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SUITABLE LOCATION SITES FOR THE CONSTRUCTION OF UNDERGROUND DAMS OR HILL LAKES BY THE CONTRIBUTION OF GIS: APPLICATION TO THE PLAIN OF SAÏSS (North, MOROCCO)

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ABSTRACT

Artificial recharge of aquifers from meteoric water or treated waste water has become a very convenient answer that allows reconstructing long-term reserves of aquifers, including those affected by over-exploitation. Through operating accentuated reasons for domestic, agricultural and industrial Pliocene-Quaternary the web of Saiss plain Suffers from a decrease in groundwater reserves and the significance of rainwater in semi-arid areas to arid, it was necessary to remedy this condition by the construction of underground dams and hill lakes. Technological tools as promised management and water conservation tend ground than the trickling namely their essential role as the main system artificial recharge of aquifers. The work presented in this paper is based on the goal of identifying, using a geographic information system (GIS), more favorable permeability areas listed for construction of underground dams and reservoirs search site retention and storage of surface area of geomorphologic next to water for their development in the form of small lakes. Things that will guarantee a better infiltration of water into the surface and groundwater certainly ensure the objective of improving their artificial recharge of groundwater conservation and sustainable resources of the plain. The method is made to develop a geographic database while specifying the thematic data on geological, hydrological and hydro-geological in the study area. Processing of the data reveals the existence of two zones of average permeability and four other high permeability endowed with a high drainage density, the latter can be exploited as holding tanks at the surface and are also suitable sites for equipment with underground dams.

Keywords: Groundwater, Plain Sais, Underground dams, Small lakes, GIS

INTRODUCTION

Historical piezometric through Morocco mostly show downward trends in groundwater level, related to a combination of overfishing and drought. Characterized by flood events of recent years. In Morocco, significant amounts of water are lost due to lack of management and lack opportunities for superficial or underground storage. Situated in a semi-arid environment, the surface of the water plain in Morocco, is facing a reduction in groundwater resources of natural phenomena (semi-arid to arid climate, periods of drought), and pressure increased anthropogenic following the population explosion mostly domestic, agricultural, and industrial. The groundwater of saïss was object of study of many researchers (Margat J., Taltasse P., 1952; Taltasse. 1953; Margat J., 1960; Essahlaoui A., 2000; Benaabidate, 2000; Amraoui, F. 2005). To deal with these risks and improve underground water performance of the study area, the rational management of both groundwater and surface water resources becomes paramount. To give support to policy makers and managers in the field, our goal is to develop a geographic database by contributions of the Geographic Information System (GIS) which aims to identify favorable areas in terms of permeability and infiltration in the plain of Saïss.

The selected sites are the ones proposed for the construction of underground dams or for development in the form of small lakes.

1. General Framework

Geographical location

The Saiss plain (our study site) is an important hydro geological unit that occupies the eastern part of Fez-Meknes basin, the latter, also called Sais basin is located in northern Morocco between the Middle Atlas in the

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South and prérifaines hills to the north with a total area of approximately 6000 km2 .It spreads to the west by the plateau of Meknes, the Meknès-Tafilalt region.

