Forage	Z	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34278	32,05056	119	IRRIG							No	
	2181	Forage	A	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34389	32,04806	126	IRRIG	50			average	2014	5	No	5
	2182	Forage	B	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34361	32,04861	126	IRRIG	50	12	22	average	2012	5	No	
		Forage	C	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34389	32,04917	128	IRRIG	50			average	2006	4	No	
		Forage	D	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34056	32,05083	118	IRRIG	60	9	18	average	2006	4	No	5
		Forage	E	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,34056	32,05056		IRRIG	60					4	No	5
		Forage	F	Sidi Khouiled	SIDI KHOUILED	Aouinet Moussa	5,33472	32,05250	121	IRRIG	40	16					No	

Fig-10 Data prepared on Excel

b- Once the Excel table imported it need to display XY data,
The coordinates cells selected accordingly to bring the simple numbers into actual points on the map with exact geographic position as it is shown on the next figure.

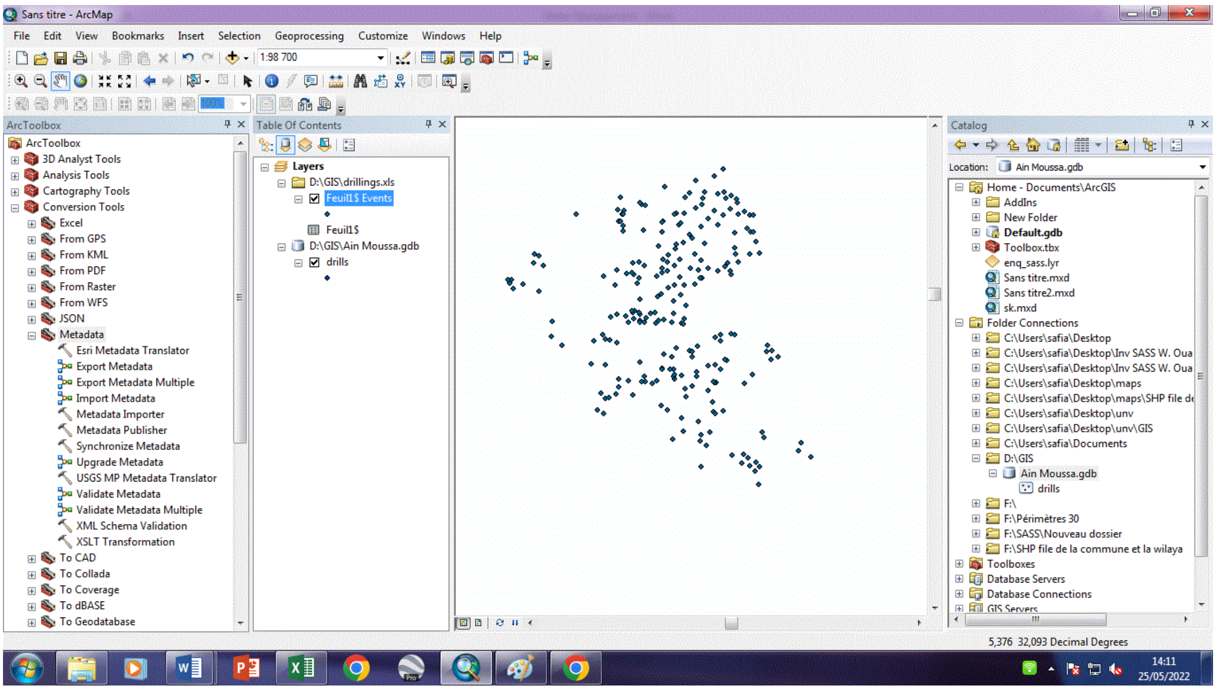


Fig-11 drillings points display

The drillings having geographic coordinates it still need to be displayed on a real satellite image for better reading that is also needed to detect and correct eventual errors in writings.

c- To be able to use the created project on different platform, for instance Google Earth it is then necessary to export the data to the appointed place on disc (Annex fig.12)

III-3- Creating the zones on satellite image

For this part the switch for Google Earth was chosen for its predisposed satellite image and the simplicity of drawing or depicting the zones.

Using the add polygon, we can create the zone following the visible chosen area borders. (Annex fig.15)

The access to satellite images helps determining the existing agriculture superficies and the nearby buildings and wetlands.

Each layer was made for specific area, one for wetlands as it is important for agriculture to visualize the eventual water bodies.

Another for buildings that show close human agglomerations.

Last the most important for this project, the agricultural zones; at first step the zones were created to visualize the irrigated area as a whole and the distribution of drillings inside the area

It is possible to make a more detailed map; delimiting parcels as seen on satellite images with help of collected field data to get more info and eventually a detailed analyses on situation.

III-3-1 from Google Earth to ArcGis and vice versa

At this point it is possible either to add the created drillings maps on ArcGis to the created zones on Google Earth or go the other way by adding the created zones polygons to ArcGis.

a- Going to ArcToolbox and check on from Layer to KML and transfer the file to Google Earth to bring the drillings to the map with satellite image and zones. (Annex fig.16)

This give us the a final image of all layers on a satelite image where it is possible to see the layering of all data and first analysis of drillings positioning and clear view of irrigated areas and first impression of studied zone.

