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An Assesment of The Space Imagery Capabilities to Water Resources Management Case Study: Al-Hammad Semi Arid Plateau, Syria

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Abstract

The AL-Hammad plateau extends over a large area in the South and South Eastern part of Syria ,the North-Eastern part of Jordan, Northern part of Saudi Arabia , and the South-Western part of Iraq. Its altitude ranges among 600-1000m above the sea level, its maximum height in Rutbah uplift at Jabal Aneizeh, the meeting point of Jordan, Iraq and Saudi border. Beyound the AL-Oulab area, the eastern part of Syria, the plateau passes into the badiat AL-Sham plain, which slopes gently towards the Euphrates River. It includes the closed drainage basins in Syria, Jordan, Iraq and Saudi Arabia. The base level of the ephemeral drainage systems is a line of Sabkha extending from Wadi Sirhan to Eastern Jabal Al-Arab which coincides approximately with the major axis of a large sedimentary depression modified by comparatively recent volcanic flows. Most of the other wadis are related to the Rutbah uplift. Tilting in Neogene times of the AL-Hammad plateau has produced a radial drainage pattern.

The water resources of the AL-Hammad region, which is located in an area where the prevailing climate is arid to semi-arid, are limited and maybe described as scarce. The proper assessment, planning and development of water resources are key elements in the overall social and economic development of the region, as a whole improper management and planning of water resources either because of lack of data or because of inadequate studies, has often resulted in over development, water quality deterioration and water supply problems in many areas.

Remote Sensing techniques were used to delineate the boundaries of different surface features, such as the permanent water bodies, mud, flats, etc. The extraction of details from satellite imagery depended on the spectral contrast between the object and its surroundings.

Landsat TM, SPOT-XS and Radar-SIR-B imagery were used to extract lineaments maps at a scale 1:50 000, and a drainage maps at a scale of 1:50 000 showing the major water bodies .

Lineaments reflecting the regional tectonic trend were all clearly displayed on the Landsat-TM imagery as straight to curvilinear topographic breaks. These lineaments are associated mainly with ridges, valleys, and drainage features. It was found that terrain elements were, in general, more readily distinguished on the radar imagery than with SPOT-XS data, although, almost all the same features could be detected on

both types of imagery. According to these investigations, unlike SPOT-XS, the radar imagery tended to mask most anthropogenic disturbances and vegetation differences, leaving largely topographic information. It has shown that a radar image can make a significant contribution in rock-type discrimination over Landsat data . The results of the study show that AL-Hammad lineaments, recognized on Landsat-TM, SPOT-XS, and Radar-SIR-B images, were caused by major faulting zones that affected the crystalline basement. Basalts are one of the main units of the crystalline basement in the region, where water shortage is a serious problem. Study of lineaments, particularly those aligned over significant distances with the main geomorphologic trends in other basaltic terrains of the region, may likewise lead to sites of groundwater .

Introduction

The water resources of the AL-Hammad region, which is located in an area where the prevailing climate is arid to semi-arid, are limited and maybe described as scarce. The proper assessment, planning and development of water resources are key elements in the overall social and economic development of the region, as a whole Improper management and planning of water resources either because of lack of data or because of inadequate studies, has often resulted in overdevelopment ,water quality deterioration and water supply problems in many areas. Moreover, since some of the more important surface water resources and aquifers are shared between two or more countries (Syria, Jordan , Saudi Arabia, and Iraq), exchange of information has been a significant constraint in their planning, development and management. The review of existing hydrological and hydrogeological information and published reports and their systematic compilation in map from should greatly assist in the assessment of the water resources in the AL-Hammad region and in identifying specific study areas where attention should be directed Remote Sensing technology has been widely used to explore and manage earth resources of which water constitutes apart. Remote Sensing technology provides space information available to the Arab League countries .

