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SEASONAL AGRICULTURAL COVERAGE AND WATER MANAGEMENT OF RIYADH ALKHABRA ALONG WADI AR RUMAH IN SAUDI ARABIA USING LANDSAT TM

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ABSTRACT :

Vegetation covers of the mapping system in the midstream of wadi Ar Rumah valley in Arabian peninsula area have been seasonally monitored, classified and evaluated, using the images of years 1994 and 1998 of 12 months. The relationship between classified images and the corresponding meteorological parameters of the area has been discussed. Water consumption of the vegetated areas has also been evaluated. The actual target of this study is to understand the seasonal variation of vegetation cover along wadi AR Rumah area using the images of years 1994 and 1998 of 12 months of Landsat/TM images and the associated water management.

INTRODUCTION:

Saudi Arabia is a part of the hot desert extending from Sahara, Africa in the west to the Thar desert in Indo-Pakistan sub-continent in the east. Vegetation, water and solar radiation are the controlling factors of the natural environment of Saudi Arabia[10]. The production of the thematic maps, such as those depicting land cover, using an image classification is one of the most common applications of remote sensing[1]. Many researchers used this technique to achieve this aim[2,3,4]. Changes in vegetation cover are amongst the obvious alterations that mankind has caused to the global environment. Historically, these changes have local or regional in effect, though widespread. For many reasons, the detection and monitoring of vegetation cover dynamics is highly desirable[5]. Remote sensing clearly plays a potential role in order to monitor fragile arctic ecosystems, although they have yet to be fully investigated[6]. This paper detect AlQassim's land vegetation cover change (mainly agriculture), and whether space observations are useful to study variation in vegetation growth along wadi Ar Rumah [10]. Studying AlQassim area along Wadi Ar Rumah is important for several reasons such as: i) Better understanding the current status of land cover/use of desert ecosystem. ii) Observing the land cover system in an active cultivation and populated area for the benefit of the desert agriculture and settlement landscape. It has to be mentioned that the total underground water supply about 75-85% of ground water reserve. The total volume is estimated to be 900000 million m^3, which was formed in the last Ice age,

15000 to 30000 years ago[8]. For the last 30 years, the crop cultivation was successfully performed by center pivot irrigation system using extracted ground water. This agricultural method is mainly progressing in Al Qassim district[9].

Location and general description of the study area:

Saudi Arabia physical geography can be divided into five regions: (i) the Western Highlands, (ii) the Central Plateau, (iii) the Northern Deserts, (vi) the Rub al Khali desert, and (v) the Eastern Lowlands. The Central Plateau geographic region, the mountains of Hejaz and Asir slope eastward toward the Central Plateau, also called Najd. Little vegetation is found in most of this region (see Figure (1). In parts of the rocky plateau, fertile oasis support large farm communities; Al Qassim is one of these oasis. During the rainy season in the peninsula, nomadic herders bring their animals to feed on patches of grass that grow in the region for a short time after occasional rainfall. The peninsula terrain is varied but on the whole fairly barren and harsh, with salt flats, gravel plains, and sand dunes but with few permanent streams. In the south is the Rub Al Khali (Empty Quarter), the largest sand desert in the world. In the southwest, the mountain ranges of Asir Province rise to over 2700 m. There is no precipitation during the months from June to September. The months from January to March are of highest precipitation. The mean annual precipitation of the past twenty years is 110 mm., which is very low, and it is characterized by an irregular distribution both in quantity and frequency.

The study area, Alkhabra along wadi Ar Rumah in the *Arabian Peninsula* between 12ºN and 32ºN latitude and between 20ºE and 35ºE longitude as illus traded in Figure (2). This particular geographical position gives the area great bioclimatic diversity. The desert of the Arabian Peninsula is located as a part of the hot desert which extends from the *Sahara* in Africa in the west to the Thar desert in Indo-Pakistan sub-continent in the east. The overall climate falls within desert and arid climates, except the Asir province where the temperature is lower and the rainfall is greater heavier than that of the remaining part of the peninsula. The area is also subjected to a significant problem with regard to desertification. Wadi Ar Rumah is also the main dry river in the peninsula; its midstream part comes through Al Qassim oasis located at the center of the peninsula desert.

The study area in central of Saudi Arabia. Ar Rumah Wadi starts from the two big volcanic mountains in the north and the south of Al-Madenah[11]. The main part of Ar Rumah passes through Al Qassim Oasis which is one of the main agricultural region of the kingdom of Saudi Arabia[9].

