

## **GIS AND REMOTE SENSING APPLICATIONS IN SANA'A BASIN STUDY ON SATELLITE IMAGE ANALYSIS OF CROPPING AND IRRIGATION WATER USE**

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### **ABSTRACT**

Remote Sensing is a technique developed for the process to obtain information on the particular phenomenon on the ground or near the use of optical sensors riding reconnaissance satellite.

While the remote sensing a branch of modern applied science, remote sensing is more effective than traditional methods, with personal efforts prepared the researcher Remote Sensing Expert Sana'a, Yemen in this frame is carried out by Landsat TM.

**Keywords:** GIS, Remote sensing, Sana'a Basin, Irrigation, Water use.

### **OBJECTIVE**

To sketches the need to know crop identification, water use by irrigated crops per sub-basin in the Sana'a Basin.

Knowledge on the acreage of qat and other crops is helpful for planning of water resources. In the Sana'a Basin generally cultivated areas are: different growth, mixed crop types, small-scale agricultural practices in the area, mountainous terrain with different slopes and aspects of the field, These problems affects mainly to the crop classification. Therefore, the spectral properties of the sample sets vary with time.

The main results of the remote sensing (Landsat TM) study are:

- A) Qat (sweeping is dreadfully on agricultural land).
- B) Grains (maize, barley, wheat ....)
- C) Grapes.
- D) Trees and natural herbs.
- E) Vegetables.
- F) Fruits.

## GENERAL INFORMATION ON SANA'A BASIN, YEMEN

Yemen occupies the South-Western part of the Arabian Peninsula.

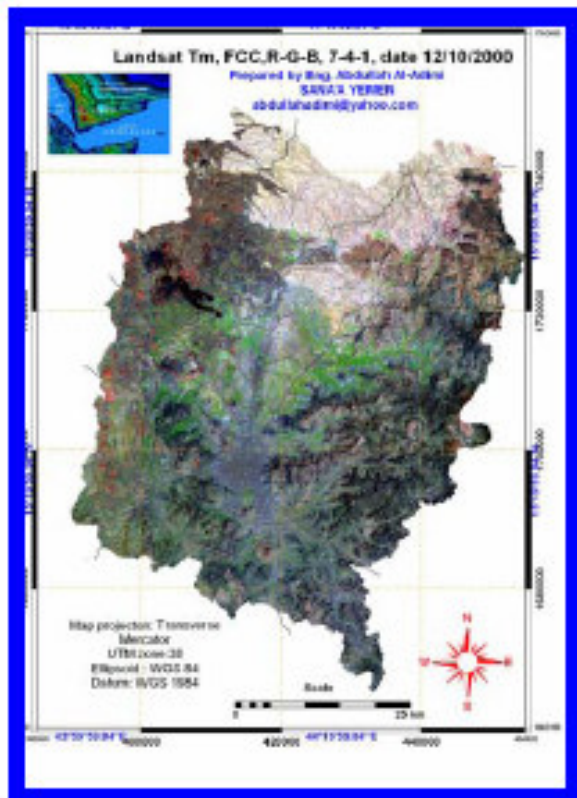
\* Location of Sana'a Basin, at the NE end of the western highland.

Zone 38

UTM X = 389800: 454600 m

UTM Y = 1665000: 1749000 m, see Figure (1)

\* Total area: 3235 km<sup>2</sup>



**Figure (1): Location of Sana'a Basin  
Land sat thematic mapper  
false colour composite showing Sana'a  
Basin**



**Figure (2) :Topographic map**

### \* **Population:**

More than two millions (most of them in urban area) see Figure (2).

### \* **Topography of Sana'a Basin:**

Sana'a Basin is an intermountain plain surrounding by mountains from East, West and South Catchment outlet at wadi Al-khared, see Figure (3).

Max. Elev = 3660 m

Min. Elev = 1915 m, see Figure (4).



