

Environmental degradation and its impact on tourism in Jazan, KSA using Remote Sensing and GIS

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ABSTRACT

This study investigates environmental degradation and its impact on ecotourism in Jazan, KSA, using remote sensing and GIS. The study aimed to employ remote sensing and GIS to study the state of the vegetation threatened by desertification in the Jazan region. Two Landsat satellite images (ETM) captured in May 1987 and May 2002 were acquired for the purpose of this study and were processed and analyzed using ERDAS Imagine V. 8.5. The final output maps have been produced using Arc GIS V.9.2. The results of the study indicated that the vegetation of Jazan was exposed to environmental degradation between 1987 and 2002, especially in the eastern highlands and mountain slopes. The area lost approximately 46 % of its total vegetation cover between 1987 and 2002, an average annual loss of 3 %. This information clearly reveals the deterioration and decline of the vegetation in 2002, a change that will inevitably contribute to the emergence of desertification and drought (Ignacio et al. 2010). In addition, the demographic growth and steady increase in population produce their own effects on the productivity of agricultural land and cause soil erosion and drying due to decreases in organic elements. All of these factors result in desertification and its associated negative effects on ecotourism in the Jazan region. In addition, this continuous loss of green spaces causes a decrease in the individual shares of green areas. Several strategies are recommended to deal with this problem.

Keywords: Environmental degradation, Ecotourism, Jazan, Remote Sensing, GIS.

1. Introduction

The problem of the degradation of vegetation and agricultural lands is one of the most important contemporary environmental challenges, as this leads to the deterioration of agricultural land and a decline in productivity. In the long term, desertification and drought may begin to affect the region concerned (Arab Organization for Agricultural Development, 2003), and these problems are the most important environmental issues that impede the plans and strategies for tourism development (TIRC, 2010). Moreover, climatic factors and human activities play key roles in the spread of desertification and drought (Shalaby and Tateishi, 2007). The multiple natural resources in Jazan form the basic sources of livelihood in this region (Jazan Emirate, 2010), and these resources suffer substantially due to tourism, economic development, and harsh environmental conditions (Ainong et al. 2006 & Aleksandra et al. 2011). Environmental degradation appears in the form of a decrease in vegetation cover (Davide and Dawa, 2009) and land degradation (Bocco et al. 2001 & Godert et al., 2001). Shrinking forests, pastures, and natural resources may cause a decrease in the biodiversity of the region and, thus, contribute to the spread of drought and desertification. Moreover, the high rate of population growth and the significant increase in the average

annual individual income level associated with the country's economic growth (Enrico et al. 2002) has increased the pressure on environmental resources to meet the increasing demand from all development sectors, including the urban, agricultural, industrial, energy, and transportation sectors (Ministry of Economy and Planning, 2010).

1.1 Problem statement

The problem of the degradation of vegetation is one of the most important environmental threats to the future of humanity because of its direct impact on human food resources and, thus, human health and the existing way of life. Jazan faces a significant problem: the decrease of vegetation and agricultural land, which contributes to desertification in the area of study. If this process continues at the current rate, it may well amplify the severity of the deterioration and cause a sharp decline in rangeland productivity, sand encroachment, and soil erosion.

2. Study area details

2.1 Geographical setting

The region of Jazan is located in the far southwestern part of Saudi Arabia near the Saudi/ Yemeni border between longitudes 42 ° and 43,8 ° East and latitudes 16,5 ° and 17 ° North (Figure 1).

