

## **Applications of Remote Sensing and Geographic Information System to Exploration of Groundwater in Different Regions in Syria**

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### **Abstract**

The new technologies of remote sensing, geographic information system and global positioning system had a great importance in groundwater exploration. Whereas the space images taken by Landsat TM, radar images by European Remote Sensing satellite ERS, using geographic information system GIS, global positioning system GPS and previous geological, tectonic, hydrological and hydrogeological studies of study regions contributed as ideal method in exploration of groundwater in those regions. By processing , analyzing of space images, compiling thematic maps of drainage, lineaments and main faults with their intensity and crossing in addition to maps of all drilled wells with their discharge and existing springs in the study of each area, study of wet faults at the end of summer through thermal band in Landsat images, subsurface faults through radar images, cross of separated faults with their accurate coordinates by using GPS and carrying out geo-electrical sounding for perspective locations and analyzing the resulted curves and assurance of existing groundwater with their water table.

We had identified many locations in Salamyeh, Sweida, Dara,a, Lattakia, Tartous and Damascus cities by using this methodology. We had drilled many of wells in the studied perspective locations, and we had good results.

**Keywords:** Remote Sensing, GIS, Exploration, Groundwater, Syria.

### **Introduction**

Groundwater is concerned with water in the saturated zones beneath the surface of the Earth. Groundwater information most useful to water resource managers includes: the presence or absence of groundwater in designated areas, the depth to groundwater, the quantity and quality of water available for development, recharge rates to aquifer, the possible impact of pumping on land subsidence, a real extent of the aquifer, locations of recharge and discharge areas, and the interaction between withdrawals at wells and natural discharge into rivers. Whereas this information is generally sought by hydrogeologists using conventional methods, remote sensing can help in the planning of

conventional measurements and can be used to estimate some hydrogeological variables quantitatively and others qualitatively.

The storage capacity of ground water reservoirs depends on their extent, which depends on geological properties of the area. Ground water forms the base flow for many streams and is the source of water for springs and seeps.

### **Studies and Investigations**

#### **1- Exploration of groundwater in Salamyeh region.**

We have started the work with expert from FAO in Salamyeh region within depletion of groundwater in that area. We should depend on space images in Landsat – TM to detect –the unclear faults. We have identified three perspective areas for groundwater with good discharge for drinking water and irrigation. By mapping of wells, springs, faults, lineaments and drainage.

#### **2- Exploration of ground water in southern part of Syria**

This study has been carried out in cooperation with GORS, BGR and FAO by using remote sensing techniques (Landsat and SPOT images). General Organization of Remote Sensing requested FAO technical assistance for strengthening its capacity in the field through a joint study in selected parts of the country, allowing for the necessary technology transfer by on-the-job training of its staff and preparation of detailed guidelines for the application of the methodology developed and tested in the field to other parts of the country.

In view of distinct environments occurring in the country and to fully test new approaches and technologies, three different hydrogeological environments were selected, namely; 1. the basaltic terrain of southern Syria, 2. the sedimentary terrain in coastal area, and, 3. the interior alluvial plain (Aldao Basin) in the Syrian steppe.

To achieve its objectives in the above environments, the project developed specific methodologies based on the integration of satellite remote sensing, GIS, traditional hydrological data and field investigations. Geophysical investigations and test drilling in selected sites were undertaken to confirm the methodological approach and theoretical assumptions made during the study.

Furthermore, the project and its results in distinct hydrogeological environments should be regarded as an application of satellite remote sensing to groundwater exploration, for future use, not only in other areas of Syria, but in similar environments outside Syria as well.

The search for promising groundwater areas involved satellite remote sensing, GIS, traditional hydrological data and field investigations-

#### **3. Thermal Survey of the Mediterranean Coast of Syria**

The survey was done for the part of the coast line of the Mediterranean sea from Raas Elbasit on the north to the border of Lebanon on the south. The width of the

surveyed surface was up to 5 km from the coastal line, the length along the coastal line was up to 150 km

The survey was aimed to find places of the unloading of fresh water springs under sea water according to supposed temperature anomalies at the sea surface. There were discovered numerous (several dozens of) temperature anomalies, part of which coincides with the anomalies discovered earlier by space photography methods. Acquired results may serve as premises for industrial application of potential sources of fresh water.

All anomalies in processed images can be divided into four groups:

- river outfalls,
- sub-water springs,
- pollutions at the sea surface,
- "hot" anomalies.