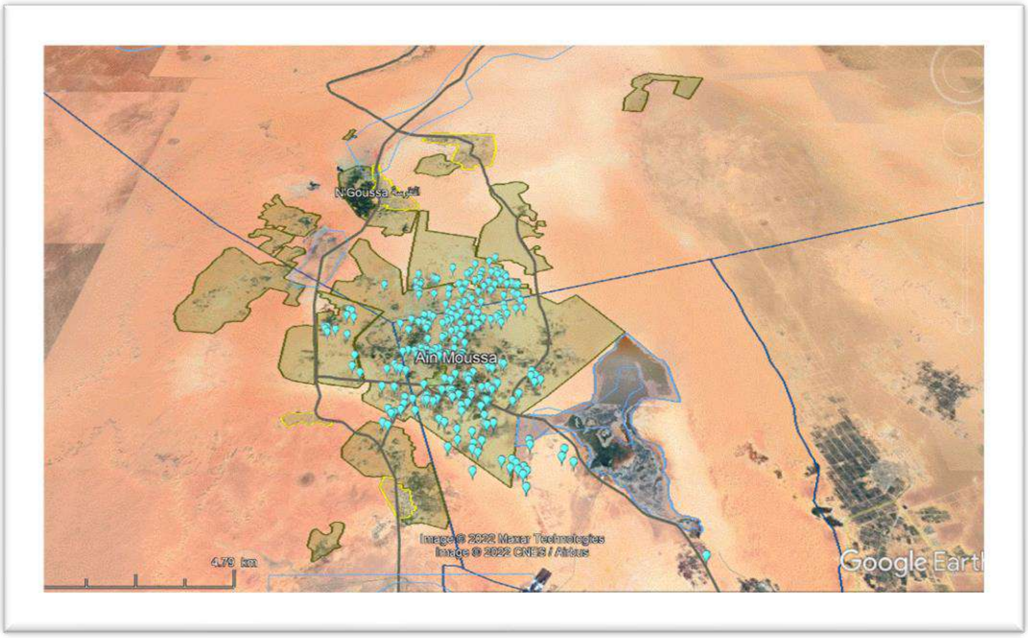
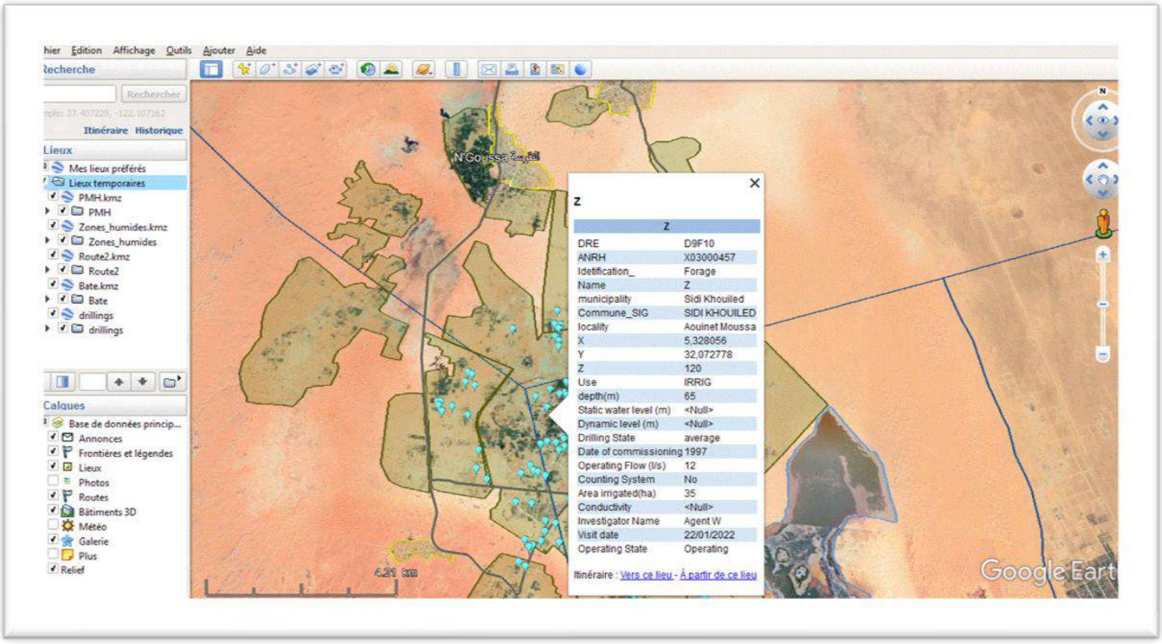


Fig-17 all layers set on Google Earth

b- To be able to go the other way, first must save the created file (Annex fig.17)

That can simply imported in arcgis using the toolbox to convert it from KML to layer (Annex fig.18)

And all information of layers can be displayed with one click to get it and that by selecting the HTML popup then clicking on desired point or selecting the Identify button before clicking.



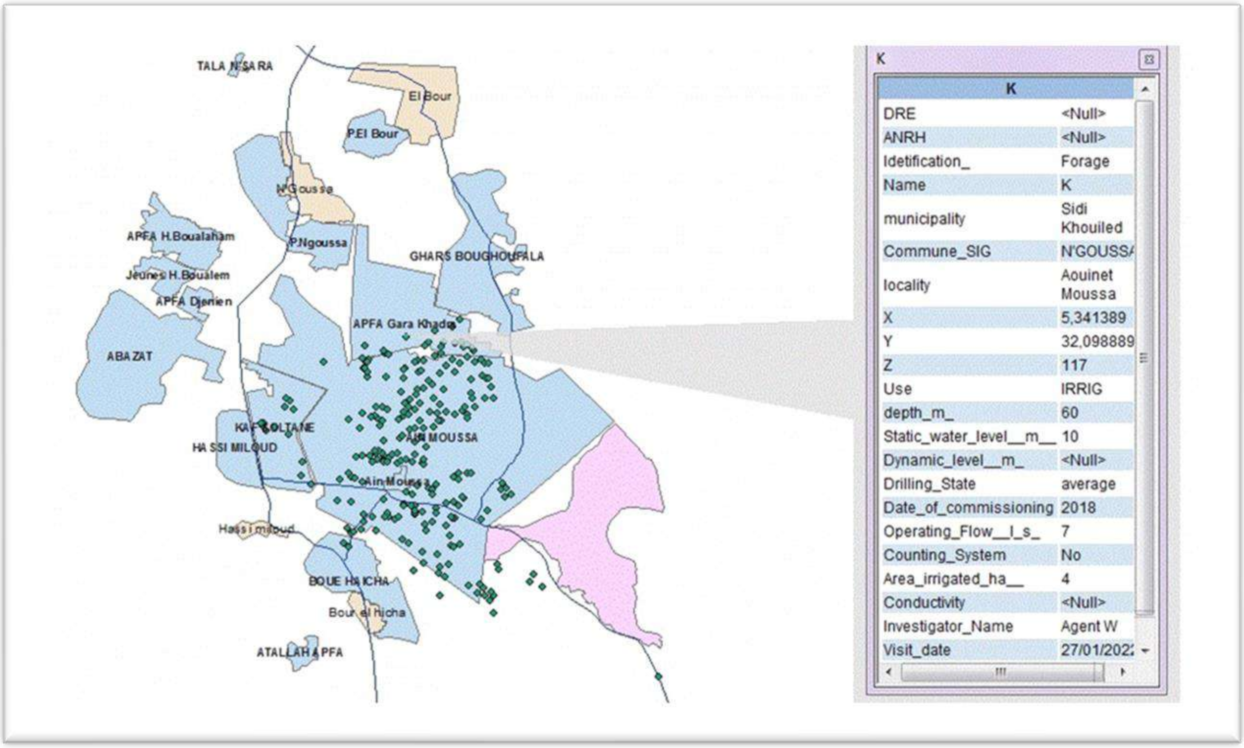


Fig-19 Data display

On the map of Ain Moussa contains three data layers - Drillings, agriculture parcels, wetland, roads and administration borders all on a satellite image. Each of the layers is listed in the table, and they can be disabled if necessary.