The maximum monthly temperature ranges between 38.6°C and 43.1°C in summer with a minimum of 20.8°C to 24.1°C. During winter, the maximum monthly temperature ranges from 18.19°C to 24.1°C with a minimum of 5.3°C to 10.9°C. It has been observed that the highest temperature prevails during the months from May to October while the lowest are observed between November and March.

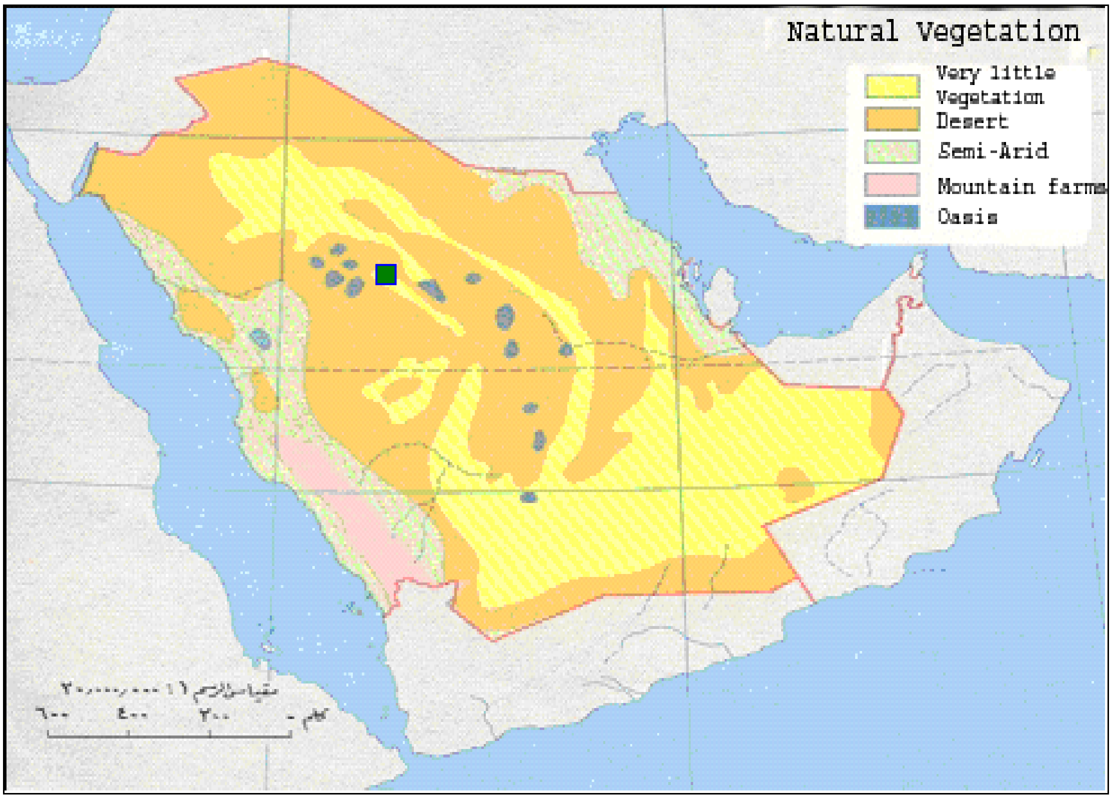

Figure (1) : Geography of Saudi Arabia (Atlas of Saudi Arabia and World, 1996).
(Location of study area).