Figure (3): Three dimensional view of Sana'a Basin, Yemen

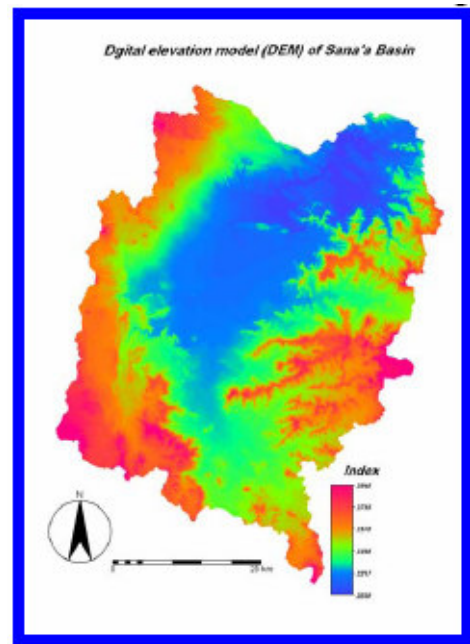


Figure (4): Digital elevation model (DEM)

**\* Climate:**

Semi-arid. Rainfall in Sana'a Basin.

The NE area in the Basin has less rainfall, the W & SW areas has more rainfall.

The mean annual rainfall in Sana'a Basin ranges between:

80 mm in the NE areas to more than 300 mm towards W & SW areas.

Max = 300 mm/year

Min = 80 mm/year

Average = 170 mm/year, see Figure (5).

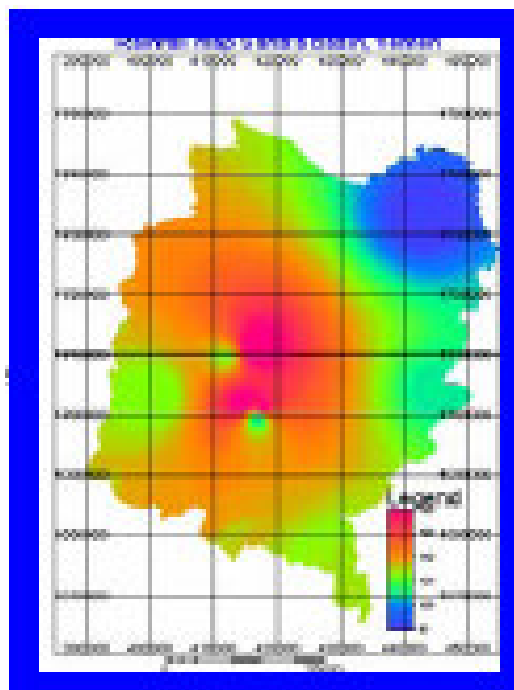


Figure (5): Raifall map of Sana'a Basin , Yemen

## METHODS OF PROCESSING SATELLITE DATA

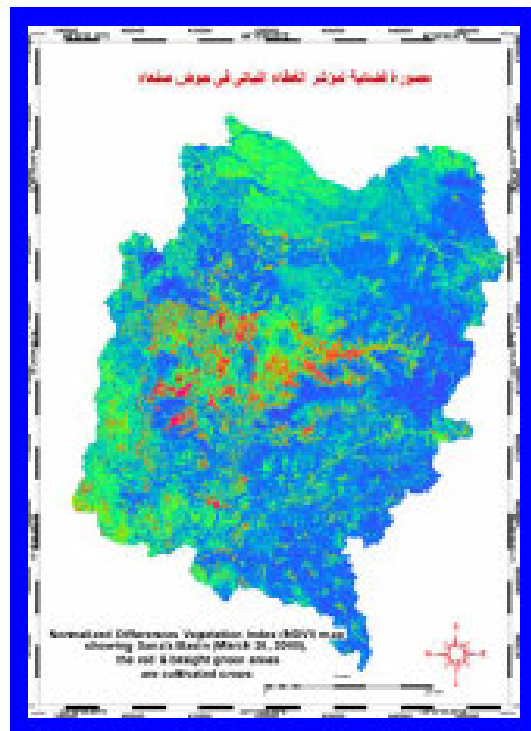
The brief description of the methods are as follows:

### A- Using RS techniques for crop classification determined by the NDVI method (Normalized Difference Vegetation Index)

While NDVI it is a good index chlorofil activity in land, was done this technique in the classification of the crop types.

The processing of the satellite data dated 26/3/2000 analysis study is used with the following steps:

- \* First data sets.
- \* Computation of the  $NDVI = (Nir - Red / Nir + Red)$ .
- \* Using available knowledge in the field.
- \* Crop identification using data from field.
- \* Other information analysis, see Figure (6).