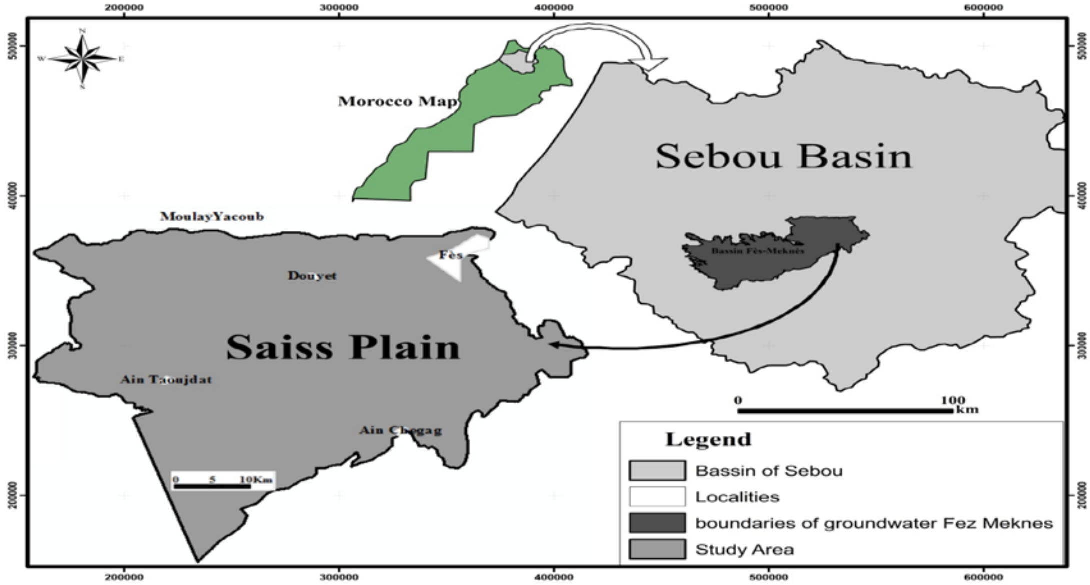

Figure 1: Location of the study area

Geomorphologic context

The plain of Sais has a decreasing altitude from south (S) to north (N) , but rises in contact prérifaines wrinkles (Jbel Zalagh and Tratt). Flexure of Ras el-Ma divides the plain into two parts: the Fez south-east (SE), that of Ain Taoujdate north-west (NW). Between this flexure and Fez extends down zone poorly drained, swampy (Pond Douyet).

Underground dams: promised solution for the sustainable management of groundwater

Concept and principle

Groundwater dams are structures that intercept or obstruct the natural flow of groundwater, and ensure their storage; they impede the flow of aquifer and reduce the variation in the level of the water table. The basic principle of these constructions is to store groundwater in tanks underground.

Benefits

Compared with surface storage, many benefits are being reported in terms of underground tanks:

A. At the difference of underground dams surface, dams involves no submergence of land and do therefore have no destruction or social problems dams.

B. In arid regions to semi-arid, underground dams ensures a strong reduction and limiting water loss by evaporation.

C. Deductions groundwater waters are also less touched by biological contamination and therefore a better quality.

D. The creation of an artificial underground retention can indeed result in:

- The increase in groundwater resources;
- Inter seasonal regulation inter annual these resources;
- Recovery and stabilization of the water table.

Conditions of the site

The underground dam site requires 3 main hydro-geological conditions to ensure a better functioning of these constructions:

A. Significant flow of groundwater Presence.

B. The best sites for the construction of underground dams where the soil is made of porous formations or high permeability rock, adapted to constitute a reservoir.

C. Presence of low permeability reservoir lands close.

2. MATERIAL AND METHOD:

The use of GIS is their contribution for decision support through the thematic treatment information plans. The spatial approach to a problem does not go without asking questions relating to the representation of space. This is why GIS is still among the giants commonly exploited tools in terms of the study, analysis, planning and updated information on integrated water resources management. The Geographic Information Systems (GIS) had valuable benefits because they are able to both store all of the information available and to facilitate handling and interpretation of data. The advantages of GIS are many especially in the area of planning and management of natural resources such as water.

The methodology used in this work is to develop a geographic information system (GIS) linked to a database specifically to the water table of the plain of Saïss. Referring to geological, hydrological, hydro geological and

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digitized and geo referenced information on the operating system of water resources in the study plain. Our business aims to determine the most suitable areas for the installation of underground tanks of their land lake hill. Something that will improve the artificial recharge of the shallow groundwater and maintain balance between output and recharge. The GIS tool is the best tool thanks to the wealth of spatial analysis operations that it can afford. These steps can be summarized as follow:

A. Collection of data for the study area;
B. Georeferencing cards;
C. The assembly of cards and then cutting each layer in the boundary of the study area;
D. Integrated data relating water points available in the study area;
E. The digitalization of geometry data;
F. The construction of the topology;
G. The implementation of links between geometric data and attribute tables.