Building a map consists of the following:

- Adding an object from the database;
- Adding a layer to the map;
- Changing the display of objects;
- Adding labels to the map;
- Display the data on map

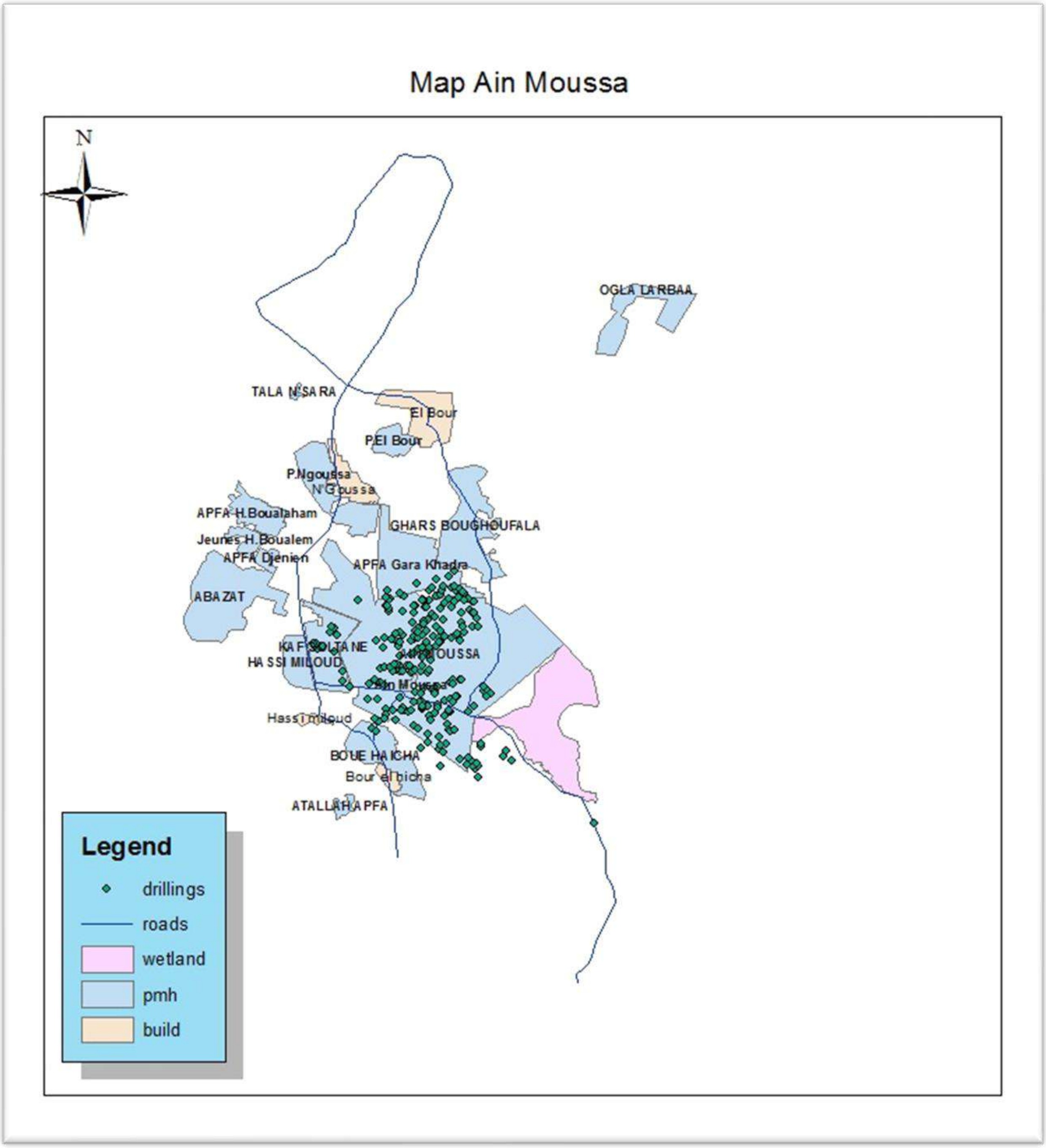


Fig.20 irrigated areas in Ain Moussa

DISCUSSION

When it comes to irrigation water management can be quite difficult to control all its aspects, multiple factors enter in the equation that need to be all treated and analyzed, from drillings position and the extracted water volume, to the irrigated area size and concentration of drillings in areas, plus the cultivated crops and their specific needs without forgetting the human factor. To process all these factors GIS can connect as much data on one map that can display it all.

ArcGIS can store and use geographic data in several formats. One way to represent geographic information - in the form of points, lines and polygons. Such a representation is called a vector data model. It is especially useful for storing and representing discrete objects such as buildings, pipelines, or parcel boundaries.

GIS can be called a database that accepts geometric information, GIS allows you to link a table and spatial data.

Much of the geographic data today is stored in Shapefiles. They store two typical point features: point and multipoint. Geodatabases implement a GIS object-oriented data model, a data model where each feature is stored as a table row.

Steps for submitting GIS project

When performing a typical GIS analytical project, we performed the following steps:

- defining the purpose of the analysis;
- creation of the database of the object (designing the database, entering and loading data into the database and managing the database);
- data analysis using GIS functions;
- presentation of the results of the analysis (in the form of a map);

Adding a layer comes from the ArcCatalog tree.

Compilation of the database

The data required for the project is located in one area and presented in different formats. To perform analysis, you need to find the data, get information about it, and copy it to the appropriate workspace. ArcMap lets you explore your data and organize it however, you like. we have built a project database that will contain all the data that we received. We browsed and copied the data using Excel and created folders to store the data and layers to represent the data. Next, using Arc Map, we mapped the datasets from the project database to explore the geographic relationships between the datasets that we worked with in the analysis process.

Adding data to a project folder consisted of the following steps:

- adding data layer to the map;
- adding city data to the map such as municipalities borders;
- creating polygons that represent the studied areas
- adding parcels Shapefile to the map;

Data

The collected data through investigation both from existing documentation of old investigation and new investigations on field was implanted in the software (ArcGIS/Google Earth) including the farmer personal information (contact and authorization...) to create an interactive map that can display easily all information straight on the geographical location to:

1st verify its accuracy

2nd to complete it with visible occupied parcels

3rd create base for analysis

Exploration

In the end, the final map can be exploited for much more analyzing while creating new areas of concentration and water volume in comparison with size of area and the planted crops.

For instance, adding crops data would give an idea on water volume needed and add to the concept of saturated area or over exploited.

Therefore, processing drillings requests can be fast and more data to help with the right decision as well as finding new area for future agriculture investment and development.