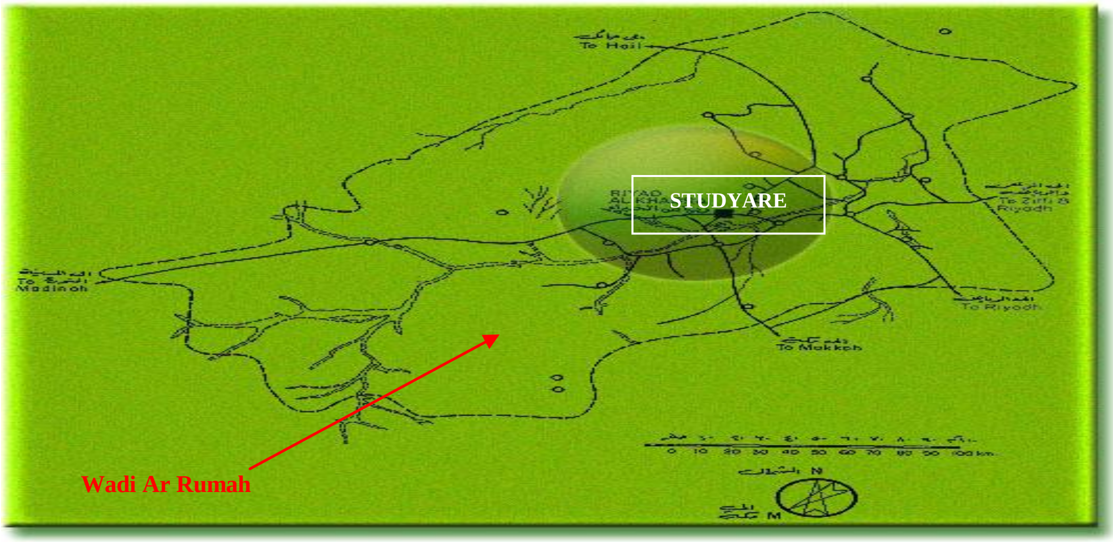

Figure (2) : Location of Alkhabra.

Evaporation is mostly dependent on solar radiation, wind velocity, humidity, type of soil, and type of vegetation and land use. The area under investigation is characterized by high temperature, low humidity, high solar radiation and hot weather during summer. Accordingly, Al Qassim region provides conditions for high evaporation rates. It varies from 133 mm/day in January to 575 mm/day in June. This value exceeds the annual precipitation; consequently the soil of the area becomes deficit in moisture content. The peak months of evaporation are June, July and August, Months of September are also considered as high in evaporation rote.

DATA DESCRIPTION :

The multispectral data used in this analysis is derived from Landsat 5 TM digital imagery. This imagery was acquired from the King Abdul Aziz City For Science and Technology (KACST), which was downloaded from the Saudi Arabia receiving station. The dates of the images used in this study are given Table (1).

Table (1) : Used LANDSAT/TM data

Images No.	1994	1998
Image -1	19 JAN	22 JAN
Image -2	28 FEB	28 FEB
Image -3		27 March
Image -4	17-Apr.	28-Apr.
Image -5		5 May
Image -6	20 JUN	15 JUN
Image -7		17 July
Image -8	23-Aug	18-Aug
Image -9	24 SEP	19 SEP
Image-10	26-Oct	21-Oct
Image-11	27-Nov.	6-Nov.
Image-12		6-Dec.

METHODOLOGY:

1-Image processing:

The study area was extracted from the full seen, and prepared for image processing analysis as subscenes. Each subscene is (512 pixels * 400 line), i,e of 18432 ha. Resampling program has been used for the image registration by selecting 10 GCP points in each image site. Making January images the basis for registration, and registering all images to January images. False color composite image of the three bands (432) has been formed for every month to detect the vegetation cover in the study area.

About 30 years ago, it has been advantageous to perform crop cultivation by centre pivot irrigation system in Saudi Arabia. This method has been mainly progressing in Al Qassim district[9]. In the present study, analysis of Landsat data for all the 22 months during the studded of the year have been carried out using Supervised classification method (Maximum Likelihood Classification) which was adopted to classify the total amount of planted vegetation cover. Many researchers also used the Maximum Likelihood method in their study[7].

This method uses training data sets of distinct spectral signatures that have been selected within the areas of exactly known identity of agricultural vegetation. Classification was carried out to estimate the percent coverage of agricultural land during each month of the year. Remote sensing software in window PC environment has been developed and used for the classification.

The study area has been visited by the researchers, where ten representative sites were selected as training sites. The location of these sites and the descriptive classification title are fed into the computer to generate the signatures of the classification process.

The accuracy assessment was detected using 10 points distributed randomly in the study area and a reference map to this area, an error matrix is produced to represent the overall classification accuracy of the resulted classes.

2-Detection seasonal vegetated cover and its relationship to water consumption:

The amount of agricultural cover in the study area was detected from the image processing of the 22 satellite images, one for each month. The seasonal variation in vegetation cover was detected by a comparative analysis of the percent cover of vegetation in each image. This was also related to the corresponding water consumption of the cultivated crops in the study area. Estimates of water consumption were acquired from the Ministry of Agriculture that is responsible of the irrigation and cultivation activities in the area under study. Cumulative sum of these water consumption values was calculated and related to the amount of vegetation cover in hectares per month and consequently per year. When relating the yearly water consumption in the study area to the total available water in the reservoir, water management practices can be defined and evaluated.

