THE USE OF REMOTE SENSING & GEOGRAPHICAL INFORMATION SYSTEMS TO IDENTIFY VEGETATION: THE CASE OF DHOFAR GOVERNORATE (OMAN)

Dr. AL-AWADHI, T.[1], AL-SHUKILI, A.[2] & AL-AMRI Q.[3]

Geography Department, Sultan Qaboos University, Oman.
alawadhi@squ.edu.om[1], ahaal-88@maktoob.com[2] & Al-amri10@hotmail.com[3]

Abstract - Extracting and identifying vegetation from satellite images is a major topic in Remote Sensing and GIS. Several techniques have been developed by scientists worldwide. This study aims to evaluate the approaches to the extraction of vegetation from satellite images and to examine each approach within the GIS environment. Three different approaches were used: the first is Normalized Difference Vegetation Index (NDVI), the second is Supervised Classification and the third is Unsupervised Classification. These three methods were examined using two Landsat scenes for Dhofar Governorate which lies in the Southern part of Oman. The two Landsat scenes were acquired on 4th May 2001. The preliminary results show that there are variations in the total areas of vegetation between the three approaches. For example, the total vegetation area using NDVI approach is just above 900 Km^2, but it increases to more than 1700 Km^2 when using upervised classification, and then it increases again to more than 3300 Km^2 when using the unsupervised classification approach.

Keywords: Vegetation, RS, GIS, Dhofar, Oman.

1. INTRODUCTION

Remote sensing and GIS techniques play an active role in solving many human and natural problems. These techniques have several advantages which lead to the understanding of these issues, their causes and how to overcome them. Remote sensing is defined as the science of obtaining information from a distance without any actual contact with the object being observed. Its idea is based on the fact that each object has it own spectral signature that facilitates its clear distinction from another object, while GIS has the ability to link spatial data and non-spatial data to support better decision-making. With the advanced technology and the availability of data these two techniques are working closely as one integrated system for solving issues.

Change detection method is one of the main applications of Remote Sensing (RS) and Geographical Information Systems (GIS) techniques. It can be applied to several applications such as urban growth, land use change, vegetation change etc. Several change detection methods have been developed worldwide to extract information from remote-sensing imageries such as Post Classification Comparison using supervised classification or unsupervised classification, Normalized Difference Vegetation Index (NDVI), Change vector analysis (CVA), visual interpretation and manual digitizing and Differencing and Rationing Image These techniques are useful tools to improve the decision processes in many applications which then can be utilised by planners, engineers, managers etc.

This study aims to examine the final results of vegetation extraction by applying three approaches: (1) Normalized Difference Vegetation Index (NDVI), (2) Supervised Classification and (3) Unsupervised Classification. Thus, the GIS and RS cover several areas in vegetation studies such as:

- The management of an integrated database for grazing
- The tracking and monitoring of vegetation change over time
- The identification of vegetation diseases and vegetation classes
- The determination of vegetation areas affected by urban sprawl

Several studies have addressed the use of GIS and remote sensing in the management and control of vegetation worldwide. Singh A. (1989), for example, reviewed digital change detection techniques that use remotely sensed data. Coppin, P. & Bauer, M. (1996), discussed the use of digital change detection in forest ecosystems with remote sensing imagery. Anderson, et al. (1976), reviewed some land use and land cover classification systems which can be used in remotely sensed data. Mahmoodzadeh, H. (2007), used remotely sensed data to monitor green space destruction in Tabriz, Iran. Adia S. & Rabiu, A. (2008), applied remote sensing and GIS in how to identify changes that may occur in the green areas. Elias, M. (2005), focused on how to use GIS and remote sensing in the management and survey of natural resources including natural grassland. Collins, J. B., and Woodcock, C. E., (1996), used several linear change detection techniques for mapping forest mortality using multitemporal Landsat TM data. Rogan J., et al. (2003), tested remote sensing to monitor Land-Cover Change with classification trees using landsat TM and ancillary data. Seto, K. C. et al. (2002), used remote sensing techniques to monitor land-use change in the Pearl River Delta. In the Arab region, there were several studies in this field such as the one conducted by Al-Azzawi, and Al-Hamamo, (2007), to estimate the size and density of timber forest in the city of Mosul, Iraq. Hremat et. al. (1999), also studied the change in the vegetation of the Jordan River basin. Al-Jasser (2009), used these techniques to track the effect of urban expansion on agricultural land in the cities of Buraidah and Forums in Saudi Arabia between 1986 to 2007. Sadoun & Al Rawashdeh (2009) also applied GIS and remote sensing techniques to manage land use on the northern part of the Jordan with more focus on the vegetation use.