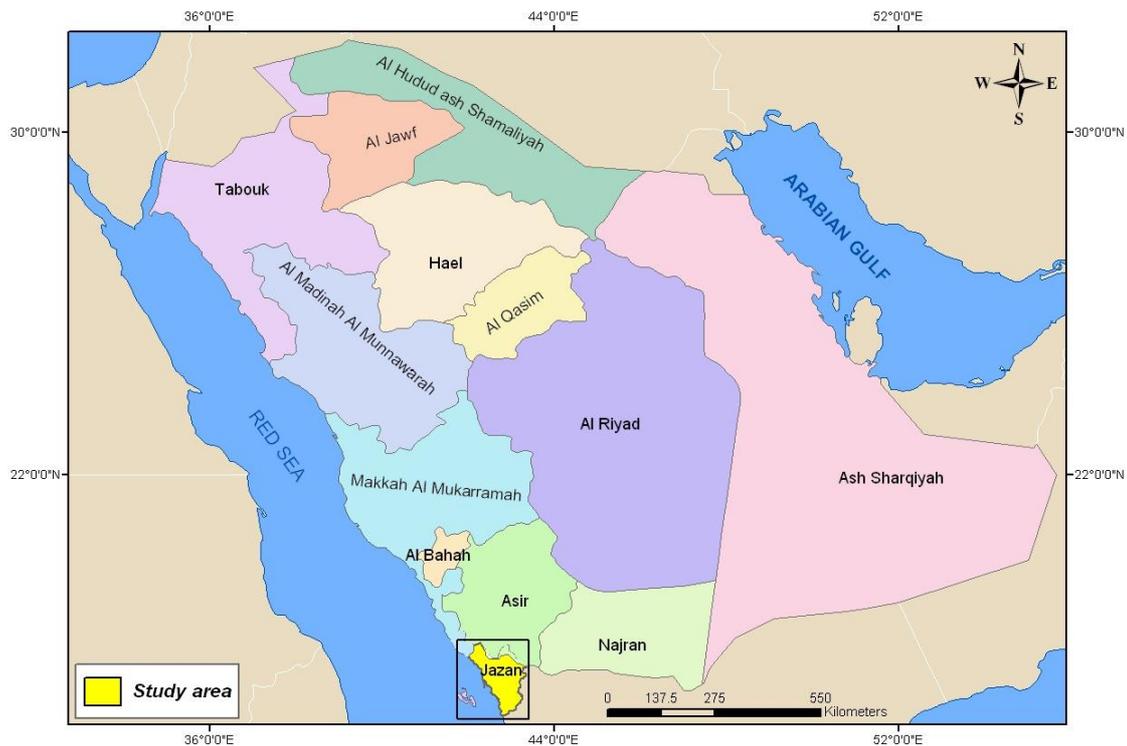


Figure 1: The location of study area

The total area of Jazan is 13,500 km², and the region includes 13 counties (Figure 2), 29 districts, and nearly 4000 villages. The most important city is Jazan, the regional capital and the administrative center. According to the results of a 2004 census, the population of Jazan was 1,186,139, and Jazan includes approximately 5.2 % of the total population of the

kingdom. The average maximum temperature is 38.5° during the summer and 30° during the winter, whereas the average minimum temperature is 29° during the summer and 21° during