RESULTS AND DISCUSSION:

1-Multi_Spectral Analysis:

Colour composites produced for the study area are presented in Figures (3 and 4), for February of years 1994 and 1998 respectively as an example. Generally the tones of red are indicative of vegetation cover. The rounded shapes appear in red are cultivated fields resulting from pivot irrigation system. From these figures, it is clear that the February image of 1994 exhibit more vegetation cover because of the growing of wheat season. Wheat had been seeding in November, the beginning of the winter. But in the image of Feb. 1998 there is less vegetation covers due to the reduced cultivated areas of Wheat. It is also observed that the amount of agriculture is less in May. This is because of the harvesting time of wheat in April. The observed percentage of agricultural land cover from May to September represent other crops such as alfalfa, barely and also trees such as palm date which grow all the year round. The spectral signatures used for the classification is presented in the Figure (5). This figure shows that the crops planted in the study area are very similar spectrally, and therefore were treated collectively in calculating total water consumption (m^3). Figure (5), shows the detailed signatures based on mean value that used in the classification process.

Classified images are presented in figures (6 and 7). Also the results of classification analysis of the percent cover of the agricultural areas is plotted in Figure (8).

From these figures, it appears that Landsat data can provide the extent (increase or decrease) of vegetation cover on temporal basis due to changes in spectral characteristics of the land cover over time. Due to cloud in some satellite images, the percentage of land cover in March and December are considered as the same as that in February and January respectively.

The accuracy of classification based on February image is found to be 90%. This accuracy is accepted for the purpose of this research. The agrometerological data are plotted in Figure (9). Figure (10) shows that the net water requirement (cubic metre/hactare) of grains (wheat), forages (alfalfa) and trees (date palm).

From Figure (10), it is found that the extent of agricultural land cover is less during May to October but the water consumption is high, while water consumption is low when the extent of vegetation cover is more in the winter season.

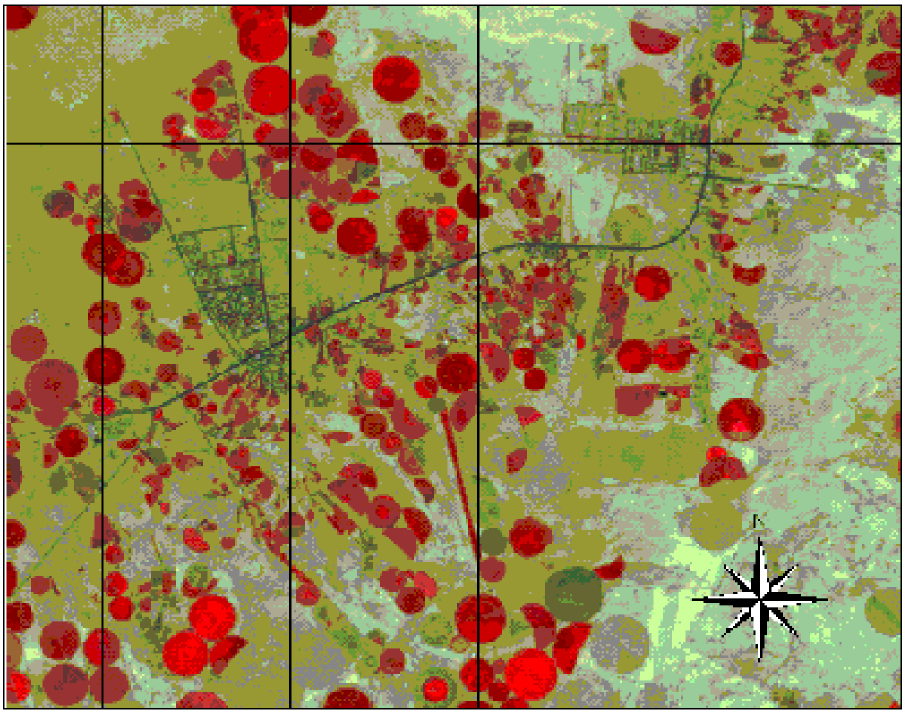

Figure (3) : Landsat TM 28 February, 1994 of Riyadh Al Khabra subscene (RGB= TM bands 432).

