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Remote Sensing

in Agriculture

Term Paper

to

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CRP 514 Geographic Information System

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May 2012

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1.0 Introduction

Land evaluation is an effective approach to measure the suitability of lands for Agricultural utilization. The availability of fertile lands is limited in Saudi Arabia due to the shortage of rainwater and underground water. Agricultural areas should be protected and considered as reservations. Land evaluation is of great importance in guiding decisions on land uses for the sake of their potential for usage and also for the sake of conserving natural resources for future generations. Remote sensing is one of reliable and effective method used for land evaluation and potential for agricultural utilization. Remotely sensed image can be used to observe the colors of leaves or the overall appearances of plants which aid in the determination of the plant's condition and further for assessing land fertility. According to (Nowatzki et al. 2004), "Remotely sensed images can be used to identify nutrient deficiencies, diseases, water deficiency or surplus, weed infestations, insect damage, hail damage, wind damage, herbicide damage, and plant populations".

2.0 Objective

This objective of this term paper is:

- To study remote sensing technology used in agricultural, the process of analyzing the obtained data and its importance in planning.
- To assess current condition of Agricultural area in Eastern Province specifically Qatif city.
- To bring awareness to Qatif residence and municipal the loss of the natural agricultural resources in the city.

3.0 Methodology

The research uses remotely sensed imagery and Google earth's Historical Imagery feature to assess the effect of urban expansion in Qatif city on mainly the agricultural lands and touch basis on the problem of sea land filling.

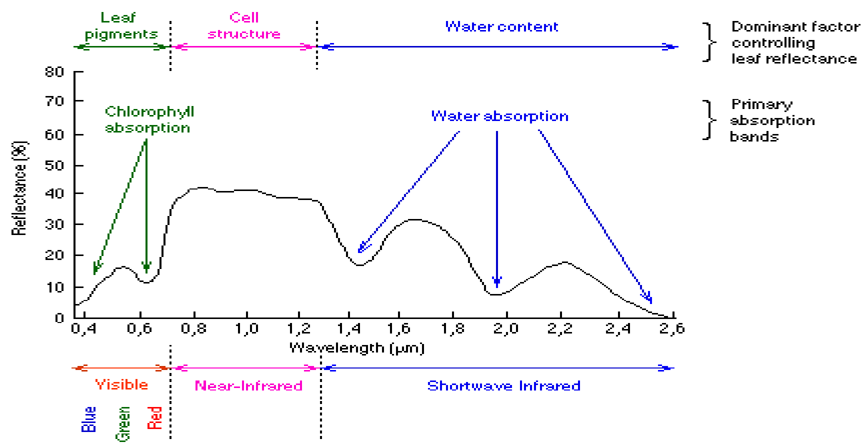
4.0 Remote sensing

It is the collection of data about an object from a distance such as satellite or airplane. Geographers use remote sensing to monitor or asses and measure phenomena found in the Earth's surface, and atmosphere. Remote sensors are the mechanical devices usually used by geographers to perform remote sensing of the environment. Similar to human eye, remote sensors spot the same visible wavelengths of light. Furthermore, energy from wavelengths that are undetectable to the human eye can be detected by remote sensors. The sensors can also observe the reflection and the radiation of energy from objects which enable geographers to obtain information about the nature of these objects.

4.1 Remote sensing in agriculture

Remote sensing technology is significant for agricultural producers. Satellites and aircraft images provide a means to assess agricultural land and crop conditions.

Since 1950s, large agricultural producers utilize this technology to assess their fields. Recently, this technology became easy to get to most agricultural producers (1). Plant's conditions can be assessed through the observation of the colors of leaves or the general look of plants. The remotely sensed image can be viewed, studied, and stored for future comparison. Chlorophyll is a green pigment found in almost all plants. Healthy vegetation appears green as the absorption in chlorophyll bands outside the green wavelengths. One portion of the light is absorbed, the other get reflected as green light scattered at the cellular boundaries to appear green both in reflection and transmission. The emerged multiple reflections, natural light create a non-polarized image. The higher the wavelengths the strong the reflection; which represent strong absorption in the leaf, as shown in Figure 1.