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ANNEXE

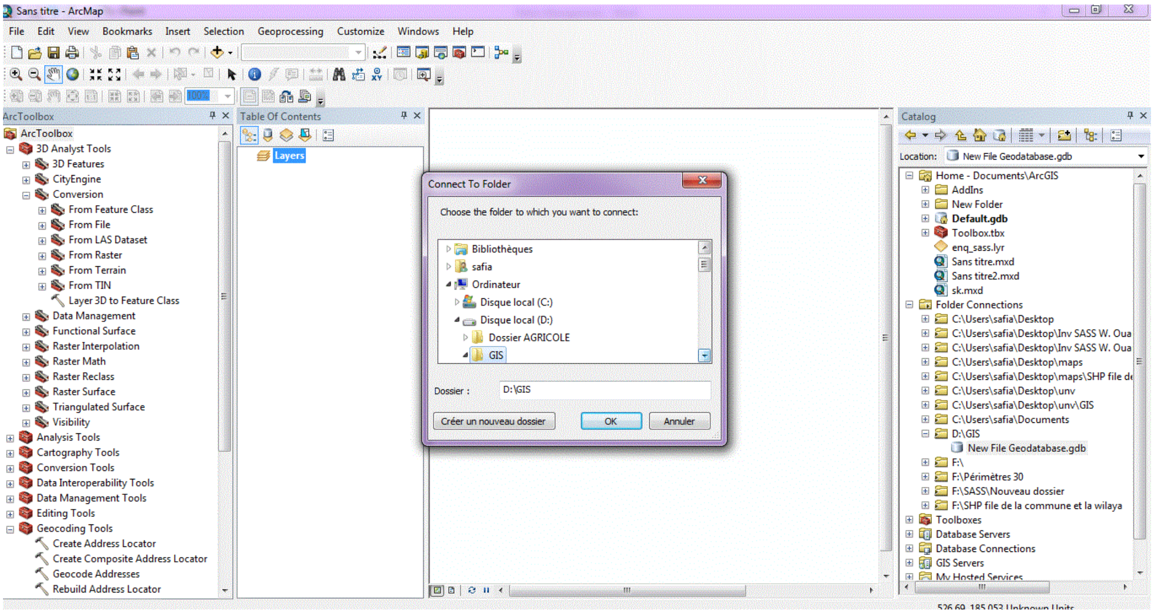

Fig-6 creating feature class

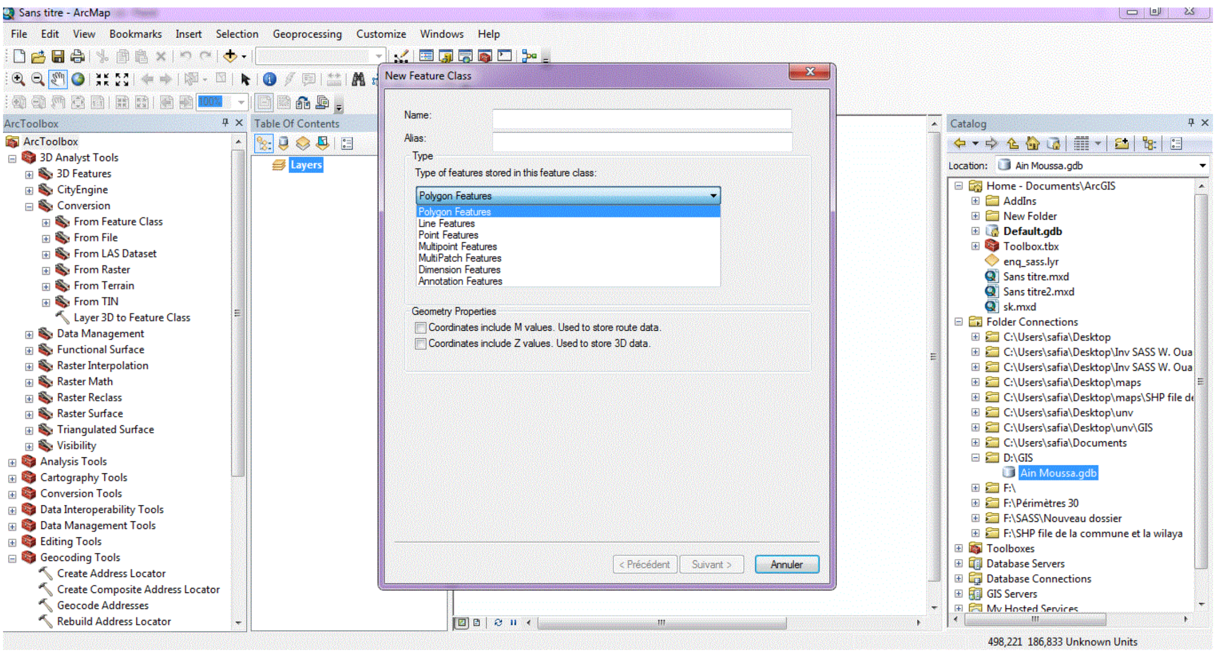

Fig-7 different types in feature class