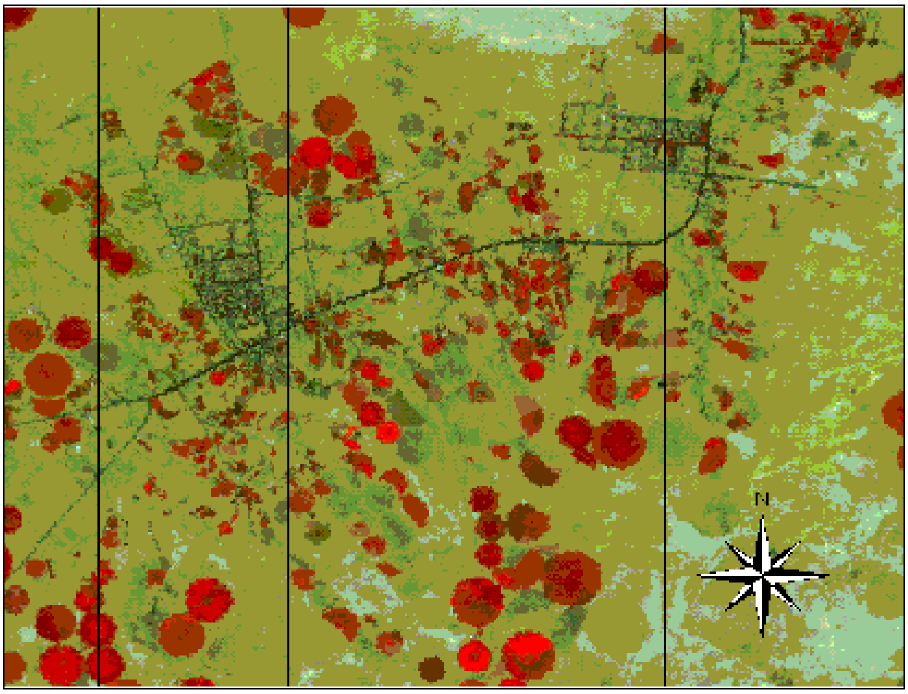

Figure (4): Landsat TM 28 February, 1998 of Riyadh Al Khabra subscene (RGB= TM bands 432).