**Figure 6: NDVI (Normalized Difference Vegetation Index) showing Sana'a Basin, the red and bright green areas are cultivated (26 March 2000)**

**B- Using RS techniques for calculate distributions of actual evapotranspiration (ETa)**

A more recently developed method allows the calculation of the actual evapotranspiration (ETa) is used Surface Energy Balance Algorithms for Land, SEBAL (Bastiaanssen 1995, 1998 a,b).

For each pixel over all areas of Sana'a basin, the daily distributions of actual evapotranspiration (ETa ) can be calculated in mm/day used ILWIS software.

**SEBAL**

Surface Energy Balance Algorithm for Land:

- \* Using thermal visible near infrared remote sensing information.
- \* Using meteorological data.
- \* Using DEM.
- \* Using energy balance at the earth's surface (EBE).
- \* Crop types Map Sana'a Basin, Yemen date 26/3/2000,
- \* Other information, see Figure (7).

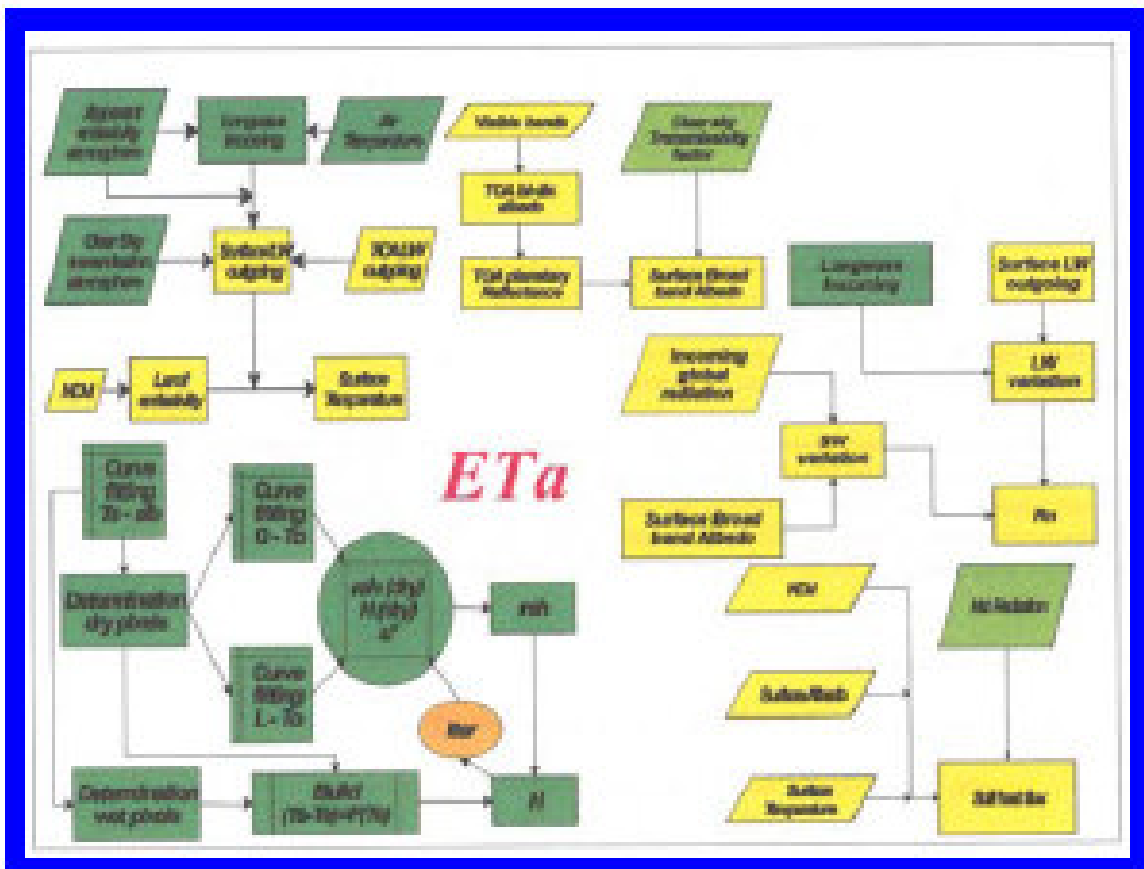


Figure (7): The SEBAL algorithms

### C- Water use

The amount of water used by the irrigated crops in the study of the Sana'a Basin can be calculated in  $m^3$ /crop type/day, the data will give direct information on.