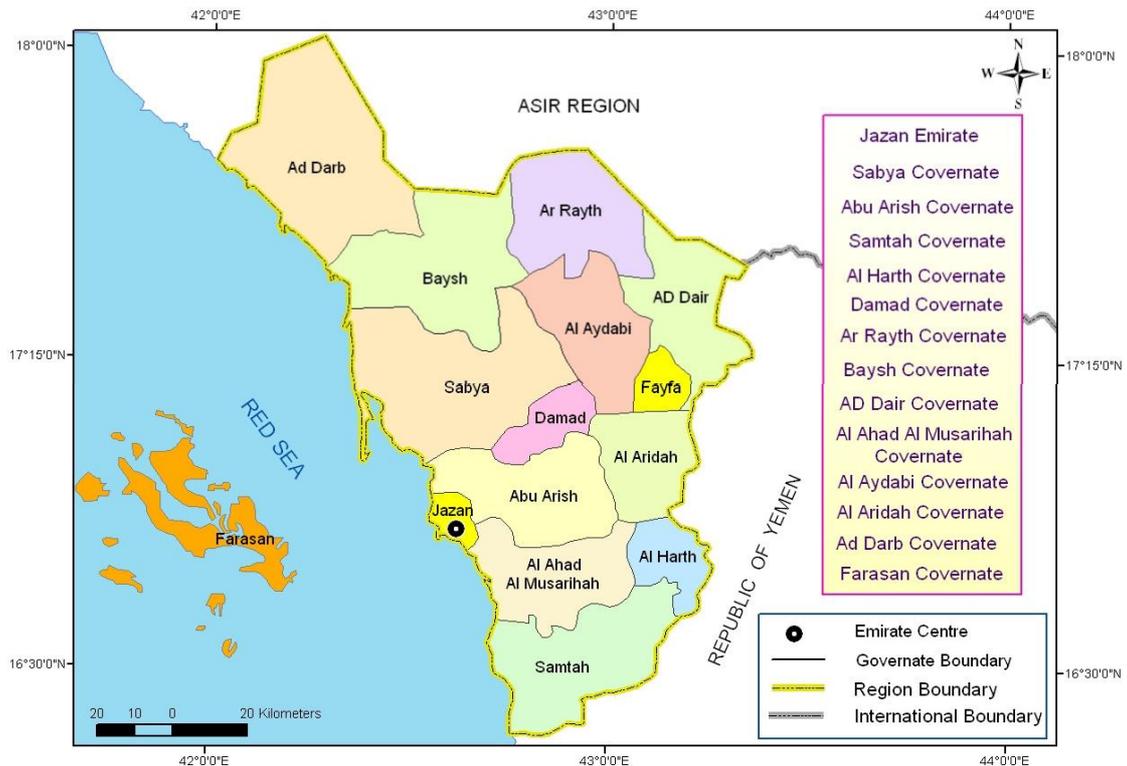


Figure 2: Jazan counties and districts

the winter. The average humidity during the past ten years was 68%: the lowest humidity was 6%, whereas the highest was 100%. The humidity is relatively high on the coast, and the prevailing winds in the region are western to southwesterly, with an average velocity of 12 km / h (Jazan Emirate, 2010).

Jazan is also the most important agricultural area in Saudi Arabia due to its high annual rainfall (90 mm). The area has different types of vegetation, which reflect the diversity of the natural landscape, and the region also has different types of soil. The most important soil type is "soft soil", which produces the finest agricultural land due to its ability to retain water and its high content of nutrients necessary for plant growth. The Jazan region is the most important tourist area in Saudi Arabia due to its varied topography and contrasting terrain and includes mud coasts, sandy beaches, beautiful islands, plains, natural forests, valleys and high mountains. In addition, there are springs, waterfalls and natural levees, and Jazan Dam is the most important tourist attraction in the region. The region also includes more than 100 forests of different sizes and a variety of trees (TIRC, 2010). The total area of land suitable for cultivation in Jazan is more than 240,000 hectares, and this area is sufficient to meet the needs of the kingdom. The region has approximately 3200 farms irrigated by water wells, including 2000 fruit farms and 1200 vegetable farms; fodder and other crops are also produced (Jazan Emirate, 2010).

2.2 Topography of the area

Jazan has a variety of topographic zones, with coastal areas that extend from north to south, 100 m above sea level. The region is also characterized by a high incidence of swamps and

salt marshes. The Tohama region is known as the most fertile area in Jazan. The Highlands region extends parallel to the Red Sea at altitudes of 200 to 300 m above sea level. The Sarwat mountains are located in the eastern part of Jazan: they are steep and rocky and rise more than 1800 m above sea level (Figure 3). Among the most prominent mountain peaks in the region are Fifa (1814 m above sea level), El-Hasher (with a height of 2307 m), and Harfan (2419 m in height). In addition, Jazan is characterized by a long Red Sea coastline from the El-Darb governorate in the north to the Samtah governorate in the south on the Saudi-Yemeni border.