Area of Investigation

The AL-Hammad plateau extends over a large area in the South and South Eastern part of Syria ,the North-Eastern part of Jordan, The Northern part of Saudi Arabia , and the South-Western part of Iraq(figure1).Its altitude ranges among 600-1000m above the sea level, its maximum height in Rutbah uplift at Jabal Aneizeh, the meeting point of Jordan, Iraq and Saudi border.Beyound the AL-Oulab area,the eastern part of Syria, the plateau passes into the badiat AL-Sham plain, which slopes gently towards the Euphrates River.

It includes the closed drainage basins in Syria, Jordan,Iraq and Saudi Arabia. The base level of the ephemeral drainage systems is a line of Sabkha extending from Wadi Sirhan to Eastern Jabal El-Arab which coincides approximately with the major axis of a large sedimentary depression modified by comparatively recent volcanic flows. Most of the other wadis are related to the Rutbah uplift. Tilting in Neogene times of the AL-Hammad plateau has produced a radial drainage pattern. The total

annual yield of the closed AL-Hammad drainage system is about 64 MCM(ACSAD,1989/Khouri,1996).

Of this total runoff, the amount of annual runoff in Wadi Sirhan is about 16.4MCM. The seasonal drainage network of the Syrian steppe is related to two main geologic and geomorphologic features (Fig. 2) ; these are the Palmyrian ridges and AL-Hammad plateau. The plateau is tilted North-Eastward, and Wadis are therefore directed in this direction and may end in the Euphrates flood plain (Wadi Swab). Others may disappear in desert sabkhas before reaching the Euphrates river (e. g. wadi El-Miah). The area of the part of AL-Hammad plateau in Syria is 31650 km², which equals 19.1 % of the whole area of AL-Hammad plateau .

The part of AL-Hammad plateau in Syria ia situated between 36º 30´ and 41º 00´ of East Longitude and 32º 15´ and 34º 15´ of North Latitude, which is bounded in the North by the Southern part of the Palmyrian ridges, and in the Northwest, by Damascus basin, and in the West-Southwest by the AL-Arab mountain. The AL-Hammad plateau consists of four geomorphologic features, Basaltic hills, the middle hill of AL-Hammad, Sirhan Basin.

The Sirhan Basin extends from Jordan into Saudi Arabia and has a total area of approximately 50.000 km² of which 15,300 km² is in Jordan (Ministry of Water and Irrigation , Jordan 1995) .

It is a closed basin with drainage converging into the low lying zone of salt flats, lakes and mud flats.

Figure 1. Shows the AL-Hammad plateau extends Over Syria , Jordan, Iraq, and Saudi Arabia

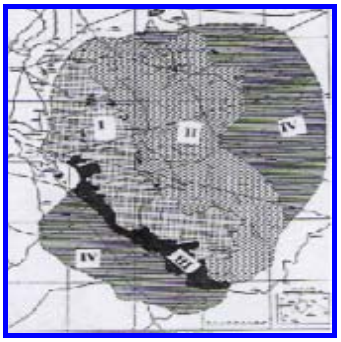

Figure 2. The four geomor-phologic features of AL-Hammad plateau I- Basaltic Hills, II- The middle Hills of AL-Hammad plateau III- Sirhan Basin. IV- Western and Eastern Wadis Regions

Application of Remote Sensing to Water Resources in AL-HAMMAD Plateau

Remote Sensing Techniques were used to delineate the boundaries of different surface features, such as the permanent water bodies, mud, flats, ..ect. The extraction of details from satellite imagery depends on the spectral contrast between the object and its surroundings.

There are many applications of Remote Sensing techniques to hydrogeological studies among them :

1- Rainfall : By interpreting the vegetation patterns and their response to the past rainfall over long period. However, Remote Sensing can only be used to obtain a general view of rainfall patterns and cannot replace actual measurements of rainfall by means of rain gauges. It is to be noted that in the AL-Hammad region, the available data were sufficient to produce a rainfall map.

2- Evaporation and evapotranspiration : These can be assessed by studying the vegetation cover through the Normalized Difference Vegetation Index [NDV1 = (B2-B1) / (B2+B1) where B represents the Band] , the albedos and the surface temperature. Although the Terms of Reference do not require the display of evaporation and evapotranspiration in map form, a vegetation Index (NDVI) map was produced as a first step .