The information elements that make up the database are classified as follow (Table 1)

Table.1: Map Elements of the extensive database

Diapers	Topology	Contents	Identifiers	Data used	Acquisition
Hydrograph	lines	Water system	Names-wadi	Map hydrogenated graphic plain of Fez-Meknes. [5]	Digitizing
Topography	lines	Contour lines	Values_ curves	Topographic map Fès-West au1 / 50000	Digitizing
Surface geology	polygone	Lithology Ages	Lithology Ages	-Map Plain hydro-geological Fez-Meknes Geological -carte Saiss basin [8]	Digitizing
Road network	lines	Road network	destination	Topographic map Fez -West 1/50000	Digitizing
Localities	polygon	Cities villages	Names	Hydrographic chart plains of Fez-Meknes	Digitizing
Limit of the table	lines	Limit-study area		([1], 2014)	Digitizing
Wells and boreholes	Points	Pumping sites	No. IRE (inventory number of Water Resources)	([1], 2014)	Scanning

Table 2: Relational Settings extensive database

Settings	Data Types	Acquisition
Pluviometer	Give annual and monthly rainfall	Interpolation
Piezometry	History Points measures (ABHS * 2014)	Interpolation
Permeability	Geological map of the area **(Figure.3)** + permeability coefficient facies	Superposition

3. DATA PROCESSING AND RESULTS

The study area is part of Fez-Meknes basin, the latter is, in turn, a sub-basin of the great Basin Sebou. It is governed by several factors (climatic, geological and geomorphologic) influencing the hydrology and hydrogeology of the plain of Saïss. The rainfall in the study area shows a temporal and spatial variability. The spatial distribution of rainfall on the Saïss tray (Figure 2) reflects the increase of this parameter with altitude and also reflects the influence of the distance Atlantic (negative gradient from south to north). An increase in precipitation intensity is observed North-west to the Southeast. The average in precipitation obtained for the station (Fez ABHS) is the order of 490mm / year.

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Figure 2: Map of isohyets of the plain of Fez (period 1978-2002)

Surface geology

The geological map (Figure.3) shows that the formations outcropping in the study and essentially Pliocene-Quaternary area represented by various deposits (sandstone, limestone, travertine, basalt flows, silt and calcareous crusts, alluvial fans and talus). The river beds are encumbered by alluvial deposits and deposits of droppings. The greatest thickness of Polio-Quaternary (70 -100m) is found in the eastern part of the study area, and thinner (20m) is localized in the western and south-eastern parts.

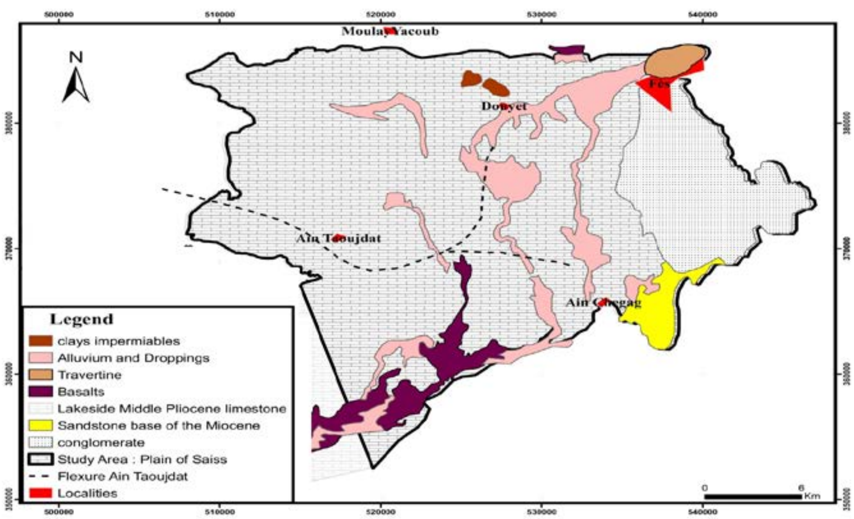

Figure 3: Geological map of the study area (taken from the hydro geological map [7]).