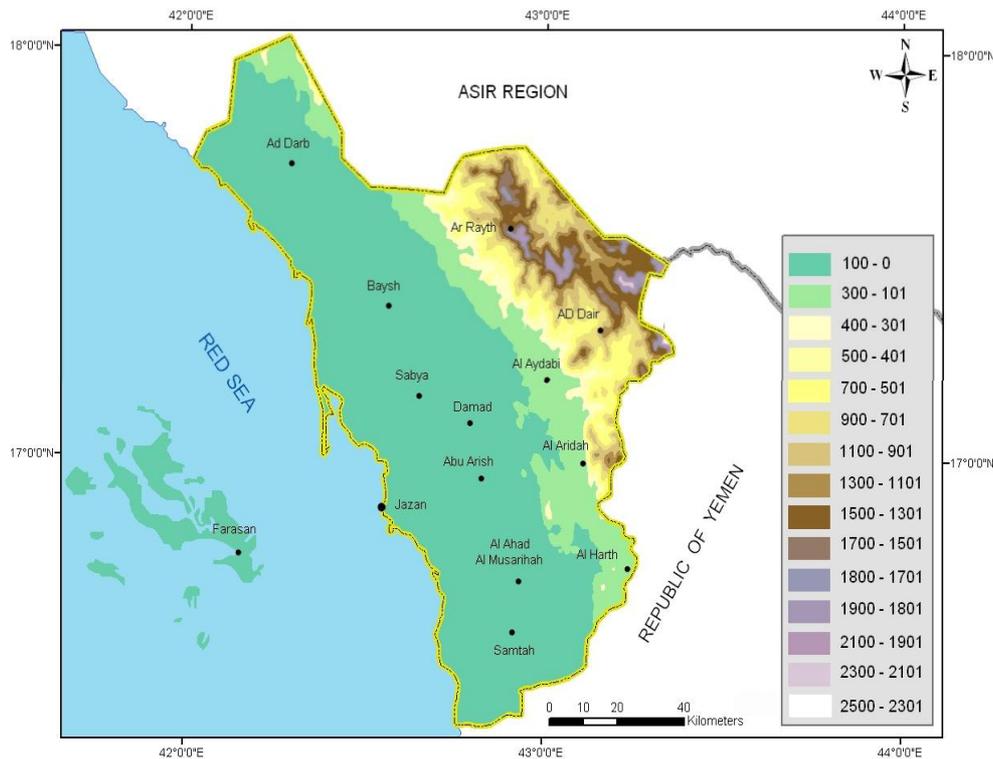


Figure 3: The topography of the study area

There are also many valleys in the region, and floods descend through these valleys from the mountains in the east toward the west until reaching the Red Sea. The most famous valleys and their tributaries are the Bish Valley (with a total length of approximately 200 km), the Jazan Valley (200 km in length), the Sebya Valley (250 km in length), the Lagab Valley (200 km in length), the Dammd Valley (160 km in length), the Atod Valley (200 km in length), and the Tashr Valley (250 km in length). The Wasaa' Valley is 150 km in length, the El-ser Valley is 150 km in length, and the Makr Valley is 15 km in length.

2.3 Vegetation and forests

The variety of vegetation in the area of Jazan is a result of the diverse terrain of mountains, plains and coasts. The coastline is dominated by mangroves. The mid-eastern slopes and plateaus of Jazan are famous for Ziziphus trees, El-Selm, El-Summer, Alorak, and certain pastoral plants. Juniper trees, Albizia lebbeck and El-Atm and other pastoral plants are found on both sides of the mountains (Jazan Emirate, 2010).

2.4 Importance of Jazan as a tourist area

Jazan is an important tourist area in Saudi Arabia due to its varied topography and contrasting terrain. The Jazan includes mud coasts, sandy beaches, beautiful islands, plains, natural forests, valleys and high mountains. Moreover, the area has abundant springs, waterfalls, and natural levees. Jazan Dam is the most important tourist attraction in the region. The region also includes more than 100 forests of different sizes and a variety of trees (TIRC, 2010). Jazan is the sixth-ranked tourist region in Saudi Arabia. If we exclude the religious tourism of Makkah and Madina, Jazan is the fourth-ranked tourist region; if ecotourism alone is considered, Jazan is the second-ranked tourist region after Asseer (TIRC, 2010).

3. Objectives of the study

The objectives of the study are as follows

1. To highlight the current status of vegetation cover in Jazan.
2. To map the degree of intensity and distribution of vegetation in Jazan.
3. To identify the effects of degradation and the decline of vegetation threatened by desertification.
4. To recommend a strategy for the sustainable development of Jazan.

3 Methodology

Two Landsat digital satellite images (Path [167] / Row [48]) captured in May 1987 and May 2002 were acquired for the purpose of this study. The image was radiometrically and geometrically rectified, calibrated for radiance using the inputs of image type, acquisition date and time, stretched using a linear 2%, and smoothly filtered. The histograms were then matched (Lillesand and Kiefer, 2007), and an atmospheric correction for the images was performed with ENVI 4.7 software (ITT, 2009). The Area of Interest (AOI) was identified on the satellite images. The desired area was then extracted from both images using the subset function. Image enhancement was implemented to facilitate the image analysis. To extract details of the vegetation from the images, a Normalized Difference Vegetation Index (NDVI) was used. The NDVI is a simple numerical indicator that can be used to assess whether the target being observed contains living green vegetation.

The NDVI is calculated as follows (Lillesand et al., 2008):

$$NDVI = (NIR - VIS) / (NIR + VIS).$$

In this equation, NIR denotes the near infrared layer, and VIS denotes the visible (red) layer. Change detection was then implemented to assess the change in the green cover between the two images and to identify areas suffering a decrease in vegetation cover. The data were processed and analyzed using ERDAS Imagine V. 8.5. Digital maps, tourist maps and topographic maps were collected from several different sources for use in the study. The final output maps have been produced using Arc GIS V. 9.2.