1. The performed work showed that thermal survey from board an aircraft is rather promising in the examination of natural resources of the Earth.

2. Suggested methods of work and apparatus proved to be applicable.

3. Results of the thermal survey of the coastal strip were verified by space survey methods and local data. Many unknown before temperature anomalies were found.

4. Processed results of the survey and compiled thermal maps open premises for industrialization of the potential sources of fresh water.

#### **4. Study of Water Perspective in Western Area of Damascus by Using Remote Sensing Techniques**

This study has been carried out for Western area of Damascus in the region from Maadar in the North to the West of Qattana in the South according to the request from the specialized bodies for getting the perspective sites for drilling water wells that will be a new water resource for Damascus City and its countryside.

We depended on identifying the water perspective for study area that its area is 314 km<sup>2</sup> on available geological and hydrogeological data of study area and on results of tectonic study that we carried out by analyzing and interpreting of space images taken by visible and radar bands.

Through the geological, water and tectonic data, we had identified three hydrogeological sections, among these sections, we identified the most perspective sites of existing ground water.

We had the following results:

1- Through space data enable in identifying main faults zones paths accurately in addition to manifesting many lineaments, cracks and secondary faults that not mapped on the geological map and it is difficult to be identified by field works.

2- The study area has been divided to three different hydrogeological sections, and there is hydraulic connection for water table in their aquifers.

3- A study of water charge in the study area has been carried out through putting a group of layers (lineament layer, lineament intensity layer, drainage layer, drainage

intensity layer and cross of lineament intensity layer with drainage intensity layer), we had the benefit of these layers for identifying the water charge paths for identifying the suggested wells locations.

4- By studying the lineament intensity layer with the drainage intensity layer, that reflects intensity of tectonic cracks which is connected directly with water charge. It was possible to get an important result of water tables of ground water in the study area, might move in a quick swing according to the precipitation for exploiting of ground water by pumping from the drilled wells.

5- Six waterfall basin have been identified in the study area by putting waterfall basin layer by using space images for environmental purposes for drawing inviolable areas that enable in exploitation and taking an overview of continuity of water table of ground water, because of connecting this system with the area of waterfall basin.

6- 36 suitable sites have been identified for drilling water wells in the study area.

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## تطبيقات الاستشعار عن بعد ونظام المعلومات الجغرافية في الكشف عن المياه الجوفية في مناطق مختلفة من سورية

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تملك التقنيات الحديثة للاستشعار عن بعد وأنظمة المعلومات الجغرافية ونظام تحديد المواقع الشامل أهمية كبيرة في الكشف عن المياه الجوفية. حيث أسهمت الصور الفضائية المأخوذة من لاندسات TM والصور الرادارية من التابع الصناعي الأوروبي ERS واستخدام نظام المعلومات الجغرافية ونظام تحديد المواقع الشامل والدراسات الجيولوجية والتكتونية والهيدرولوجية والهيدروجيولوجية السابقة لمنطقة الدراسة في مناطق مختلفة من سورية كطريقة مثلى في الكشف عن المياه الجوفية فيها. وذلك بمعالجة وتحليل الصور الفضائية وإنشاء خرائط غرضية للمسيلات المائية والقسمات الخطية والفوالق الرئيسية وكتافاتها وتقاطعها بالإضافة إلى خرائط مواقع كل الآبار المحفورة مع تصاريحها والينابيع الموجودة في منطقة الدراسة، ودراسة الفوالق الرطبة في فصل التحاريق من خلال النطاق الحراري في صور لاندسات، والفوالق تحت السطحية من خلال الصور الرادارية، وتقاطع الفوالق المتباعدة مع أخذ أحداثياتها بدقة بواسطة جهاز GPS وإجراء مسح جيوفيزيائي - كهربائي لمواقع الأمل وتحليل المنحنيات الناتجة والتأكيد على تواجد المياه الجوفية ومنسوها.

حيث تم تحديد العديد من المواقع في مدن السلمية، السويداء، درعا، اللاذقية، طرطوس ودمشق باستخدام هذه المنهجية وتم حفر العديد من الآبار في مواقع الأمل المدروسة وأعطت نتائج جيدة.

**الكلمات المفتاحية:** الاستشعار عن بعد، نظام المعلومات الجغرافية، استكشاف، المياه الجوفية، سورية.