Geomorphology

The usefulness of this context is to characterize the types and nature of relief's namely low areas and high areas. This step is applied to the determination of the suggested depressions to form a surface water storage tank. Hence the need to develop a digital terrain model (DTM) (Fig. 8) making topographic coverage of the study area. In order to have a generally saw-dimensional zone, the DTM is subsequently converted mode (3D) (FIG. 9).

Hydrographic

The Sais plateau is drained by Fez river and tributaries on the right bank of the river Mikkes as N'ja (Fig. 4). All these rivers are tributaries of Sebou. The flow of these rivers is generally from SSE to NNW except N'ja river that has a general NS direction, and Fez river which flows from west to east. These last two are born at the Saïss basin, and are almost exclusively powered by the rainfall over the basin. The main rivers draining the area are: Fes river which

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starts at the source of Ras El Ma, drains the table until the release of Saiss tray and N'ja river.

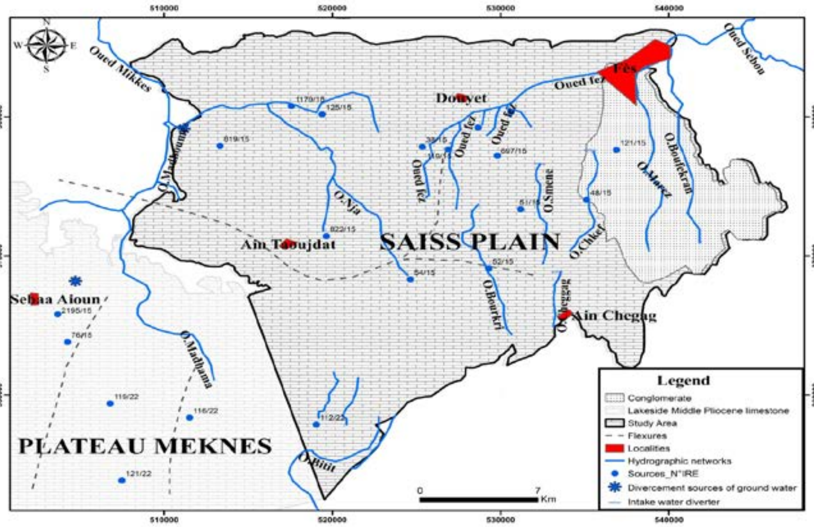

Figure 4: Map of the Hydrographic Network of the Plain of Saïss

Hydrogeology

There are two main aquifers in the area: the Liassic lime stones and quaternary lacustrine lime stones. In the studied plain, Quaternary lime stones form a layer which piezometry depends heavily on rainfall, recharge and topography. The water table in the area is very important. It is this which ensures the most part of the water supply of the city of Fez and irrigation of surrounding countryside. The Lias form a deep aquifer captive, artesian, which flows in some areas with loads of over 150 m above the ground. This layer can communicate directly (power of the shallow aquifer through deep water) by flexures, or indirectly leakance with groundwater lacustrine lime stones which are the most accessible reservoir in Meknes-Fes basin.

In order to follow the evolution and distribution of water points (wells and boreholes) across the study area, the projection of the various water points (Figure.5) is made on the map of the plain. The map confirms a high concentration of the wells which is observed in the northern part and north-east of the study area. Piezometric map of the area is carried out thereafter (Figure.5).