4. Results and discussion

4.1 NDVI

The NDVI results indicated that the highest value of greenness for the vegetation in 1987 is 0.6, whereas the highest value in 2002 was 0.3. This difference indicates the occurrence of deterioration and decline of the vegetation and the natural forest between 1987 and 2002 in the Jazan region. Figures 4 and 5 show the NDVI values for the area of study in 1987 and 2002, respectively. To verify these results, field surveys of several randomly selected sites in the area of study were conducted, revealing that the number of forests has decreased in the tourism area (the region of the mountains and the northeast highlands). This result means that deterioration, a decrease in vegetation, and a lack of natural forests have affected the region, emphasizing the urgent need for a strategy to preserve and protect the vegetation and forests from environmental degradation, especially because these areas are characterized as areas of significant tourism importance (TIRC, 2010).

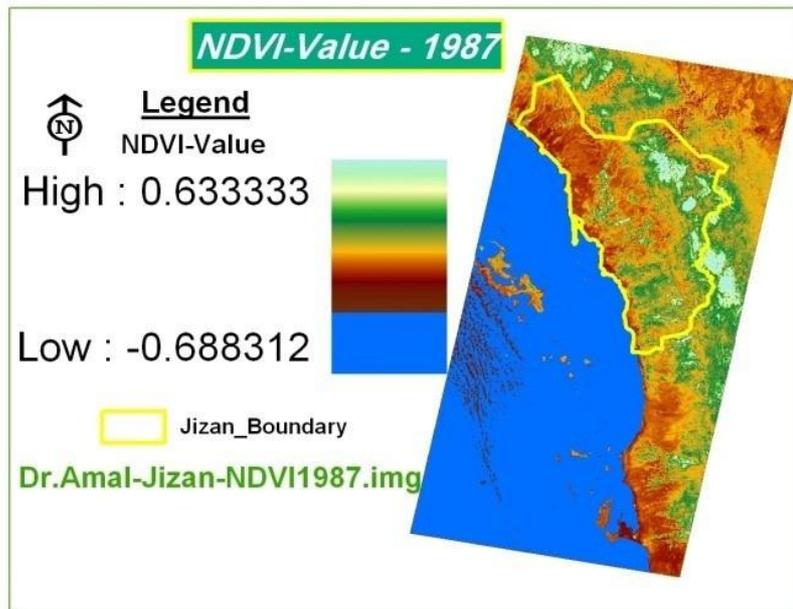


Figure 4: NDVI values for the area of study (1987)

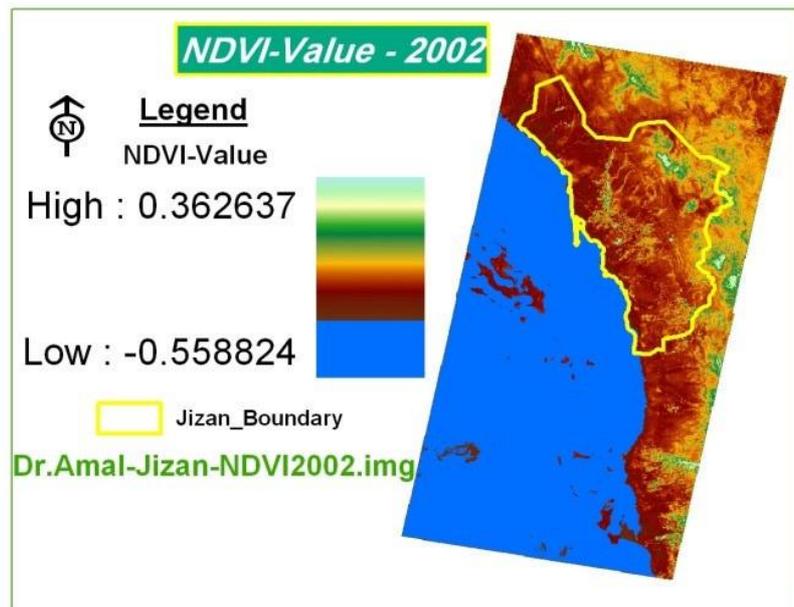


Figure 5: NDVI values for the area of study (2002)

4.2 Density and distribution of vegetation

The results of the analysis of satellite images for Jazan showed that the area is exposed to severe vegetation degradation, especially in the eastern highlands and mountain slopes, in the following areas: Viva Heights, Rit Governorate, Aldair Governorate, Samtah Governorate, Damd Governorate, Alaidabi Governorate, and ElAreda Governorate. Other regions also show reductions in vegetation cover but to varying degrees. Figure 6 shows that the intensity and distribution of the vegetation in 2002 differ significantly from the corresponding values in 1987. The total area of vegetation in 1987 was 1,080.387 km², and it decreased to 586.741 km² in 2002, indicating that the area lost approximately 46% of its total vegetation cover between 1987 and 2002, an average annual loss of 3%.