Typical spectral response characteristics of green vegetation (after Hoffer, 1978)

Figure 1 Spectral Signature

4.2 Active and Passive Remote Sensing

Several types of remote sensing technologies are available; **Active Remote Sensing** refers to the reflection of radiation and electromagnetic energy from manmade source such as Radar or Sonar Systems, which produce microwave radiation that reflect to a receiver. This system is not common in agricultural. **Passive Remote Sensing**, unlike active, refers to the reflection of radiation and electromagnetic energy from natural source such as the Sun. passive system is the most used system to for agricultural. Passive system senses the electromagnetic energy reflected from the plants. The sensors of this system can be mounted on either satellite or Aircraft.

4.3 Electromagnetic Energy and plant's spectral signature

In passive remote system, when sunlight approaches the plant, it will be reflected, absorbed or transmitted. What dictate the proportions of energy among these three are the intensity of the wavelength of the energy and the individual features of the plants such as the color of the plant's leaves and the way leaves are attached to the plants. Chlorophyll and the absorbed wave's energy, which represent the first proportion of sun electromagnetic energy, are what give the plant's leaves the green color. The second proportion of sun electromagnetic energy will be transmitted through the leaves and the third proportion will be reflected. The three electromagnetic waves proportions will be deducted by the remote sensors. The difference of the ratios of these proportions will give each plant type its unique spectral signature. More illustration can be seen in Figure 2

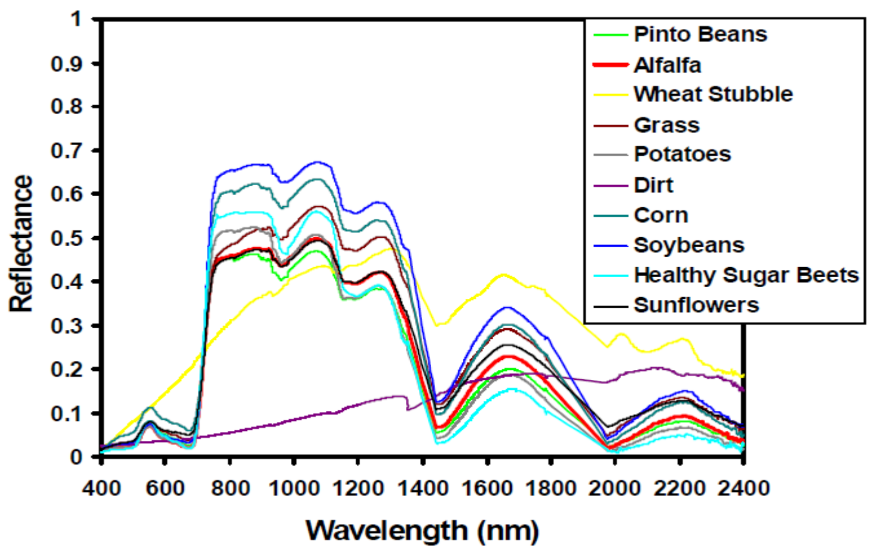


Figure 2 Spectral signatures of crops

4.4 Crop Health Assessment

One major advantage of remote sensing is the assessment of the crop health. Stressed plants, for example, can be identified. Figure 3 illustrates a comparison between healthy and stressed sugar beets.

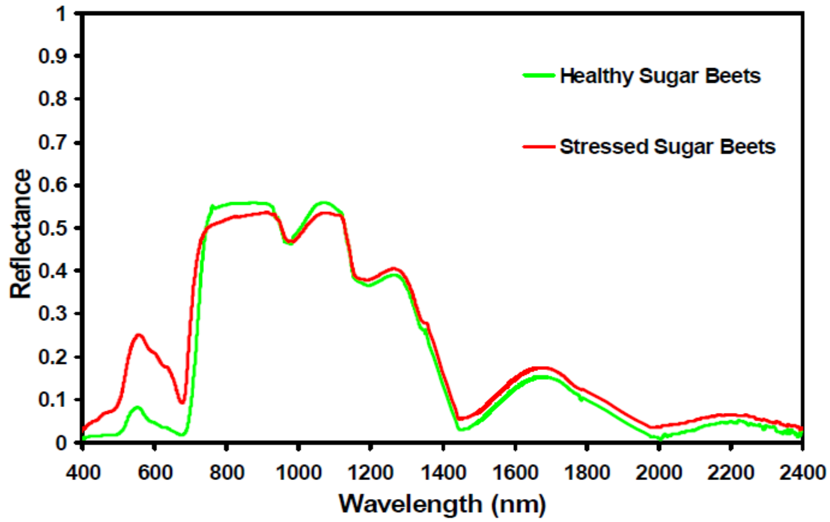


Figure 3 Spectral signatures of healthy and stressed sugar beets

The spectral signature of typical healthy sugar beets should be used as basis for the comparison. The stressed plants will show different reflectance level from those that are healthy. Vegetation index compares the reflectance level of the plants along different wavelength to better assess the plant's health condition.