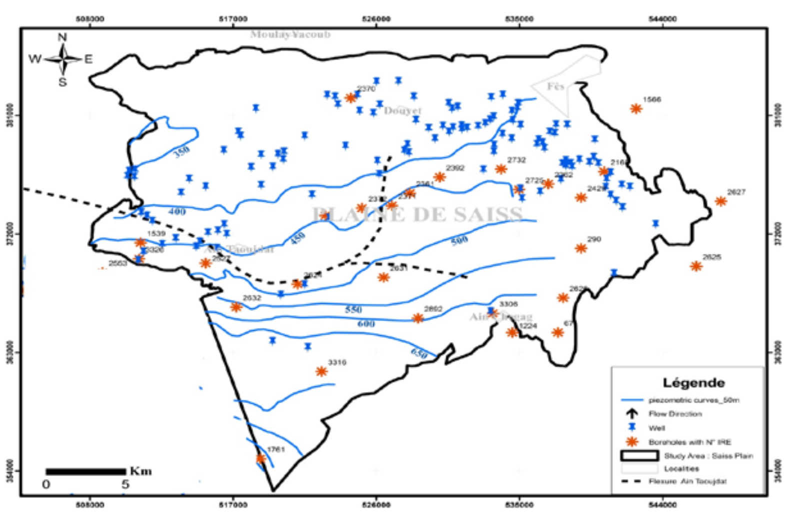

Figure 5: Piezometry of groundwater and distribution of water points in the plain of Saïss.

To study the impact of spatial and temporal variations of precipitation over the evolution of the groundwater table we were led to make a correlation between rainfall and piezometry of the web (Figure.6). The results show that changing the

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depth of the water in the surface water table is influenced by rainfall variations. The recharge rate of the aquifer is strongly related to rainfall intensity and characteristics of the formations traversed (permeability).

Table 1: Coordinates piezometers use

Piezometers	No. IRE	X	Y	Z (m)
1	1197-1115	531.750	380.250	385 9
2	2762/15	2762/15	537, 325	372.600
3	2253/15	2253/15	520.900	378.840