This paper is divided into six sections: the abstract which outlines the work, the introductory section which briefly presents the use of GIS and remote sensing in the field of vegetation, two sections about the methodology used in this research paper and the final results. The last part summarizes the paper.

2. STUDY AREA

The study area is part of Dhofar Governorate which is the largest region in Oman covering almost 100,000 km^2 and having a population of 249401 according to the 2010 census. Dhofar Governorate is located in the southern part of the Sultanate of Oman bordered by the Republic of Yemen from the south, the Kingdom of Saudi Arabia from the west and the Arabian Sea from the east. It is divided into 10 zones known locally the Willayats (states). The largest town in Dhofar is Salalah. In the past, Dhofar was the main source of frankincense in the East, but now mostly used locally. Dhofar is divided into three geographic regions as shown in Figure 1: (i) the coastal plain region, (ii) the mountainous region and (iii) the desert region.

The total natural pasture in Oman is approximately 26,067 hectares according to Oman Pasture Database Project which was conducted by Ministry of Agriculture in 2008. 23.8% of these areas are available in Dhofar Governorate. Natural pasture in Dhofar consists of natural grass, which mainly grows in the summer season and natural trees. Thus, to complete this work a small part of Dhofar Governorate was used, which is covered by two scenes as shown in Figure 1.

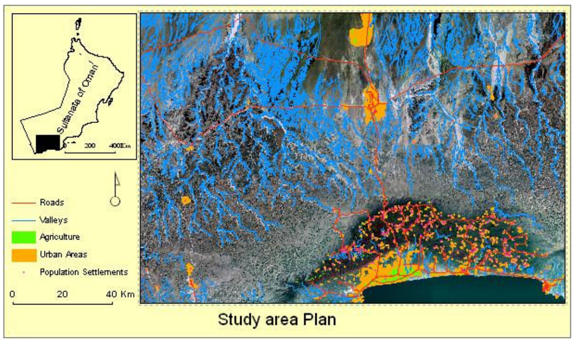

Figure 1: study area plan

3. RESEARCH METHODOLOGY

The research method is based on the integration of GIS and remote sensing. Three Remote sensing techniques were used to identify and extract vegetation. The image preparation and vegetation extraction were completed in ER Mapper, while the final results were managed using ArcGIS (ArcInfo level) version 10.

Two Landsat scenes for Dhofar region were used to implement the methodologies. In order to use these two scenes, several steps were followed to prepare for an accurate extraction and detection. These vital steps are: image registration, image enhancement and image mosaic as discussed by Macleod R. and Congalton R., (1998) and Mahmoodzadeh, H. (2007). These scenes were acquired on 4th August 2001. These scenes were corrected and geo-referenced to WGS 1984 zone 39 using a road network layer which was prepared for Oman 2003 censes. The accuracy of image registration was assessed by using Root-Mean-Square (RMS). The RMS error for Landsat images 0.5 pixels is almost acceptable as illustrated by Yuan D. and Elvidge C. (1998). Then, the two scenes were mosaiced to have one complete image. The image was then enhanced to improve the quality and clarity of the image. The below chart describe the whole methodological process.