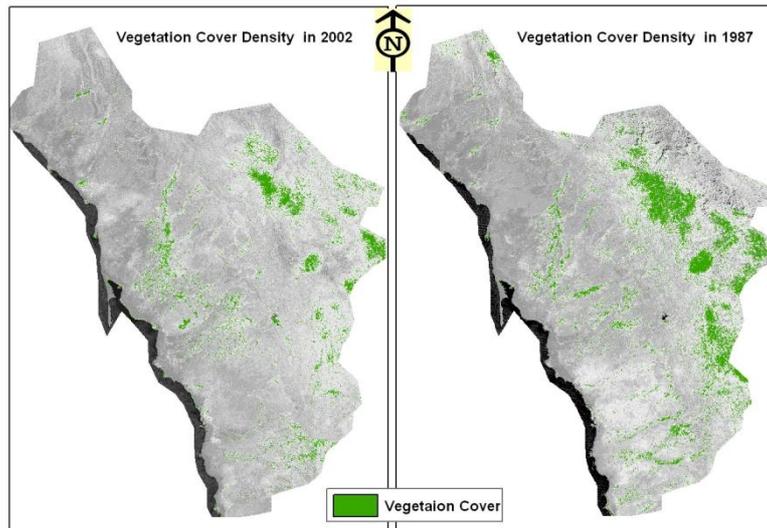


Figure 6: the intensity and distribution of vegetation in the area of study (1987, 2002)

The green cover represented approximately 8% of Jazan in 1987 and decreased to 4.3% in 2002. This difference clearly indicates the deterioration and decline of the vegetation from 1987 to 2002, a change that will inevitably contribute to the emergence of desertification and drought in the region (Figure 7).

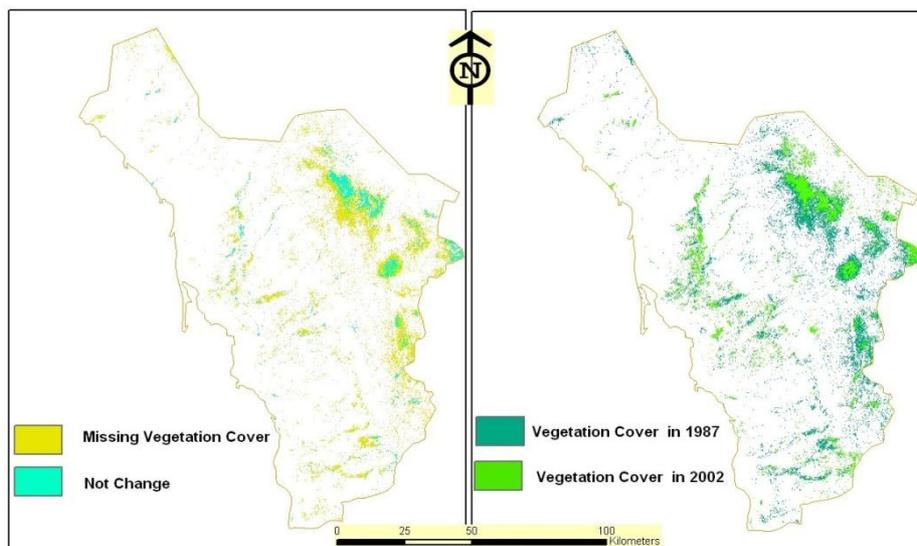


Figure 7: Degradation and decline of vegetation (1987, 2002)

It is necessary to identify the areas that suffer the greatest from the decline of vegetation and the lack of forests and to calculate the area of vegetation lost in these areas. Table 1 and Figure 8 show that most of the provinces lost between 17% and 74% of their vegetation cover.