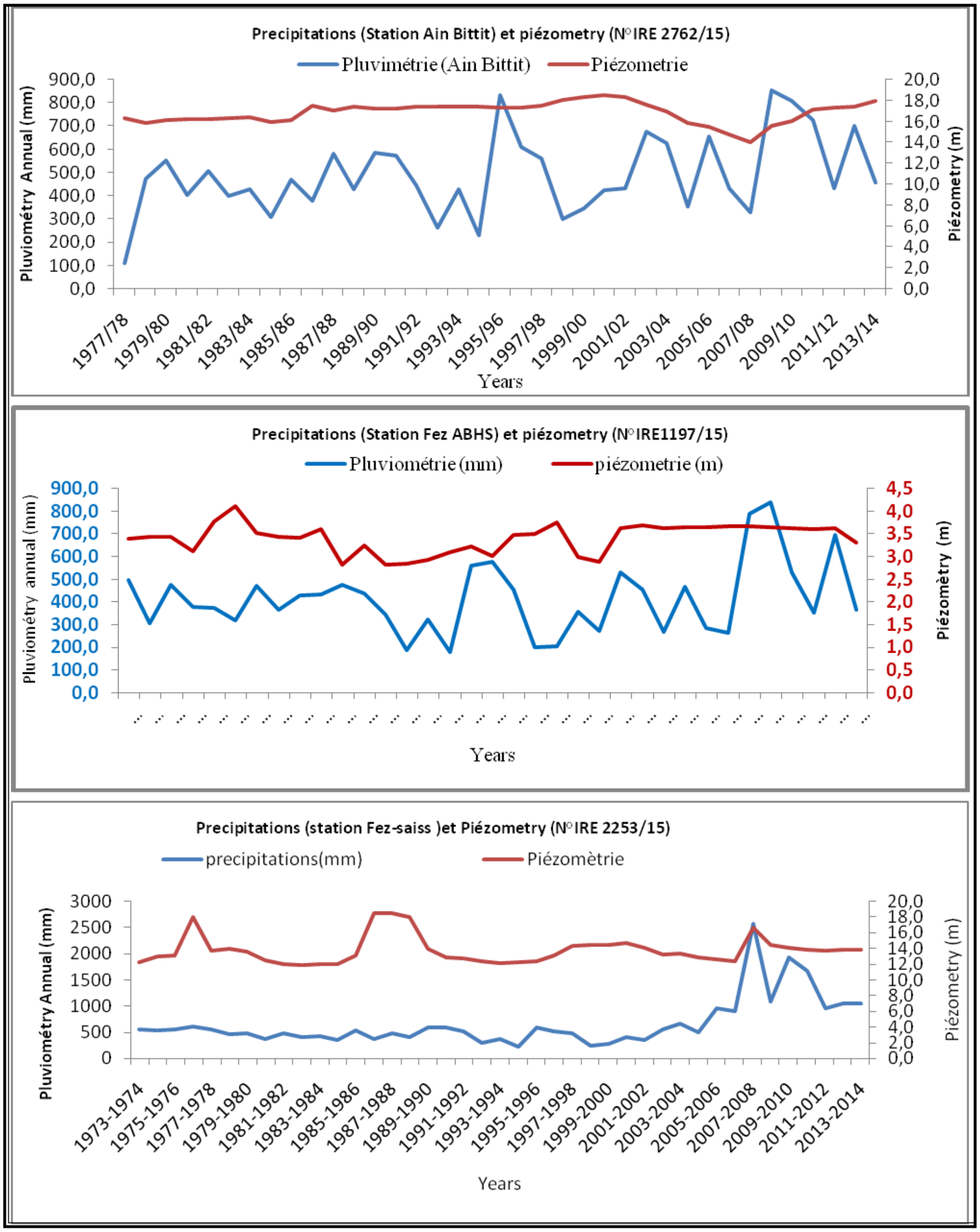

Figure 6: Correlation between rainfall and depth of the water in the shallow water table

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Development of a single support results

The goal is to obtain new information that result in the representation of various outcomes by fusion to a single medium in order to make a more comprehensive analysis (Figure 2). From these hydro geological data (surface slick threatened), water (drainage density of the area), geology (geological formations and their permeability) and morphological (reliefs areas that can serve as surface water retention basins) the work is done in locating areas of high permeability and can best qualified beings as storage areas of surface water courses.

Permeability Card Making

This factor is the striking point for the proper sitting of the location of an underground water tank, for this it is necessary to develop a permeability map (Figure.7), the task calls for the Use of the geological map (Figure.3)

Table 3: permeability coefficient of infiltration of certain rocks [8]

Rock	Perméabilité log (K m / s)	Coefficient Infiltration	Infiltration
Gravel	-3 To 0	**6**	Strong
Alluvium river	-3 To 0		
sandstone	-5 To -4	**4**	Average
Conglomerate	-5 To -4		
Sand	-7 To -4		
Sandy loam	-8 To -4		
Silt	-9 To -5		
Clay loam	-11 To -8		
Clayey sand	-8 To -5		
Basalt	-8 To -6		
Marl	-10 To -8		
Sandy clay	-10 To -6		
Limestone	-11 To -9	**2**	low
encroûtement	-11 To -9		
Dolomite	-11 To -9		
Gypsum	-12 To -10	**1**	Tr Bachelor flaw
Clay	-12 To -9		

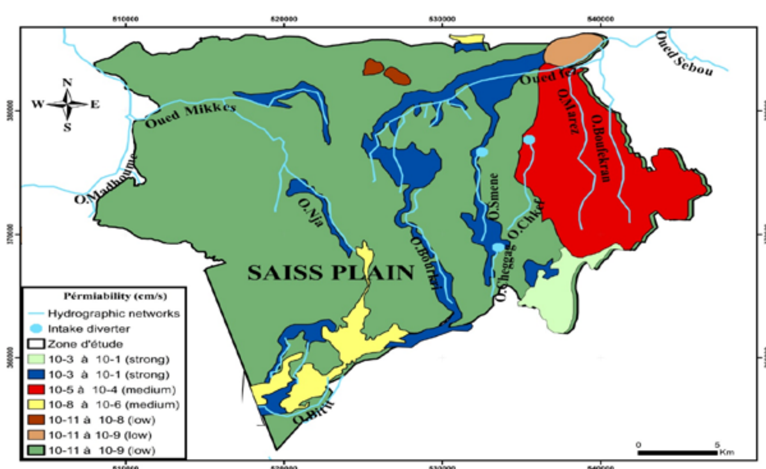

Figure 7: Surface permeability card with the hydrograph of the study area.