4.5 The Electromagnetic Spectrum

Electromagnetic spectrum is the energy transmitted from the sun. Light or electromagnetic energy waves travel similar to water waves; wavelength is the distance between two subsequent waves' peaks. Electromagnetic spectrum range consists of all possible frequencies of electromagnetic radiation. Remote sensing for agricultural application cover small portion of the electromagnetic spectrum wide range. It extends from Visible Region which starts at around 400 nm to Infrared Region that ends at around 25 µm. Figure 4 illustrate the range of the electromagnetic spectrum. The green color wavelength should locate somewhere around 500 nm.

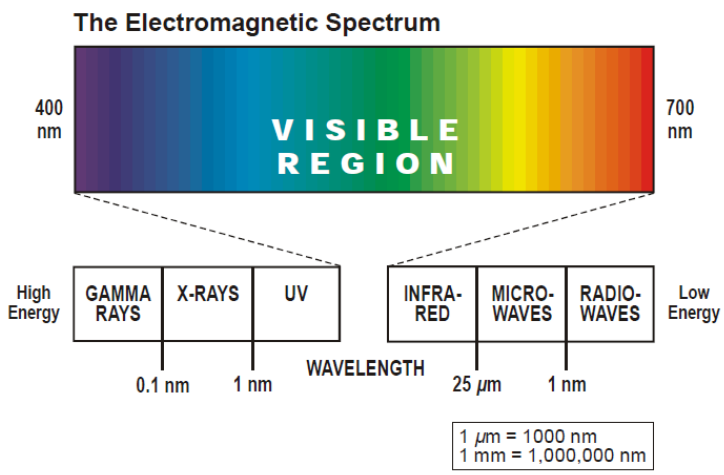


Figure 4 the Electromagnetic Spectrum

4.6 System Resolution

A wide view of earth's surface and features can be remotely sensed. Various techniques are available to analyze the collected data. The remotely sensed ground reflection can be utilized to assess the property of vegetation. Resolution is the intensity of details of an image. It is usually measured to the smallest object/details that can be captured. Extend on the other hand is more related to the width of coverage. Both resolution and extend are used to measure the quality of an image or the feature of an object. Several factors need to be considered to assess the capability of remote sensing for certain application such as vegetation. The remote sensing system includes four resolutions: Spatial resolution, Spectral resolution, Radiometric resolution, and Temporal resolution.

2.6.1. Spatial resolution

It refers to the smallest object that can be detected on the ground. In photograph, pixel is the smallest data crystal. Spatial is the reflection of the photographic pixels on the ground. The higher resolution of an image, the smaller the area covered in one pixel.

2.6.2. Spectral resolution

The smallest portion of the electromagnetic spectrum is called band. The higher the spectrum resolution, the shorter the width of the wave length. Spectral signature can be used to identify the different material and minerals. If enough detail of wave length interval are available that cover the spectral range, a more sophisticate type such as multispectral or hyperspectral used to measure the energy as they are more sensitive. Crop condition can be assessed using these technologies.

2.6.3. Radiometric resolution

Refer to the ability of sensing the miner difference in the reflection level. More precise picture can be obtained with higher radiometric resolution as it can detect precisely the small difference of the reflection level and electromagnetic spectrum.

2.6.4. Temporal resolution

It refers to the frequency of area coverage. Normal satellite provides data every time orbiting over an area, while Geo-satellite has the ability to continuously provide remote sensing. Airplane remote sensing can be used for higher frequency sensing which is more expensive that satellite imagery. One advantage that flight timing can take the weather condition in consideration.

4.7 Agricultural Remote Sensing Process

The process of agricultural remote sensing involves an interaction between Sun's electromagnetic radiation and the targets of interest, the plants. Figure 5 illustrates the seven steps required for agricultural assessment. The illustration is applicable to both imaging and non-imaging (Electromagnetic) sensing systems.