### D- Using RS techniques for change detection of cultivated area

Detection the change in operation of designation of the disagreements in solver of thing or phenomenon introduces and that in his observer in several times different. The changes on observer depend on the changes values digital for visible space digital.

Knowledge on the change detection of cultivated area chose wadi Dula hamdan and wadi Dhahr, where qat cultivation is concentrated.

## RESULTS

The main results of the remote sensing (Landsat TM) study are:

### 1- Crop identification in the Sana'a Basin considered as:

- A) Qat (sweeping is dreadfully on agricultural land).
- B) Grains (maize, barley, wheat ....) and mix.
- C) Grapes.
- D) Natural vegetation (tree)
- E) Vegetables.
- F) Fruits.

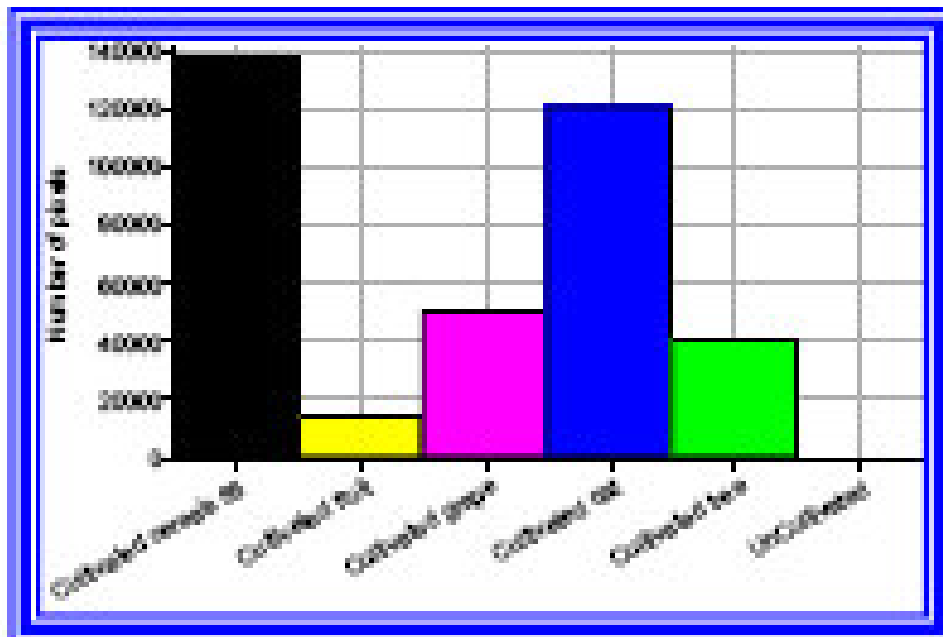


Figure (8): Crop types [Number of pixels]

2- The cultivated areas (ha) by crop types in the Sana'a Basin date 26/3/2000 have been listed in Table 1.

Table (1): Crop types and cultivated areas (ha)

| No.          | Description                  | No. of pixels (npix) | Percentage (%) | Area (m <sup>2</sup> ) | Area (ha) |
|--------------|------------------------------|----------------------|----------------|------------------------|-----------|
| 1            | Cultivated grains & mix - 86 | 137558               | 37.81          | 85973750               | 8597.38   |
| 2            | Cultivated fruit             | 13897                | 3.82           | 8685625                | 868.56    |
| 3            | Cultivated grapes            | 50654                | 13.93          | 31658750               | 3165.88   |
| 4            | Cultivated qat               | 120920               | 33.24          | 75548750               | 7557.5    |
| 5            | Cultivated tree              | 40724                | 11.20          | 25478750               | 2545.3    |
| <b>Total</b> |                              | 363753               | 100.00         | 227345625              | 22734.6   |

3- The location of cultivated areas by crop types in the Sana'a Basin is shown in Figure (9).