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Permeability card is subsequently transformed into three-dimensional (3D) for determining both the shape of the reliefs and the permeability of the flush soils.

According to the general analysis of this card one can conclude that the sites formed by sand and river beds are the most privileged in our study and therefore the best choice for a large infiltration surface water and groundwater reservoirs. The second choice, areas of sandstone, loam and sand, with an average infiltration, the parties formed by limestone have low infiltration. The localities of clays remain unfit either with very low permeability see raincoat

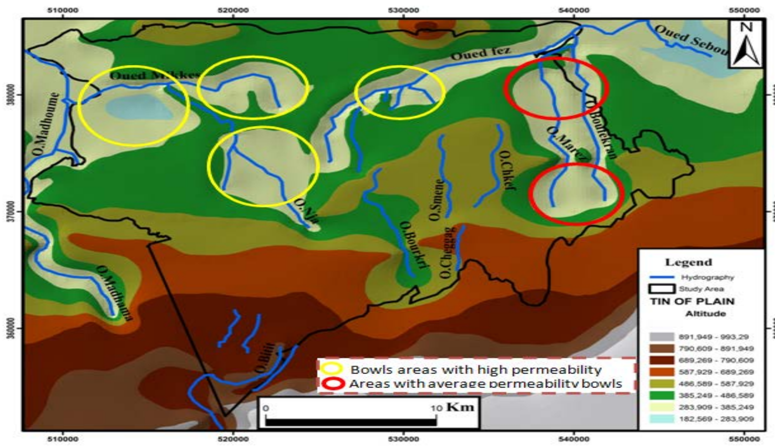

Figure 8: Map Digital Terrain Model (DTM) the study area with hydrography

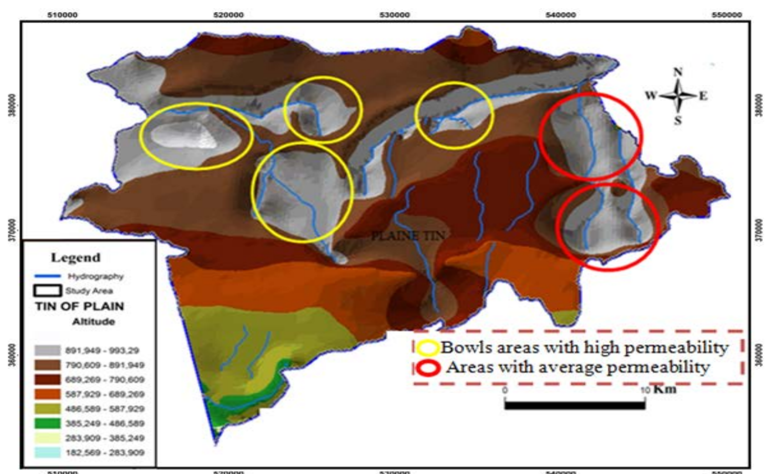

Figure 9: Map Digital Terrain Model (DTM) the study area with hydrography (seen in 3D)

4. CONCLUSION:

Promote infiltration at suitable sites, injected by sinks rainwater and storing water in reservoirs or tanks tend underground and surface, are beneficial approaches that reduce allowances and promote control storage of a highly sought water resources. The rapid expansion and developing irrigated areas in the Saïss plain is mainly based on groundwater reserves. Situation that requires intervention, sometimes urgent to protect these resources and face the drawdown recorded in recent years. The objective was to meet the major socio-economic challenges as a scientific challenge and an investment for the future of the entire region. It is therefore necessary to use innovative search tools and decision support. This is why the use of the multiple functions of GIS across Saïss tray as it has been presented in this article, helped to highlight areas of high permeability. And therefore offer the best suitable sites the location of underground dams to improve artificial recharge and conservation reserves in the surface water table in the plain studied. However, this work revealed the existence of two average permeability zones and four other high perm abilities endowed with important hydrographic and an average of favorable inter annual precipitation. The task performed Considers made to provide a knowledge base for information, the decision

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support and planning. It is aimed at both the development of professional planning as economic actors, and managers of the environment.

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