Table 1: Degradation and decline of vegetation on areas of the region

Region	The area km ²	Area of vegetation in 1987 / km ²	Area of vegetation in 2002 / km ²	Area of vegetation loss from the year 1987-2002 m / km ²	% of loss between 1987 and 2002
Fifa	196	57	20	37	64.9
Alaidab	868	185	51	134	72.4
Ar Rayath	997	178	147	31	17.4
Al-Dayr	871	152	80	72	47.4
Samtah	1188	81	48	33	40.7
Besh	1365	41	39	2	4.9
AL-Aridah	653	117	31	86	73.5
Damd	324	28	19	9	32.1
Al Harath	379	42	15	27	64.3
Total	6841	881	450	431	48.9

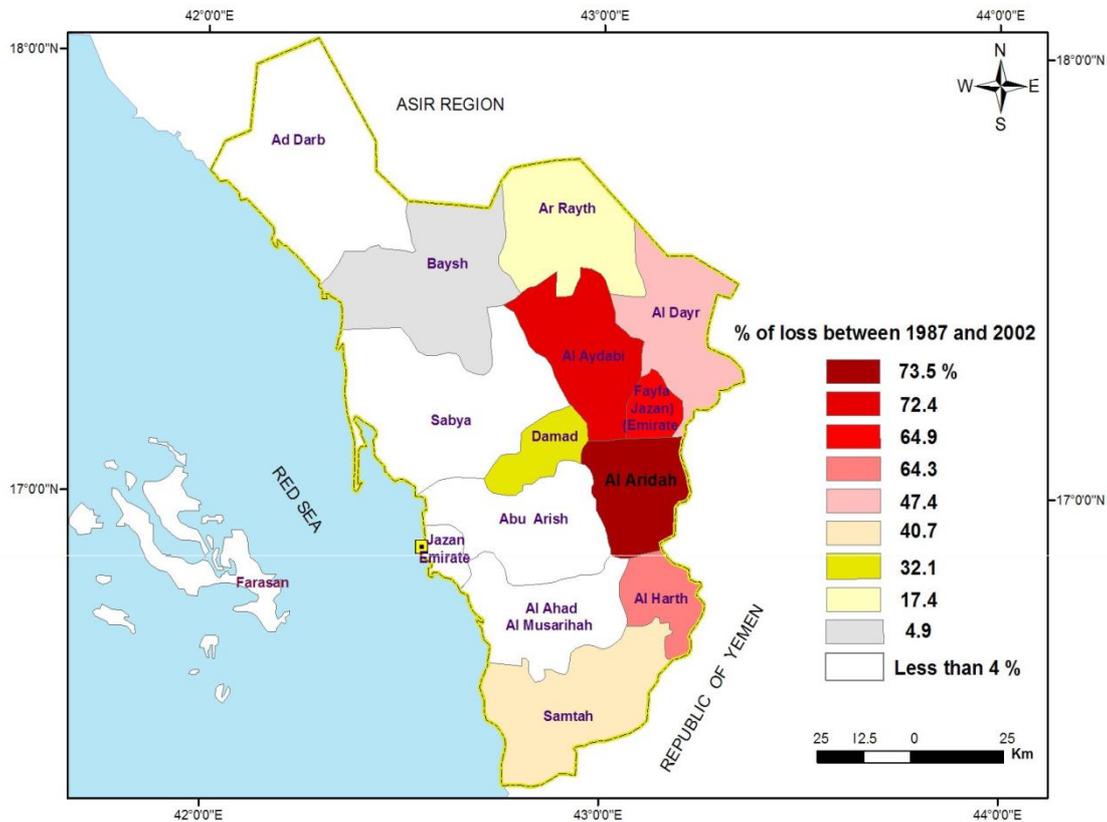


Figure 8: Percentage of vegetation loss in the area of study between 1987 and 2002

The provinces can be classified into the following three categories

- (a) High degradation: the provinces of AL-Aridah, Alaidabi, Fifa, and Al Harath.
- (b) Medium degradation: the provinces of Al-Dayr, Damd and Samtah.
- (c) Low degradation: the provinces of Ar Rayath and Besh.
- (d)

It is clear that the mountain areas and the slopes of the hills and plateaus (northeastern area) are the areas showing the most marked degradation. These areas are affected for several reasons, including erosion (Alatorre and Begueria 2009), overgrazing (Holechek, 1980), random firewood collection, and population growth.

4.3 The per capita share of green areas

The per capita share of the green areas in 1992 was approximately 1269 m², and it decreased to 495 m² in 2005 (Ministry of Economy and Planning, 2010), indicating that the per capita share of green areas decreased by 61%. This finding also emphasizes the loss of vegetation and the lack of forests in the Jazan region.