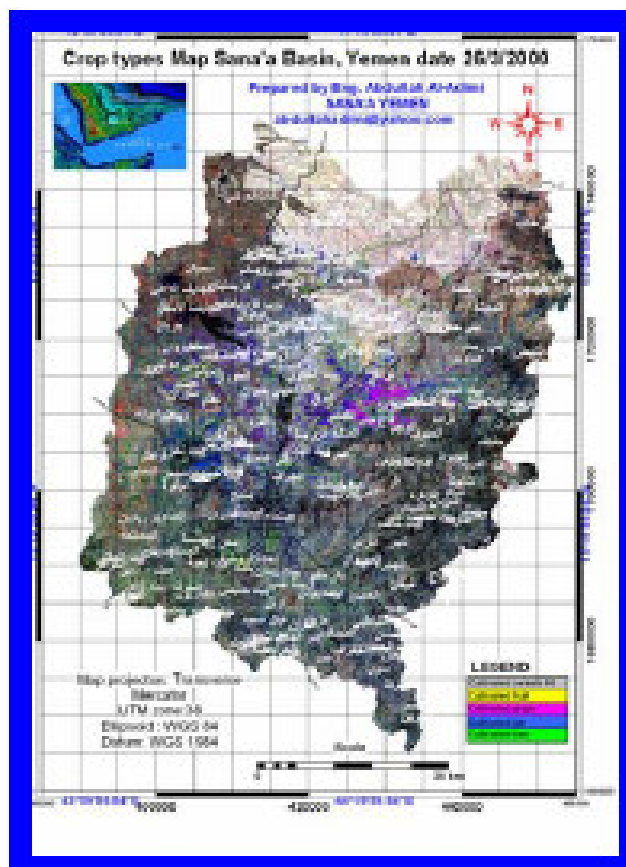


Figure (9): Crop types Map Sana'a Basin, Yemen date 26/3/2000

**showing the result from the crop classification**

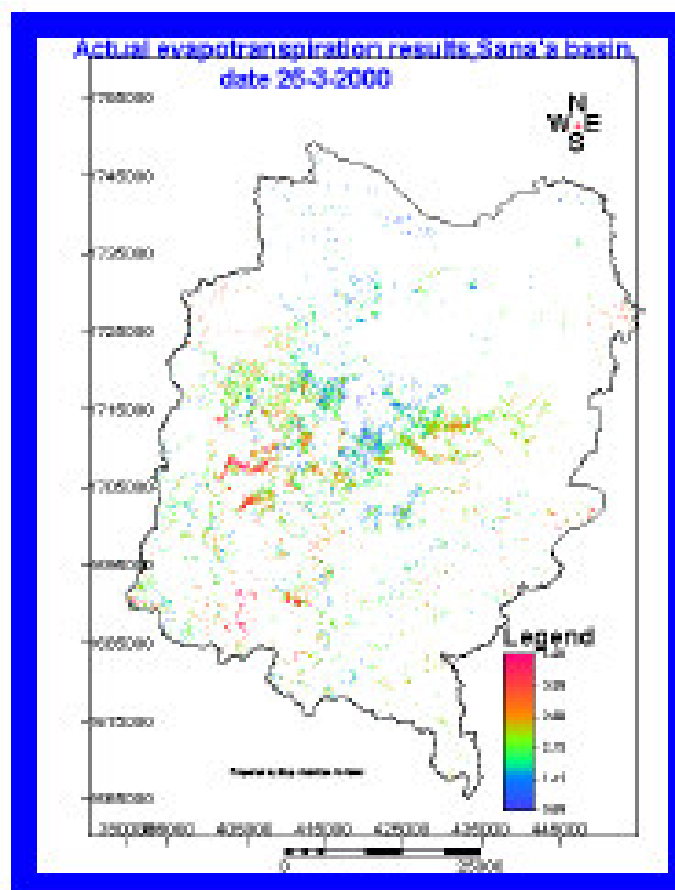
**4- Actual evapotranspiration (ETa) determined**

The daily actual evapotranspiration (ETa) rate ranges from 0.09 to 6.0 mm/day according to the SEBAL method "Surface Energy Balance Algorithms for Land", based on the analysis of satellite image dated 26/3/2000 from the landsat by used ILWIS software, see Figure (10).

The high rate of actual evapotranspiration, notices in this map on wadi Dula hamdan wadi Dhahr wherecultivation is concentrated Qat and wadi AsSer where cultivated Qat and Grapes.