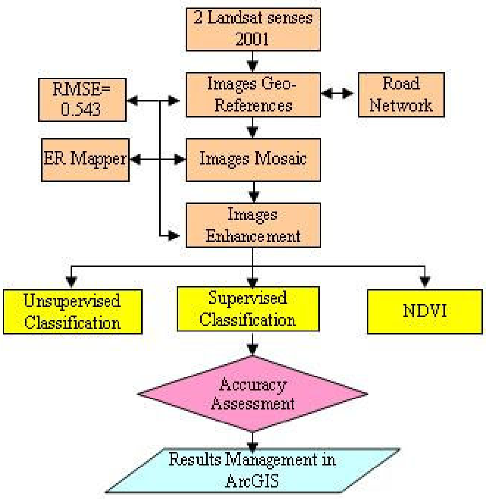

Figure 2: Methodology flowchart

Figure 3: The two Landsat scenes after mosaicing

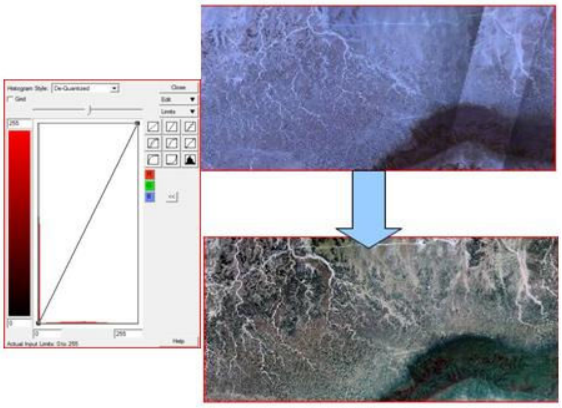

Figure 4: the Enhancement processes for the two Landsat scenes

Vegetation has a unique spectrum signature that is different from other types of land cover classes. The highest vegetation reflection is in the green Zone. In the near infrared (NIR), the reflection is much higher in the visible band because of the cellular structure of the leaves. Therefore, vegetation can be determined by the high NIR.

In this research, three different approaches have been implemented to extract the vegetation using ER Mapper Remote Sensing Software. These approaches are: (1) Normalized Different Vegetation (INDV), (2) Supervised Classification and (3) Unsupervised Classification Vegetation. The NDVI is strongly correlated to the green leaf biomass (Tucker, 1979). The NDVI method is calculated by = $\frac{b4-b3}{b4+b3}$. The symbols b4 is near infrared and b3 is red which refer to Landsat band 4 to band 7. The following figure shows that the vegetation appears in red colour after infrared and near-infrared waves were used, which represents the fourth band of Landsat image. To obtain this form, only band 2, 3 and 4 were employed.

Figure 5: Vegetation in red colour as a result of using band 4, which represents the NIR

The other two approaches are based on Supervised and Unsupervised Classifications which are part of post-classification comparison method or direct classification method. The supervised classification is based on the user definition. The RS software determines the spectral signature of the pixels that meet the user define, and uses this information to assign each pixel with a new value as discussed by Congalton (1991) and Almutairi and Warner (2010). For this work 25 spectral classes were used to get better decisions as shown in Figure 6.

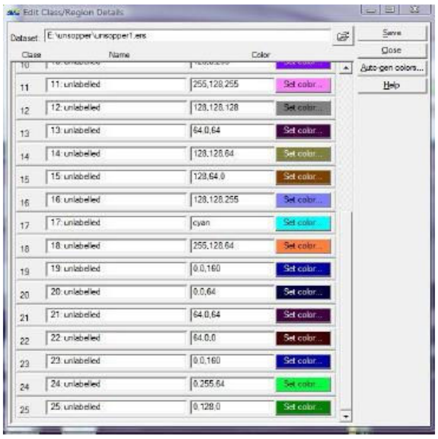

Figure 6: Spectral classes in ER Mapper software

The third approach is unsupervised classification. This approach is based on the natural groupings of the spectral properties of the pixels which are usually selected by the RS software without any influence from the users. For this work, maximum-likelihood was employed. 50 samples were selected to represent the pasture areas and plants. These samples are called Veg as shown in Figure 7. The purpose of this quite big number of samples is to gather the largest possible number of spectral radiation of all types of plants in the study area. The samples were distributed systematically to cover most of the study area as illustrated in Figure 7.

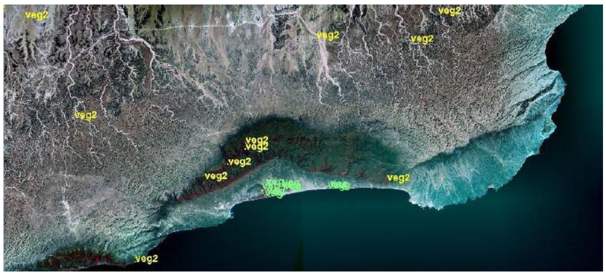

Figure 7: the distribution of systematic simples in the Landsat image

Finally, the results were converted to vector data format to be able to manage it in the GIS environment. GIS environments were used to distinguish between natural vegetation and agriculture area and also to mange the final output. Some map overlay operations available in ArcGIS software were used to examine the final results. Other techniques such as visual interpretation methods such as shape and texture as well as experience were used.