5. Conclusions

The most important findings of the study are the following

1. The mountainous region and the Eastern Highlands of Jazan, considered the most important areas for ecotourism, have suffered from vegetation degradation and a lack of forestation between 1987 and 2002.
2. The areas most affected are Fifa, Alaidabi, and EL-Areda, with detectable effects in the other regions. According to this information, a strategy is immediately required to reduce the degradation of the vegetation to protect and develop the vegetation cover threatened by desertification.
3. The study has shown that the total loss of vegetation between 1987 and 2002 has reached 493.64 km², indicating that the area lost approximately 46% of its total vegetation cover between 1987 and 2002, an average annual loss of 3%.
4. The study has shown that the proportion of vegetation in the area of Jazan was 8% in 1987 and 4.3% in 2002.
5. At the province level, the amounts of loss of vegetation, forests and natural pastures are 134 km² in the province of Alaidabi, 86 km² in the province of Al-Arda, 72 km² in the province of Al-Daer and 37 km² in the heights of Fifa.
6. The study has shown that the per capita share of the green areas in 1992 was approximately 1269 m², whereas the corresponding value was 495 m² in 2005. This result implies that the per capita share of green areas decreased by 61%, a finding that also emphasizes the loss of vegetation and the lack of forests in Jazan.
7. The study has shown that the highest value of the NDVI greenness vegetation index was 0.633 in 1987, whereas the highest value of the index decreased to 0.362 by 2002.
8. The decline of vegetation and the lack of natural forests have led to the emergence of desertification to varying degrees for reasons that include water erosion, landslides, urban encroachment and logging.
9. The study emphasized the importance of remote sensing and geographic information system technologies in assessing the change in vegetation and natural forests.

5.1 Recommendations

It is necessary to prepare an urgent strategy to address the environmental degradation found by the present study. The strategy should be based on the elements described below.

5.2 The protection of the soil from erosion

It has been observed that the decline in vegetation cover and the loss of forestation in Jazan occurred primarily in the mountainous areas, in the Eastern Highlands and in the basins of the high mountains. This decline is a result of soil erosion caused by water. When water contacts the soil surface, the impact causes the removal of the grain surface and shelves containing organic materials and alluvial mud and, thus, changes the soil texture. This erosion increases the surface slope from 8% to 15%; if the surface slope increases more than 10%, then a rainstorm will erode more than 25 tons of soil per hectare (Holechek, 1980). An FAO report (1983) indicated that a rainfall of 40-50 mm over gradient areas produces a flow of 50 tons of material per km² (FAO 1983). Soil erosion can be controlled with cover and barrier methods. The cover methods include mulching, cover crops and green manures, green manures, mixed cropping and inter-cropping, early planting, crop residues, agroforestry and minimum cultivation. The barrier methods include man-made terraces, contour plowing, contour barriers, natural terraces, and media lunas.

5.3 Guiding and controlling urban expansion

Urban expansion can be managed by preparing master plans that identify major sustainable uses of land based on the future population growth rates. The master plans should contain detailed maps that show buffer zones that will help in the conservation of forests and green areas to combat vegetation degradation. These measures will assist in the preservation of these sites and protect them from unplanned uses. In addition, the plans will direct urban development away from these green areas and forests for their preservation.

5.4 Establishment of pastoral and environmental reserves

Reservation is one of the most effective means to maintain natural pastures and development. This method has previously been implemented in areas of certain ancient kingdoms. This approach can be applied by preparing a set of procedures for the protection and development of vegetation and natural forests to stop environmental degradation in the areas that represent tourist attractions, especially the northeastern part of Jazan. The most important actions to be taken are the following

1. The preparation of laws and legislation for the protection and development of vegetation, forests, grasslands, natural grazing, and logging; preventing indiscriminate logging; and requiring that local authorities and official bodies be competent to monitor the application and implementation of such laws and legislation
2. Encouraging friendly ecotourism programs through the preparation and implementation of national policies to embody the principle of sustainable tourism
3. Building an environmental and tourist spatial database including all spatial data, such as land-use maps and satellite images, to be used by investors, decision makers and planners and in the formulation of plans for comprehensive development (Wang et al., 2010)

4. Monitoring the density of vegetation, forests and natural pastures on a regular basis in the area of study
5. Adopting the principle of sustainable environmental development in future development projects (Wild et al., 2010)
6. Involving citizens in the management (Japhet et al., 2006) and environmental protection of natural resources through the dissemination of the concept of environmental degradation and its negative consequences for the land and for the rights that are affected by degradation
7. Raising the environmental awareness among the population of the communities in the Jazan area through various media

6. References

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