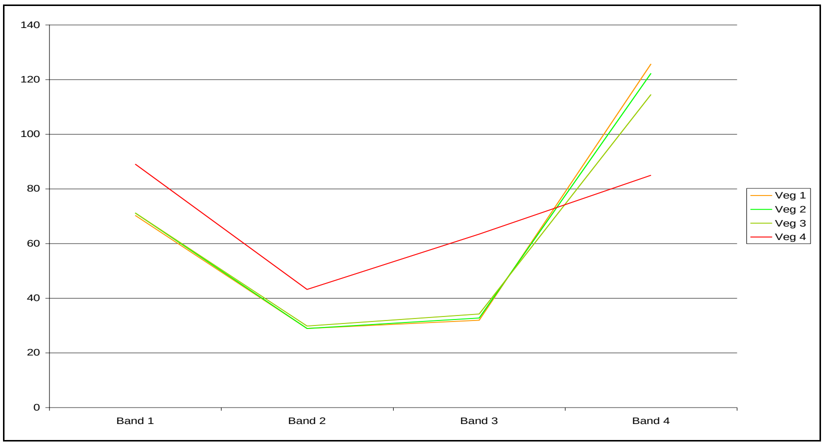

Figure (5): Mean plot of signatures

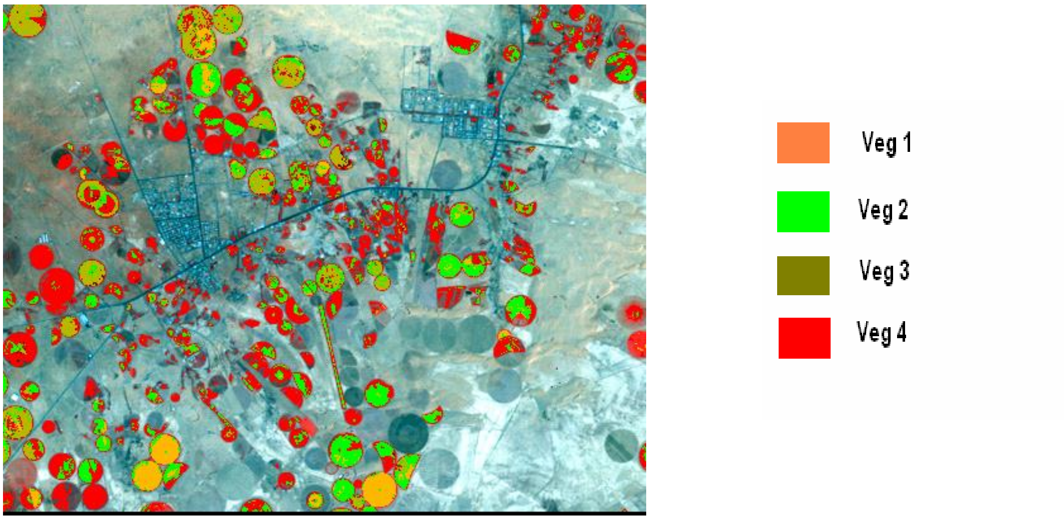

Figure (6) : The classified image obtained using Maximum Likelihood classifier of February, 1994. Veg 1 denotes to alpha alpha, Veg 2 barley, Veg 3 palm tree, Veg 4 Wheat.

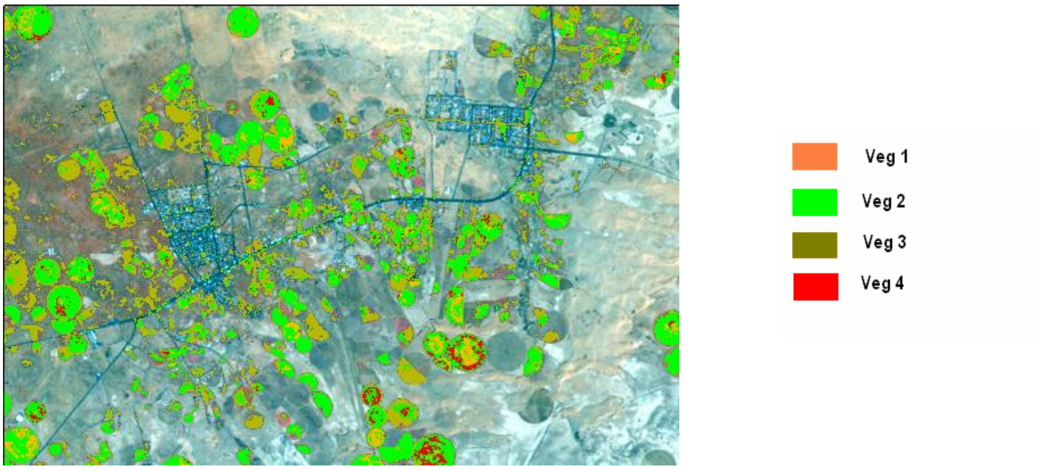

Figure (7) : The classified image obtained using Maximum Likelihood classifier for Feb., 1998. Veg 1 denotes to alpha alpha, Veg 2 barley, Veg 3 palm tree, Veg 4 Wheat.

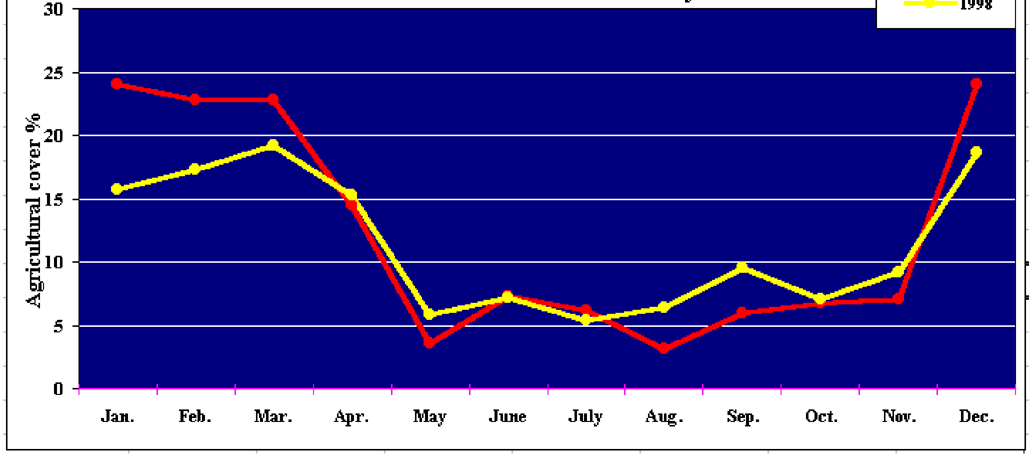

Figure (8) : Agricultural cover transition of Qassim area along Wadi Ar Rumah from Landsat TM 1994 and 1998 data analysis