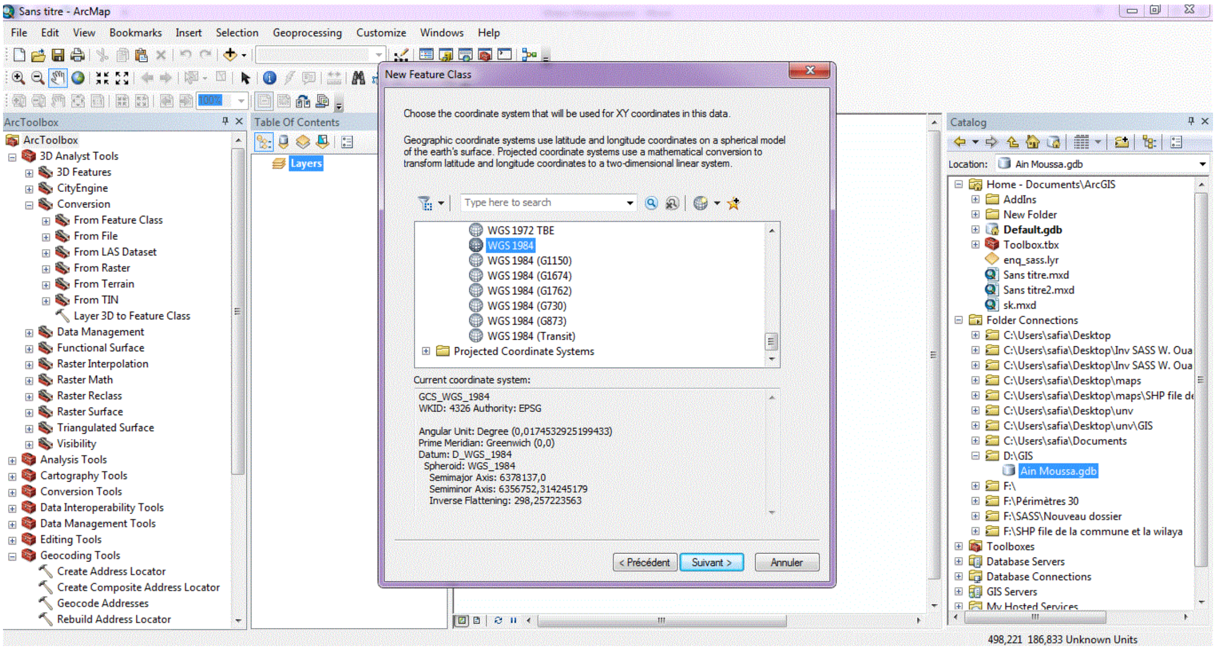

Fig-8 choosing coordinates

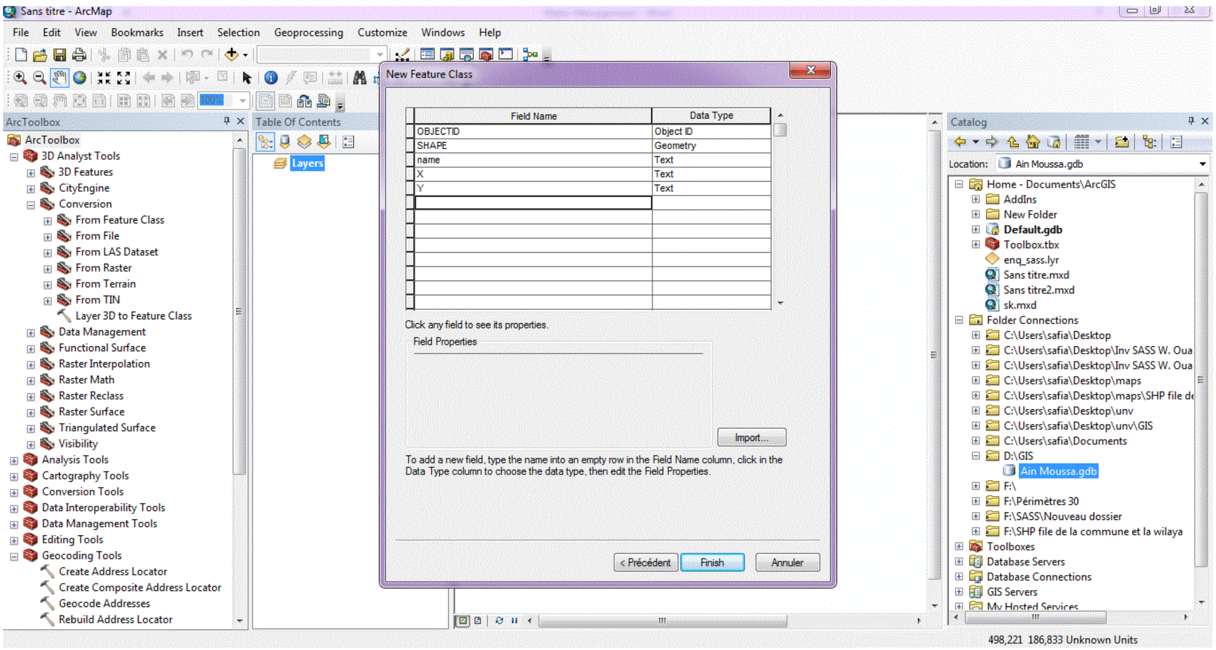

Fig-9 adding database table

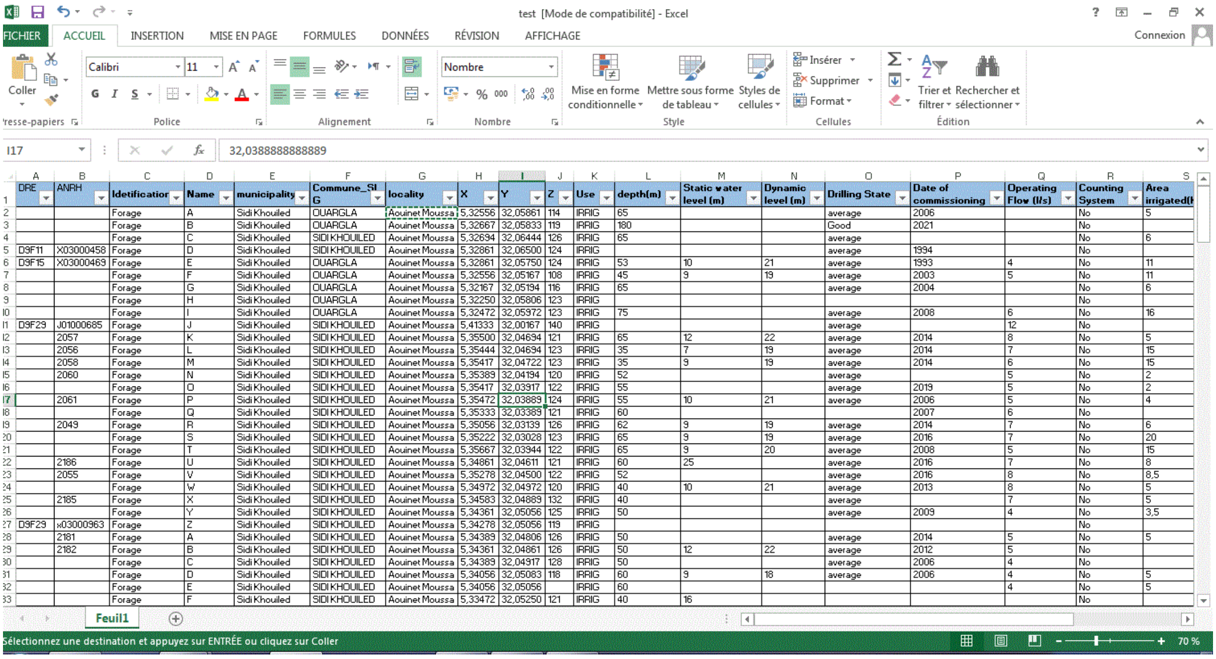

Fig-10 Excel table example

d- The Table is then selected and added straight from add data