3- Soil Moisture : Soil moisture occurs within the surface layers of the ground. The preparation of soil moisture maps needs satellite imagery which cover the same period, and thus a soil moisture map could not be produced.

4- Water Quality : This is limited to surface water quality assessments, which are not accurate for a regional level. The terms of Reference require the mapping of water quality for groundwater. Data for this have been made available through many reports and studies.

5- Lineaments :These were extracted from satellite imagery on a regional and detailed level.

Lineaments reflect geological structures such as faults, fractures, folds, ect. Landsat-TM, Spot-XS and Radar-SIR-B imagery were used to extract lineament maps at a scale of 1:50,000 , and drainage maps at a scale of 1 : 75,000 showing the major water bodies.

This work was undertaken using the visible and near infrared spectra of the Landsat –TM – high radiometric resolution – (Figure 3), Spot-XS (Figure 4), and Radar-SIR-B (Figure 5) imagery .

Figure 3. Landsat – TM image covers the area under stud

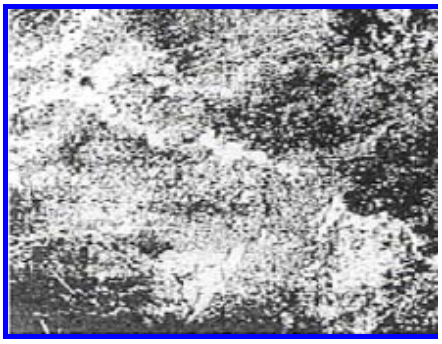

Figure 4. Spot-XS image covers the area understudy

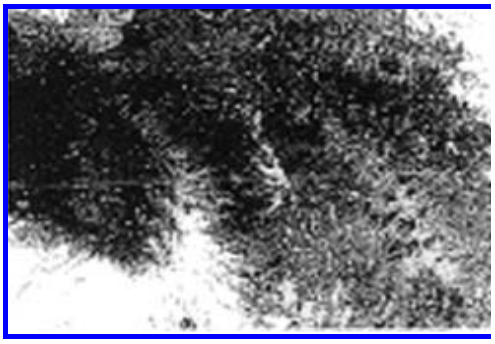

Figure 5. Radar – SIR – B image covers the area under study

Methodology

Choice of the imagery : in order to meet the requirements of the project, imagery with the following specifications were utilized :

Spatial Resolution

For the 1:75,000 maps, the spatial resolution on the ground is approximately 30 meters, and for the 1:50,000 maps, 20 meters. For this resolution, the maximum graphical error (Em) is approximately 0.4 mm (or 0.4 x 10^{-3} meters) calculated as follows (D'Hollander, 1999) : Em – 2.7 Es

Where Es is the standard deviation of the graphical error taken as 0.15 mm. The value of the Em on the ground is :

(i) for a map scale of 1:75,000

Em – 0.4 x 10^{-3} x 75,000 = 30 meters.

(ii) for a map scale of 1:50,000

Em – 0.4 x 10^{-3} x 50,000 = 20 meters .

For this accuracy of resolution, the most appropriate type of imagry for (i) is Landsat TM imagery with resolution equal to 30 meters . And for (ii) Spot-XS (Color composite) and Radar SIR-B imagery with resolution equal to 20 meters.

Radiometric Resolution

It discriminates between the different features on the imagery, especially those corresponding to water bodies, and land systems. For this purpose, a byte of 7 bits representing the radiometric value of each pixel is sufficient. This corresponds to 128 gray levels. Landsat – TM has 30 meter special resolution in the visible and near infrared part of spectrum and 8-bit (256 levels) of signal quantization. Spot-XS has 20 meter special resolution in visible and near infrared part of the spectrum and 7 bit (128 levels) of signal quantization. Thus, both imagery are more than *Spectral Resolution.*

This requires the visible and near infrared spectra, both being available in Landsat – TM and Spot-XS imagery. Both imagery were selected for semi regional (1:75,000) and details maps 1:5,000 .