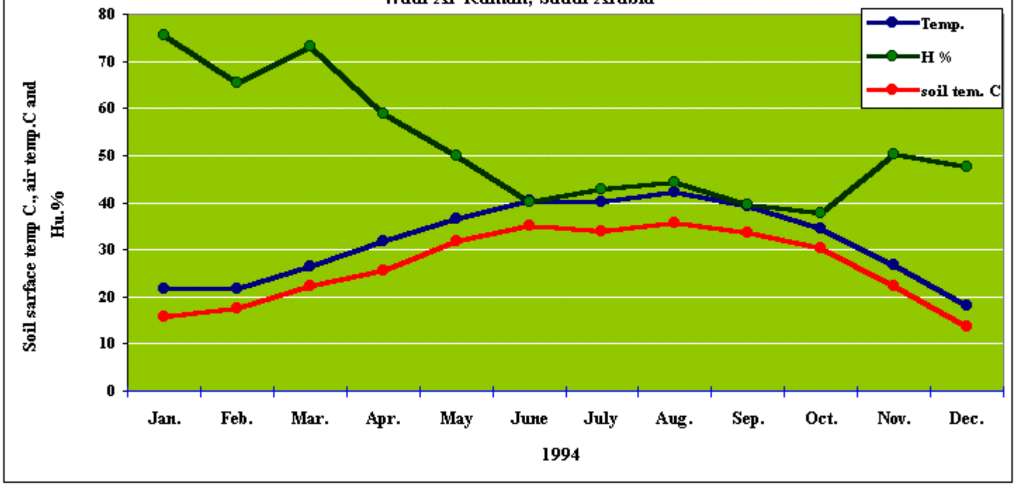

Figure (9) : Surface soil temperature, air temperature, Humidity in the mid-stream of Wadi Ar Rumah, Saudi Arabia

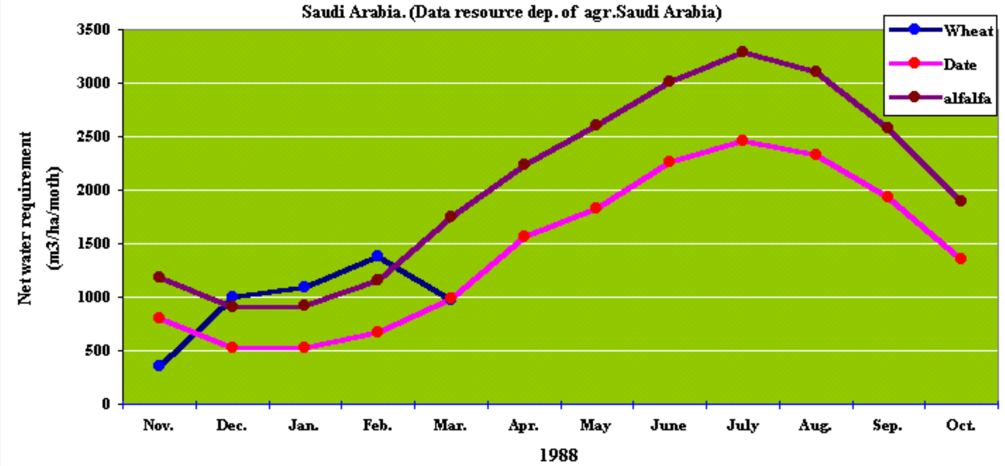

Figure (10) : Net water requirement for wheat, date and alfalfa in the mid-stream of Wadi Ar Rumah, Saudi Arabia. (Data resource dep. of agr.Saudi Arabia)

2-Water Consumption Assessment:

From landsat image curve in Figure (8), the total area coverage (ha) and water consumption data can be calculated as follows:

Image area in hectares:

1 pixel = 30 * 30 = 900 meter square

= 900/10000 ha = 0.09

512 pixel * 400 lines * 0.09 meter square

= 18432 ha

Vegetation coverage per month and the associated water consumption derived from the Figure (9) are calculated and given Table (2) for year 1994 and in Table (3) for year 1998.

Tables (2&3) demonstrate the total area of cultivations of Riyadh Alkhabra area (ha), along Wadi Ar Rumah. This area is derived from the results of MLC classification. The cultivated crops are mainly wheat, alfalfa, barley and Palm trees. By knowing the water consumption (m^3)/crop/ha/month, the above calculations were used to estimate total water consumptions (m^3) for the three crops in the entire cultivated area in Alkhabra area of the two years. The water consumptions of year 1994 is higher then that of year 1998 due to the reduction of the cultivated areas in the year 1998.