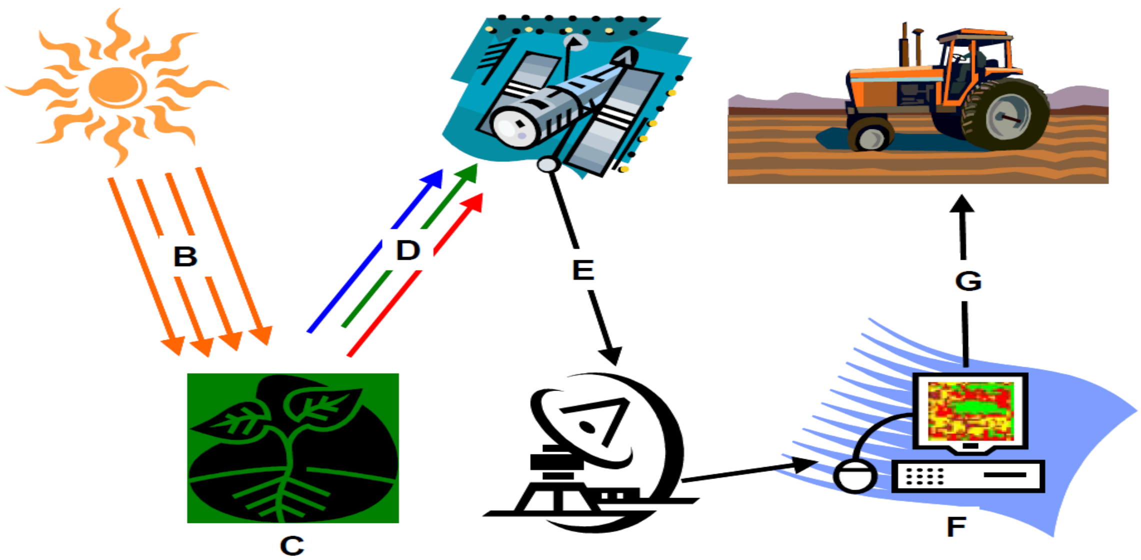


Figure 5 The remote sensing process

A. **Illumination (Sun)** - the first step for remote sensing is to have an energy source that illuminates and provides electromagnetic energy to the target of interest, in agricultural, the sun is the source of illumination.
B. **Radiation** - as the electromagnetic waves travels from the sun, it will be interacted with the atmosphere as travel to the target and back to the sensors.
C. **The Target (Plants)** - after the electromagnetic wave makes its way to the plants, the intensity of the interaction with plants will depend on the characteristics of the target plants and the quality of the arrived radiation. A proportion of the electromagnetic wave will transmit through the leaves.

D. **Sensors** - The sensor that can be mounted to satellite or aircraft detects the reflected electromagnetic waves. They collect and record the reflected electromagnetic radiation after traveling through the atmosphere.

E. **Processing Station** - after the electromagnetic energy recorded by the sensor, the collected data will be transmitted to the ground, to a receiving and processing station.

F. **Analysis -** the received data about the plants will be processed and interpreted into useful information such as images, numbers and graphs the target.

G. **Implementation -** the final step of the remote sensing process is the assessment of the vegetation and, also problem solving and field correction incorporating the received and analyzed information.

The whole of these seven steps are essential for remote sensing, the collected data and imagery should be stored for future comparison and assessment.

5.0 Historical Imagery in Google Earth

It is a feature that Google Earth provides to travel back in time and view the various places. The feature gives us the ability to see the require information for the analysis of past records of various places and to see how places have changed over time.

Currently, the important places in US can be traced back to as far as 1950, and UK to around 2000. Unfortunately, for Saud Arabia the tool provides imagery back to 2004. This interesting tool enables the comparisons, and could provide valuable information, that can assist in the studying of urban growth and it effect to the surrounding agricultural lands. For example, below are “before and after” shots for some location of what used to be called Qatif oasis:

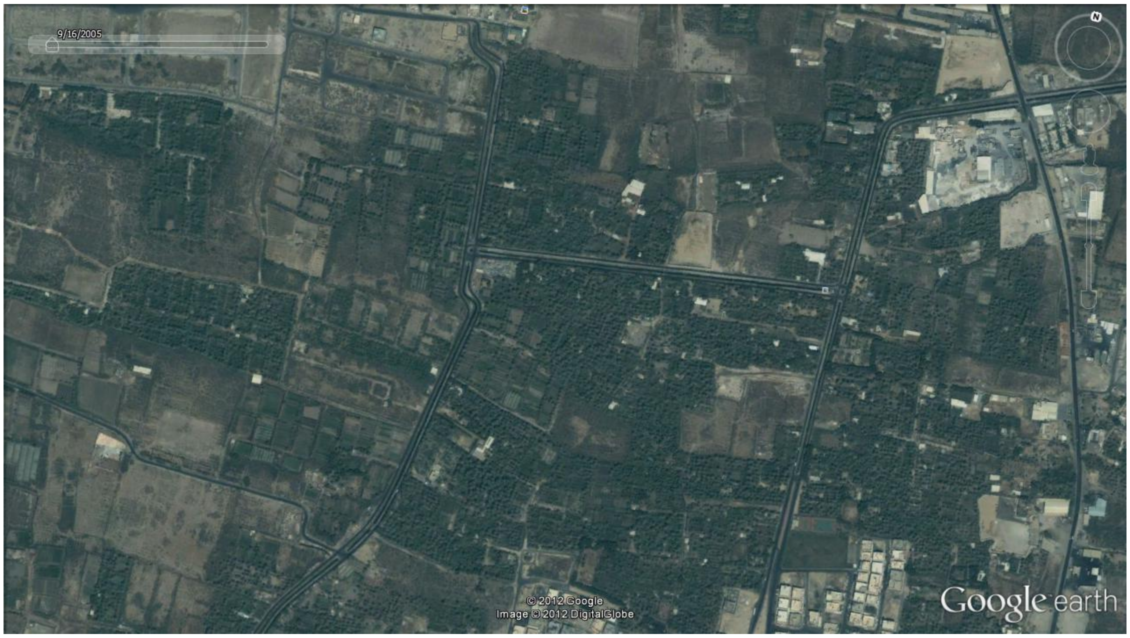


Figure 6 Some of Qatif Farms – Before Urban Expansion (2005)

Figure 7 Some of Qatif Farms – After Urban Expansion (2011)

Figure 8 Qatif Shoreline North Tarout Bay – Before Urban Expansion (2004)

Figure 9 Qatif Shoreline North Tarout Bay – After Urban Expansion and Sea Landfilling (2011)

Change is obviously, a dramatic shrinking of agricultural lands due to the unplanned urban expansion. The impact of this expansion is irreversible. Satellite images highlights the urban expansion in Qatif, the before, satellite images were taken back only as far as 2004. Agricultural lands were a lot healthier than what they are right now; in six years, a tremendous damage has been occurred, and if this expansion kept unplanned, Agricultural lands will be vanished.

6.0 Coastal Land Filling

It is the process of filling the sea to prepare it for urban expansion; the process in much of the cases ends up damaging the marine biology. A report on coastal land filling (UNEP, 1997) has shown Saudi Arabia along with some other Arab countries, Jordan and Egypt, had performed physical alteration and destruction of habitats on the coastline for the purpose of urbanization and coastal development. Filling had caused significant destruction of marine habitats and marine environment. Mangroves, sea grass and algae are essential for fishery in the Arab Gulf. Filling does not just damage the covered areas but also the surrounding areas due to the increase of the turbidity in the water.

7.0 Recommendation

- Agricultural researchers should utilize Google earth historical imagery to study the condition of the vegetation and to observe how fields have changed over time.
- People need to realize the importance of reserving the natural resources of agricultural beauty for the future generation.

- Municipals, Ministry of Economy and Planning and other governmental agencies should put restrictions on urban development and expansion to protect the agricultural area.
- Urban expansion should be planned through the municipals and planning ministry.
- City zoning should be clear to real state offices and legislation should govern the trading.

8.0 Conclusion

Agricultural areas are limited in Saudi Arabia. This natural resource should be protected and preserved for the future generation. Remote sensing is one of reliable and effective method used for agricultural lands evaluation. It can be used to observe the colors of leaves and appearances of plants which aid in the determination of the plant’s condition, crop health and, also can be used further to assess land fertility. Urban growth has negative effect on the surrounding agricultural lands. Citizens and concerned government agencies need to realize the importance of reserving the natural resources of agricultural. Google Earth Historical Imagery is a tool that researchers should utilize to study the condition of the vegetation and to observe how fields have changed over time.

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