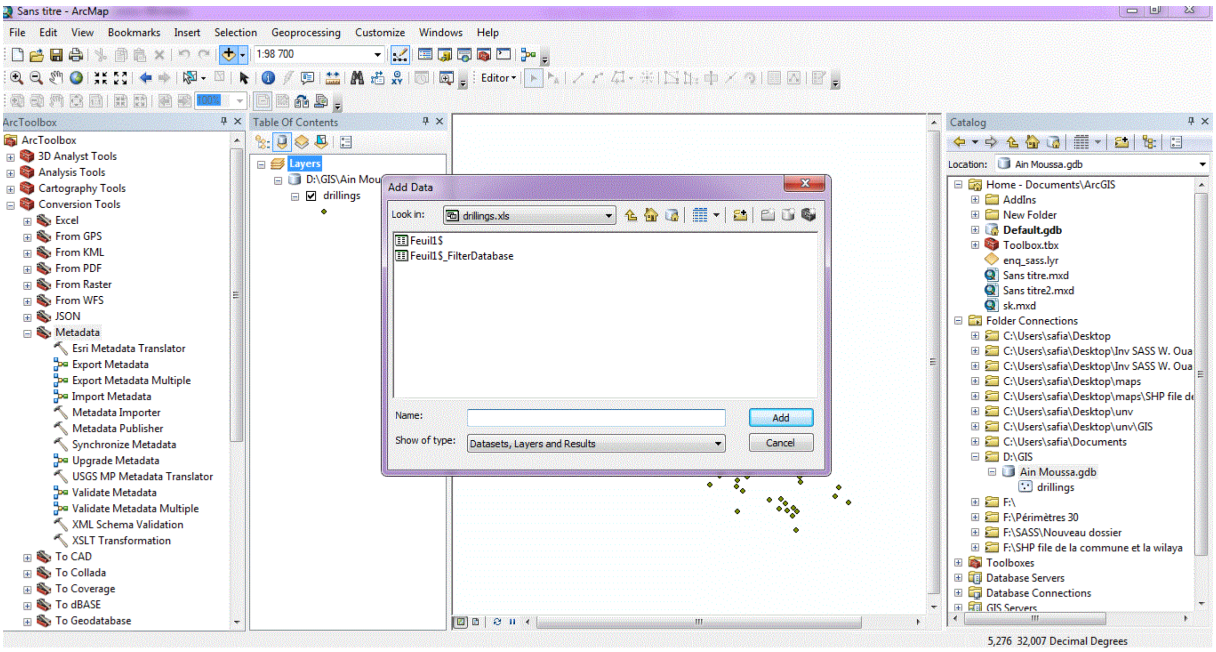

Fig-11 Importing Excel table

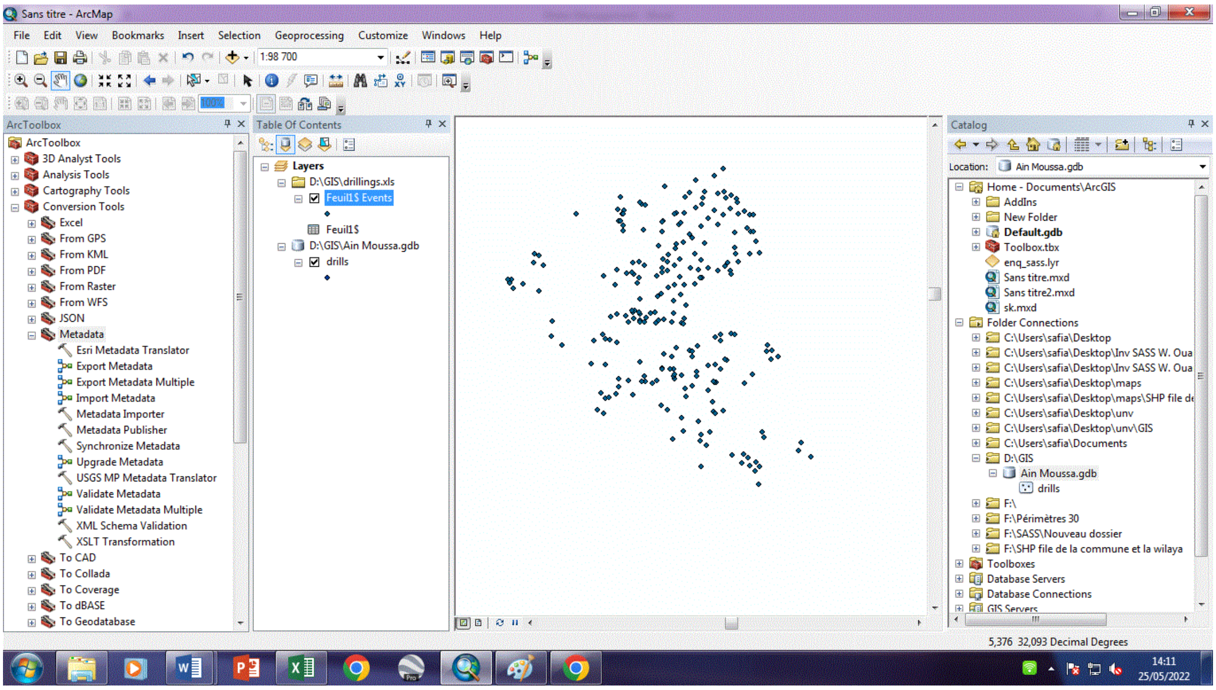

Fig-12 drillings points display

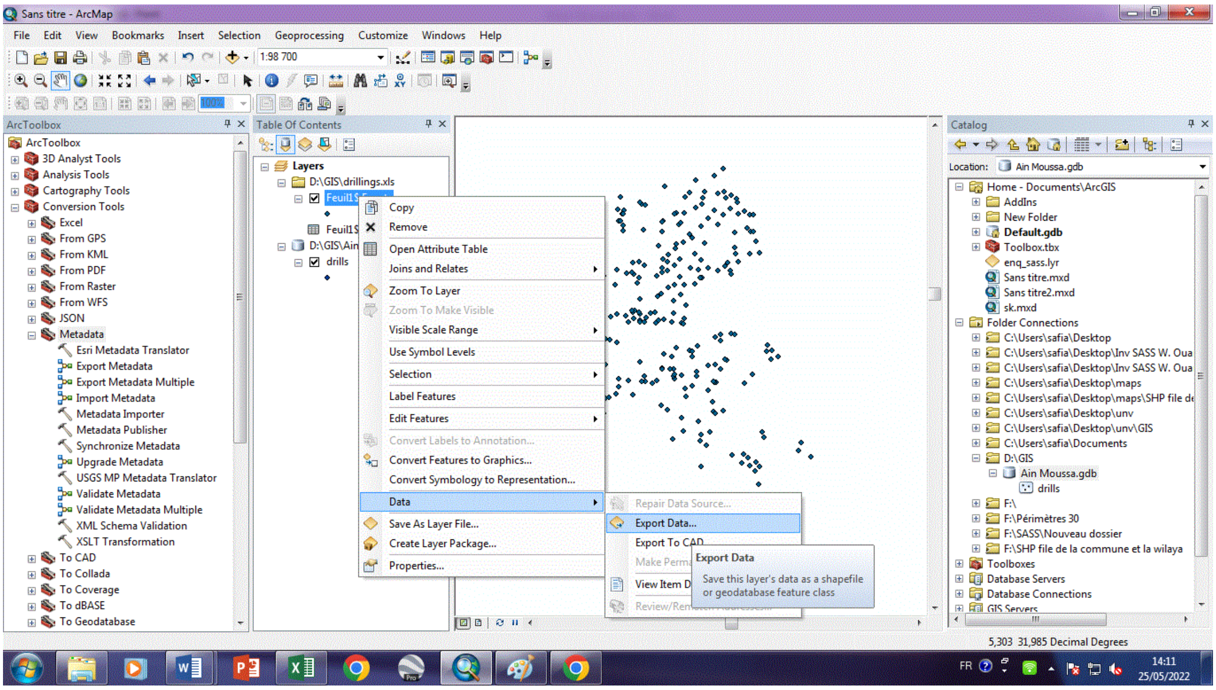

Fig-13 Export data to project