The amount is estimated to be about 90044190.72 m3, which constitutes about 0.01% of the total water in the reservoir ($9x10^{11}$ m^3) of year 1994, but it was 0.0001 for year 1998.

This parameter is considered as an indicator of water consumption from the reservoir and calls for similar cultivated area in order to assess the amount of water used for irrigation in AlQassim along Wadi Ar Rumah area, and the future sustainability of water use. It is also important to carryout specialized studies on rates of reservoir recharge in the area under study in order to assess the water budget of this irrigation method (pivot), and consequently ground water management schemes.

CONCLUSIONS:

The cultivated areas in 1998 was less than 1994 due to two reasons, the first, increased the costs of the irrigation water and the marking price goes down by the Government. The assessment of agricultural land cover in the study area could be done successfully with the help of remote sensing satellite data. An assessment of water consumption in the area could also be done. The information derived through similar studies can provide the Government with necessary data for crop estimation and water budget planning in the country. This would help to achieve a sustainable development in the future. It is also concluded that water consumption rate per month can be estimated using the classification of land cover and the consumption rate for each particular crop.

Table (2) : Water Consumption (m^3) /month in the study area of year 1994

Month	Percent Cover from the image (18432 ha)	Area (ha)	Sum of water consumption(m^3) for total agriculture /ha	Water consumption (m^3) /month
January	24	4423.68	2500	11059200
February	22.8	4202.50	3350	14078361.6
March	22.8	4202.50	2750	11556864
April	14.5	2672.64	3850	10289664
May	3.6	663.55	4500	2985984
June	7.3	1345.54	5350	7198617.6
July	6.2	1142.78	5880	6719569.92
August	3.1	571.39	5500	3142656
September	5.9	1087.49	4500	4893696
October	6.7	1234.94	3300	4075315.2
November	7.1	1308.67	2450	3206246.4
December	24	4423.68	2450	10838016
Total		27279.36	46380	90044190.72

Water reservoir = $9x10^{11}$ m^3

% of water usage of Al Khabra area along wadi Rumah in 1994 :

[90044190.72/$9x10^{11}$] x 100 = 0.01

Table (3) : Water Consumption (m^3) /month in the study area of year 1998.

Month	Percent Cover from the image (18432 ha)	Area (ha)	Sum of water consumption(m^3) for total agriculture /ha	Water consumption (m^3) /month
January	15.7	2893.8	2500	7234500
February	17.3	3188.7	3350	10682145
March	19.2	3538.9	2750	9739751
April	15.3	2820.1	3850	10857385
May	5.8	1069.06	4500	4810770
June	7.2	1327.1	5350	7099985
July	5.4	995.3	5880	5852364
August	6,4	1179.6	5500	6487800
September	9.6	1769.4	4500	7962300
October	7.1	1308.6	3300	4318380
November	9.2	1695.7	2450	4154465
December	18.6	3428.3	2450	8399335
Total		25214.6	46380	87599180

Water reservoir = $9x10^{11}$ m^3

% of water usage of Al Khabra area along wadi Rumah in 1998 :

[87599180/ $9x10^{11}$] x 100 = 0.0001

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الغطاء الزراعي الموسمي وإدارة المياه لمنطقة رياض الخبراء على طول وادي الرمة في المملكة العربية السعودية باستخدام صور الأقمار الصناعية (MT)

سلطان بن حسن السلطان

مركز السلطان للبحوث البيئية – طريق المدينة والقصيم – رياض الخبراء – السعودية

لقد تم مراقبة وتصنيف وتقييم الغطاء النباتي موسمياً لمنتصف وادي الرمة بالجزيرة العربية باستخدام صور الأقمار الصناعية لاثنى عشر شهراً في عامي ١٩٩٤، ١٩٩٨.

كذلك تم مناقشة العلاقة بين تصنيف الصور الفضائية، وما يقابلها من متغيرات مناخية. كما تقييم استهلاك المياه للمناطق المنزرعة.

إن الهدف الفعلي لهذه الدراسة هو تفهم تغيرات الغطاء النباتي الموسمي على طول وادي الرمة مستخدمين صور الأقمار الصناعية لاثنى عشر شهراً في عامي ١٩٩٤-١٩٩٨، وعلاقة تلك الصور بإدارة المياه.