4. RESULTS AND DISCUSSION

The final results show that there is massive fluctuation in the vegetation extraction using the three different approaches as summarized in Table 1. The highest vegetation extraction areas were identified by using supervised classification approaches, while the lowest were shown by using NDVI approach. For example, there was more than 350% increased in the total vegetation extraction by using supervised classification approach than NDVI approach.

Table 1: The total vegetation areas of each approach and the last three columns represent the comparison results between the three approaches

Approaches	Km^2	%	SC %	UC %	NDVI %
Unsupervised Classification (UC)	3298.41	8.76	100	52.05	27
Supervised Classification (SC)	1716.66	4.56	-192	100	52.9
NDVI	906.20	2.41	-363	-189.2	100
Study area	37655.1	100			

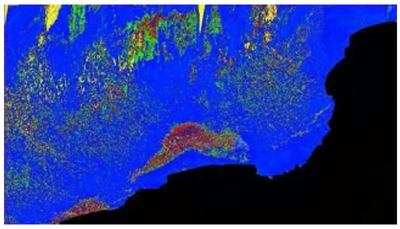

Figure 8: Unsupervised Classification Results

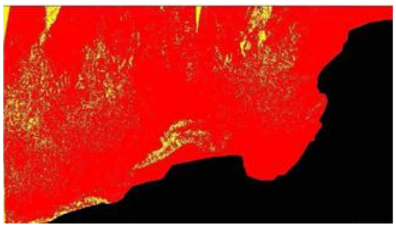

Figure 9: Supervised Classification Results

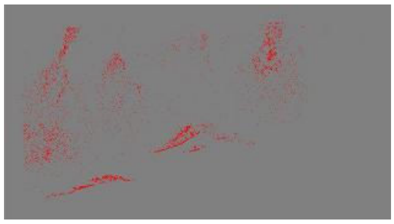

Figure 10: NDVI Results

Figure 8, 9, and 10 show the final output map for each approaches. The visual comparison of the final output showed that, there was inconstancy of final output as presented in Figure 11. The unsupervised classification results (blue) do not present vegetations well, while the supervised classification results (green), the vegetations appear very intense and unrealistic, but the NDVI results (Red) match the reality. NDVI results represent a compromise between supervised and unsupervised results.

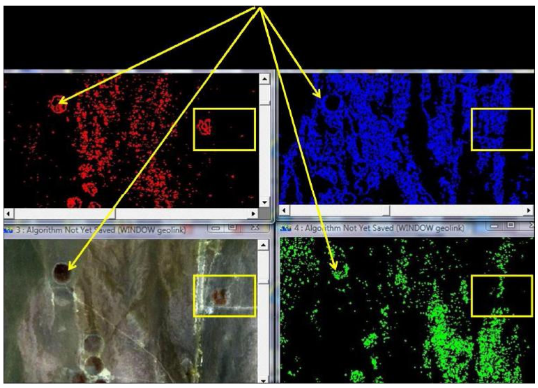

Figure 11: The ability to show the vegetation between the three approaches

5. CONCLUSION

Remote sensing techniques and GIS environment have increasingly been acknowledged as the most successful techniques for environment conservation and land resource management. Recently, more precise data have become available widely in digital form. These digital data can assist to protect our environment.

This paper discussed three different approaches to extract vegetation using remote sensing and GIS techniques. The final results showed large variations of results in using these three approaches. The results did not show any consistency in the final results. The difference came from different sources. It completely depends on the image resolution and methodology adopted for extraction as well as user requirement on the supervised classification approach.

After the operations were conducted on the three approaches used in the extraction of vegetations, and after the vegetation area was calculated and compared with visual comparison of other data, the best approach to draw vegetation using satellite imageries is the NDVI approaches. This is because of the total vegetation areas from this NDVI approach is closer to reality as pointed out in visual comparisons. This method also depends on the degree of vegetation cover.

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