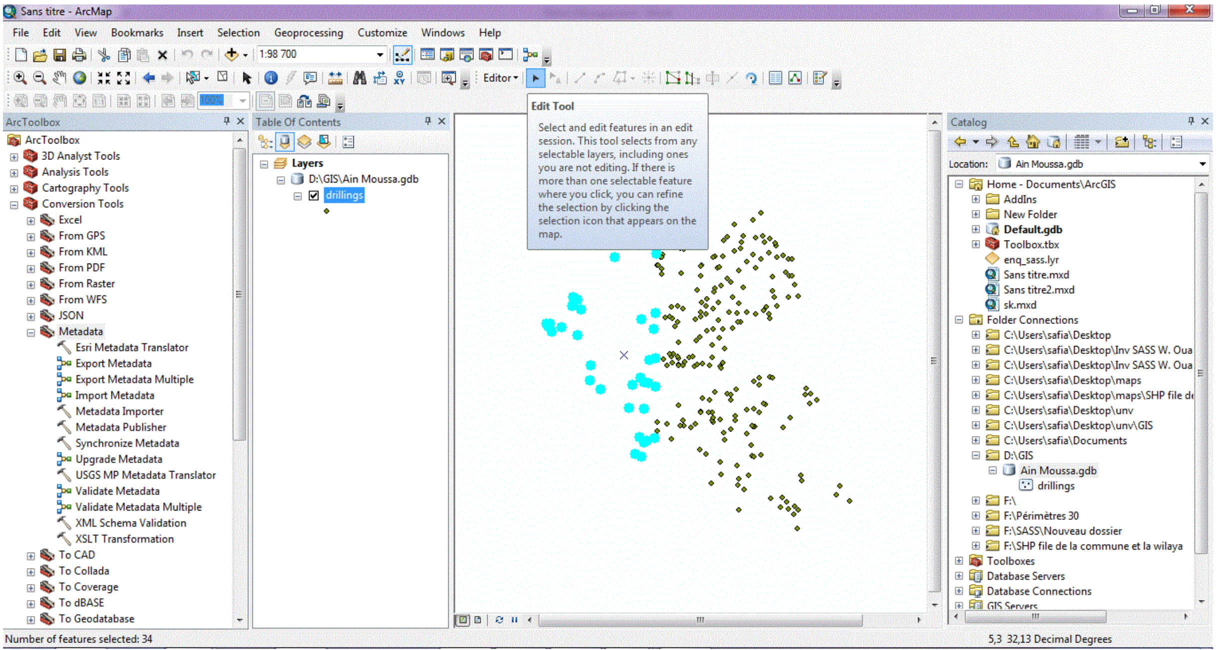

Fig-14 Editing the points

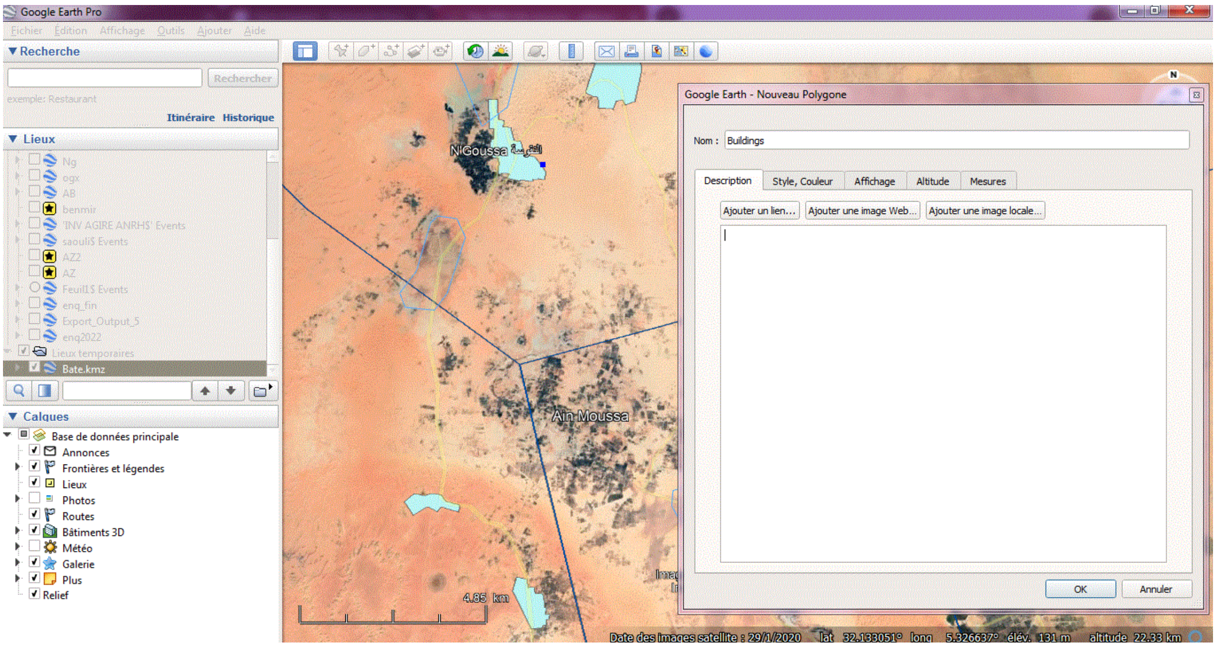

Fig-15 creating zones on Google Earth

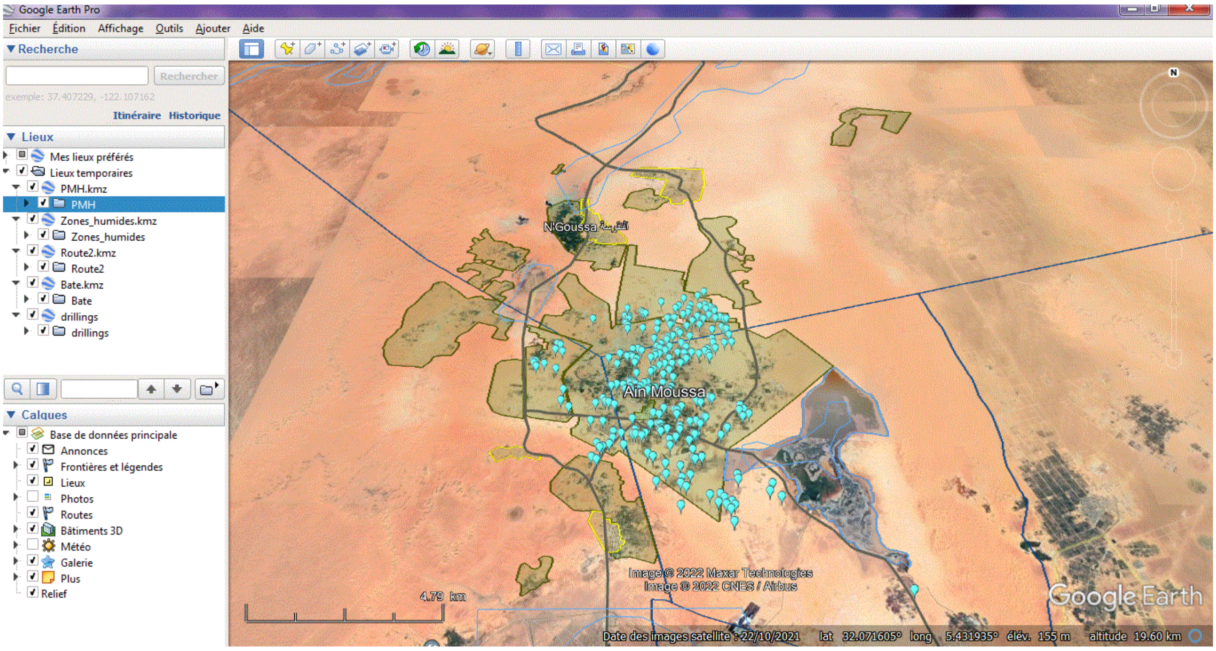

Fig-16 adding drillings layer from ArcGis to Google Earth