According to determination the annual (ETa) by use Penman method, Sana'a Basin ranges between 2200 mm/year to 2500 mm/year:

- Max (ETa) in June
- Min (ETa) in December



**Figure (10): Actual evapotranspiration (ETa) Map of Sana'a basin date 26-3-2000**



#### 4- Crop water use determined

The cultivated areas by crop types in the Sana'a Basin date 26/3/2000 have been listed in Table 2.

**Table (2): Crop types and water use m<sup>3</sup>, Sana'a basin, Yemen**

| Crop types and water use (m <sup>3</sup> ), Sana'a basin, Yemen Prepared by Eng. Abdullah Abdulwahed Al-Adimi                               |   |                                |                  |                  |                |                    |              |        |
|---|---|--------------------------------|------------------|------------------|----------------|--------------------|--------------|--------|
| An overview of the cultivated areas (ha) by crop type and its respective water use (m <sup>3</sup> ) using Landsat-TM, NDVI, date 26/3/2000 |   |                                |                  |                  |                |                    |              |        |
| No  | Description                                   | Cultivated grains and mix - 86 | Cultivated fruit | Cultivated grape | Cultivated qat | Cultivated tree    | Uncultivated | Total  |
| 1   | Sana'a Basin Area (ha)                        | 8597.38                        | 868.56           | 3165.88          | 7557.5         | 2545.3             | 300785.4     | 323520 |
| 2   | Sana'a Basin Area Percentage of Total         | 2.66                           | 0.27             | 0.98             | 2.34           | 0.79               | 92.97        | 100    |
| 3   | Sana'a Basin Cultivated Area (ha)             | 8597.38                        | 868.56           | 3165.88          | 7557.5         | 2545.3             |              | 22735  |
| 4   | Sana'a Basin Cultivated Percentage of Total   | 37.82                          | 3.82             | 13.93            | 33.24          | 11.2               |              | 100    |
| 5   | Sana'a Basin Water Use (m <sup>3</sup> ) 86   | Rain fed crops                 | 7729             | 44437.3          | 73758.3        | Natural vegetation |              | 275923 |
| 6   | Sana'a Basin Water Use 86 Percentage of Total |                                | 6.13779992       | 35.2888157       | 58.5733844     |                    |              | 100    |