Data needed

In order to supplement the satellite imagery with other necessary data and information (existing maps showing drainage systems, surface water polygons, main urban areas, ..etc), it was obtained from a part of the digital map of the world (DCW : Digital Chart of the World). In addition, other data as drainage systems, geological and hydrologeological maps of Syria, Jordan, Saudi Arabia and Iraq, were collected from different references, publications, and reports .

Preparation of the Preliminary Regional Hydrological Map

Part of digital map of the world (DCW), geological and water resources map of Syria, Jordan, Iraq and Saudi Arabia, were used for extracting the AL-Hammad zone information. Using GIS software, the following tasks were performed :

-Complition of the AL-Hammad regional map by joining the different sheets of the DCW map .

-Selection of the appropriate projection system consistent with the shape and extention of the AL-Hammad in Syria, Jordan, Iraq and Saudi Arabia.

The conformal conical Lambert projection was selected as being the most suitable for mapping .

The Role of Remote Sensing Technique :

An obvious application of satellite imagery is map updating. The operation consists of the delineation of boundries and the determination of surfaces of individual features, such as permanent water bodies.

The sequence of operations is : image enhancement, geometric correction, visual interpretation, followed by digitizing.

Lineament Mapping

Lineaments reflecting the regional tectonic trend were all clearly displayed on the Landsat - TM imagery as straight to curvilinear topographic breaks(Fig. 3). These lineaments are associated mainly with ridges, valleys, and drainge features. It was found that terrain elements were, in general, more readily distinguishable on the Radar imagery (Figure 5) than with Spot-XS data (Figure 4), although, almost all the same features could be detected on both types of imagery.

According to these investigation, unlike Spot-XS, the radar imagery tended to mask most anthropogenic disturbances and vegetation differences, leaving largely topographic information. It has shown that a radar image can make a significant contribution in rock-type discrimination over Landsat data if used alone.

The viewing geometry of spaceborne Radars is an Important consideration in discriminating the topographic and structural features on Remote Sensing. Harris (1995) has suggested that maximum enhancement of the topography occurs when slopes oriented +/- 20º from the normal to the radar look-direction. Singhroy *et al* , (1993) have reviewed both the radar look and incidence angles for the structural mapping of relatively low-relief basins.

It was found that band 7 of the Landsat –TM is the best for tracing lineaments. Also, bands 1 and 2 of Spot-XS were preferred for lineament analysis (Figure 6), because of the low reflectance range of the vegetation. Spot images with 20 m resolution were not found to be significantly different from TM images with 30m resolution .

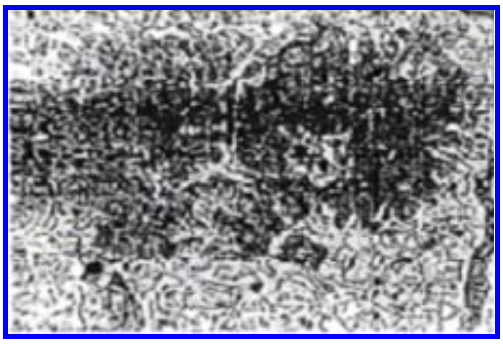

Figure 6. Lineament Analysis from different space images

Conclusions

The results of the study show that AL-Hammad Lineaments, recognized on Landsat – TM , Spot-XS, and Radar-SIR-A images , were caused by major faulting

zones that affected the crystaline basement. Basalt is one of the main units of the crystalline basemnt in the region, where water shortage is a serious problem. They are more often than not weatered and have been affected by important tectonic events in their geologic history. Study of the lineaments, particularly those aligned over significant distances with the main geomorphologic trends in other basaltic terranes of the region, may likewise lead to sites of groundwater.

In View of their textural characteristics, Radar imagery is thought to be particularly sensitive to structural lineaments. The existing spaceborne radar imaging of lineaments is hindered by rigid viewing angles with respect to topographic slopes .

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