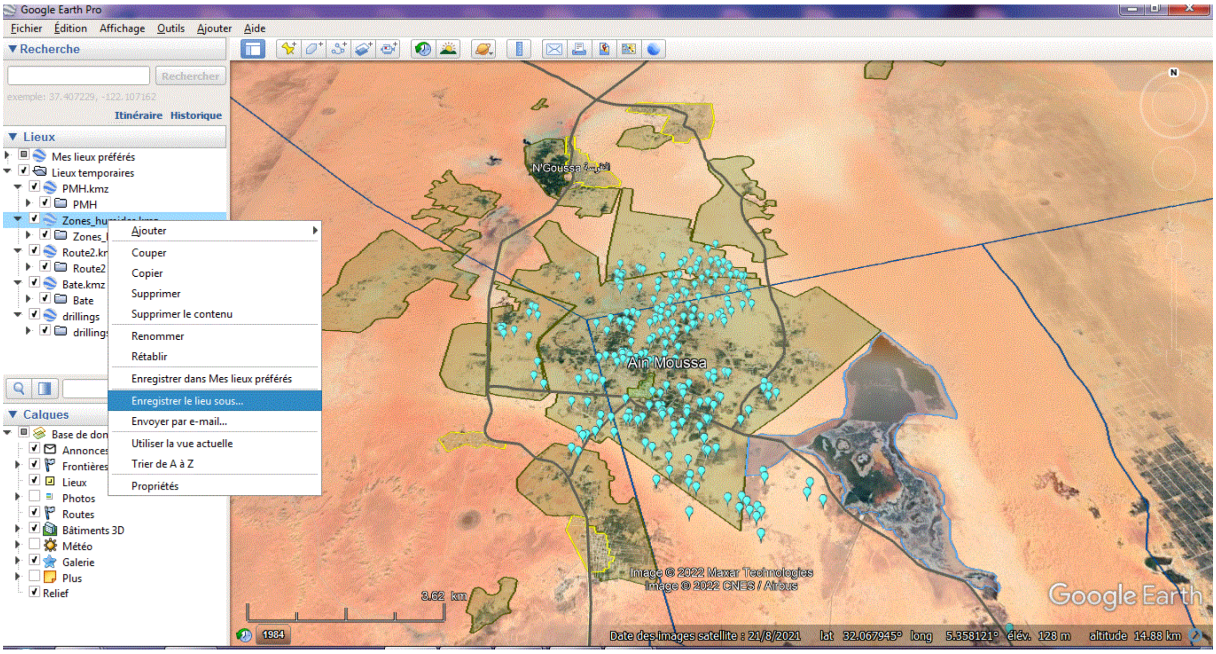

Fig-17 saving project

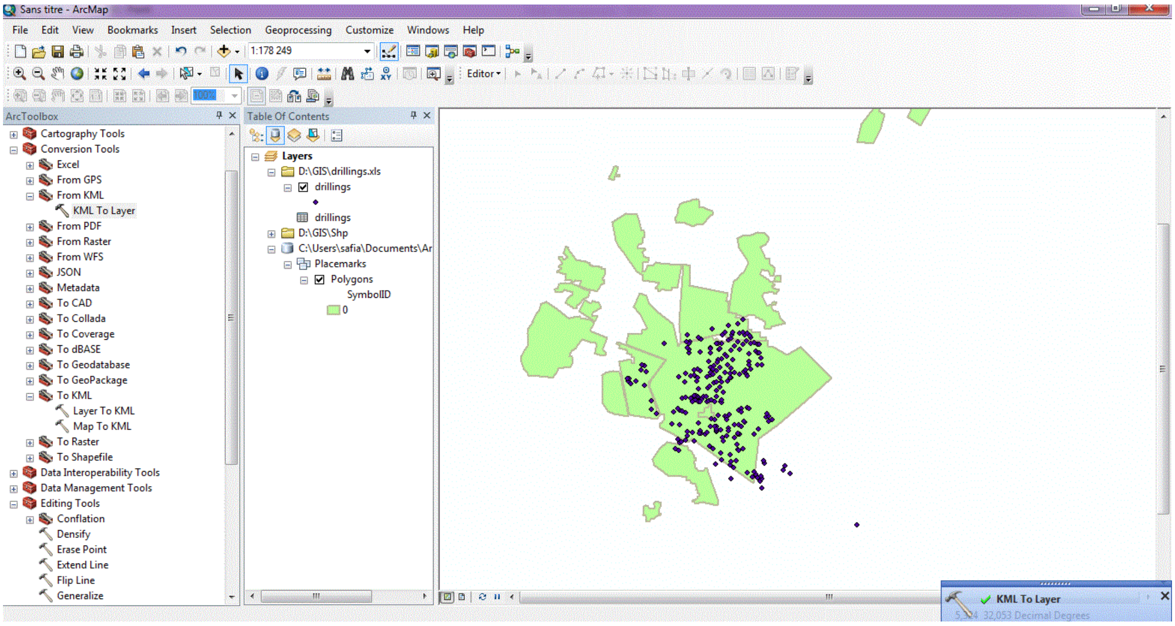

Fig-18 converting from KML to layer

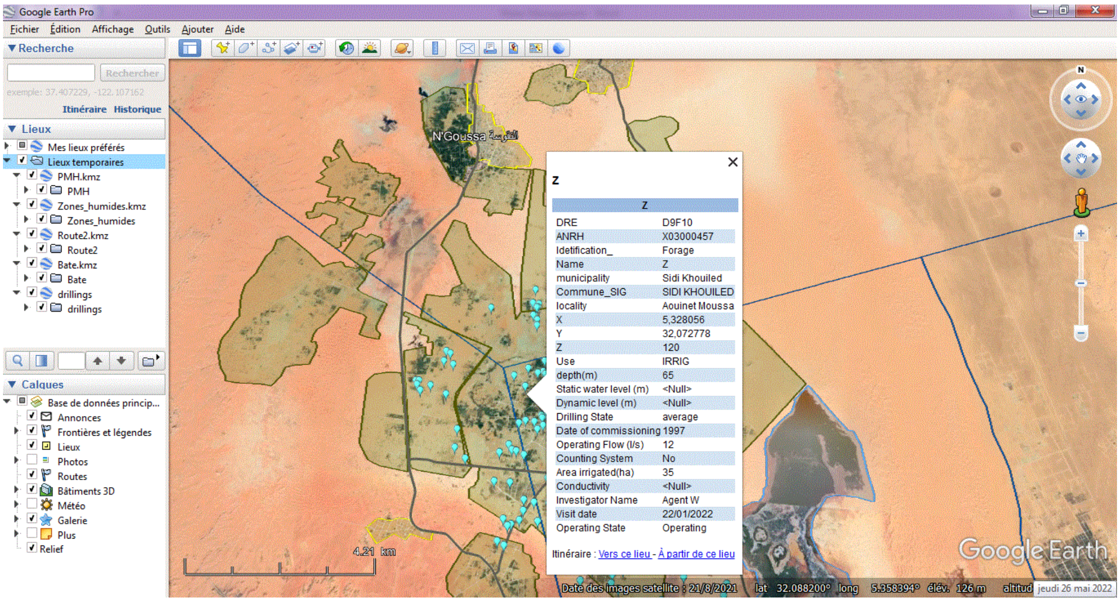

Fig-19 Data display