**Some Pictures for Crop types**



**Grapes**

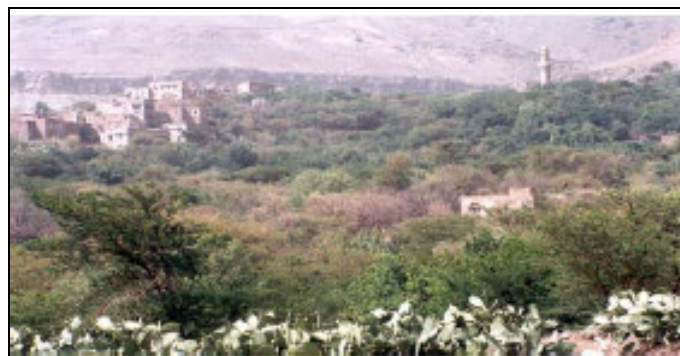


**Qat**



**Qat, Fruit and Natural vegetation (tree)**

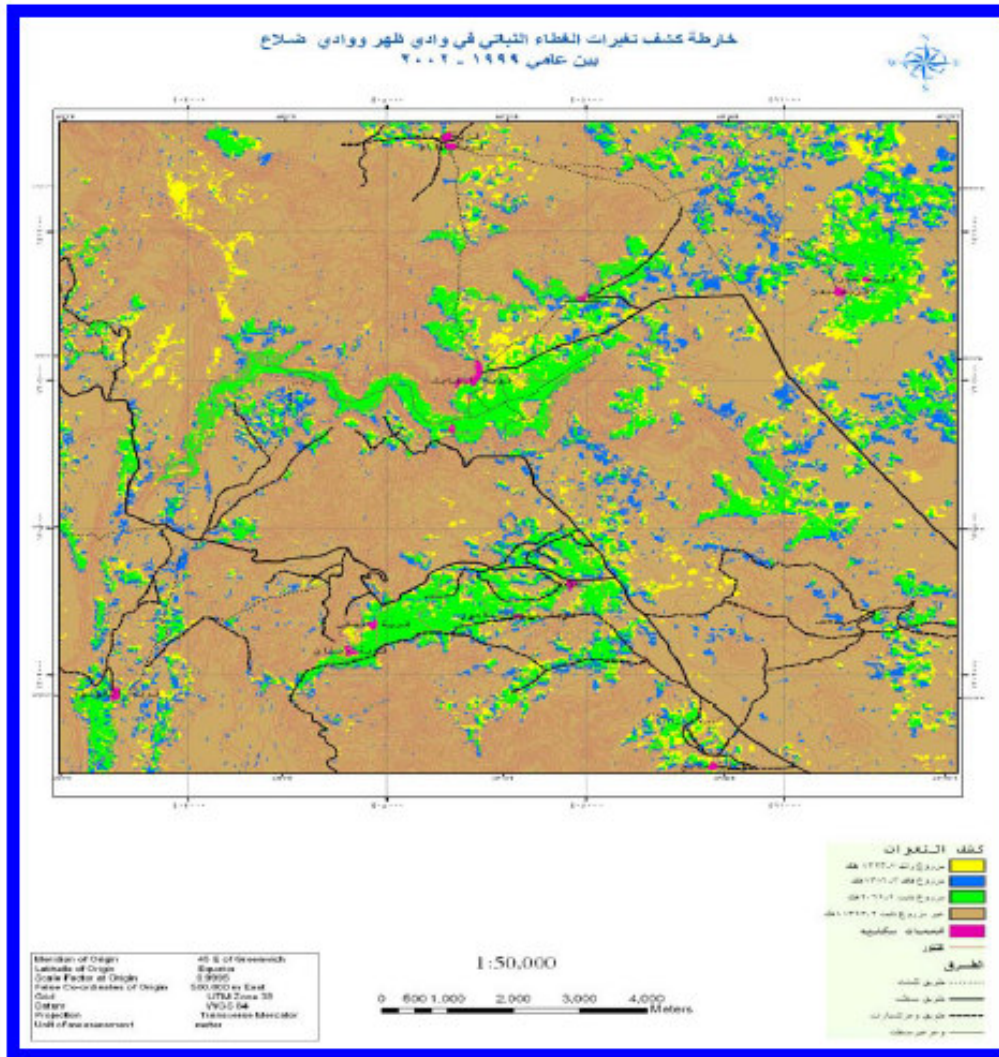
**Rain feds crops**



**Natural vegetation (tree)**

**Some photos showing crop types examples on the cultivated area**

**4- Other useful results** for example cultivated area change detection in wadi Dula' Hamdan and wadi Dhahr between 1998 and 2001, Figure (11).



**Figure (11): Example on the cultivated area variation**

**CONCLUSIONS**

- 1- Remote sensing technique is more effective than traditional methods that rely on surveys and field measurements require much time and effort and making human cadre of traditional methods difficult process and useless.
- 2- Remote sensing technique is a tool for:
  - Identification of cultivated areas.
  - Identification of crop type.

- Determination of actual evapotranspiration (ET<sub>a</sub>).
  - Identification of cultivated area variation.
- 3- As outlined in this study bases on satellite image (landsat TM) date 26/3/2000:
- Cultivated grains and mix (37.82%) Cultivated fruit (3.82%) Cultivated grapes (13.93%) Cultivated qat (33.24%) and Cultivated trees (11.2%) from the total cultivated areas of Sana'a Basin.
  - Qat (59%) grapes (35%) and fruit (6%) from the total water use of crops.
  - Qat and grapes are the most dominant, irrigated cultivation.
- 4- Annually increasing qat cultivation steadily at the expense of other areas of crops.
- 5- As outlined in a recent search on the qat the following points are:
- Qat one of the sources of incurable diseases and the person who chewed Qat constantly chewed qat annually with the equivalent of 6 kg of toxic pesticides found in qat leaves,
  - Decreased cultivation of coffee in Yemen because of cultivation of qat cash crop.
  - The average daily amount to spend consumers purchase of Qat per day 170 million YR.
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- 3- Satellite images (Landsat TM).
- 4- Topographic maps scale 1:50000.