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Full Length Research Paper

Effect of the influence of heat and moisture changes of desert area around the Euphrates on the recent dust storms in Iran using Landsat satellite images processing

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In the last few years, the dust storms which head from Iraq to Iran have become a bio-environmental problem for the residents in West and South West Iran. Apparently, the temperature changes in the study area trigger these dust storms, and in the meantime, the decrease in the water level of Euphrates river and its adjacent lakes are the main culprits that intensify the storms. This assumption was investigated using remote sensing. In order to study land surface temperature and water level changes in the Euphrates and the lakes in the region, the thermal band-band 6 and staking of bands 5, 4 and 3 of Landsat 5 were utilized, respectively. According to the Landsat covering the study area, it was divided into three parts that include Syria (Area 1), Boundary (Iraq and Syria, Area 2) and East of Bagdad deserts (Area 3). The results showed that the temperature changes in various periods in Areas 1, 2 and 3 increased from 43.5 to 50, 40.5 to 49 and 28 to 46, respectively. Comparing the satellite, images recorded from 2003 to 2009 showed a high decrease in water level in the Euphrates and the lakes in its vicinity. This study, moreover, showed that the influence of land surfaces temperature and moisture changes might create dust storms indicating that remote sensing is a useful tool in large scale and international level studies.

Key words: Variation of heat and moisture, dust storm, remote sensing, Euphrates, Iran.

INTRODUCTION

In last few years, dust storm has become a major problem in West and South West of Iran. Wind erosion in Syria desert, Iraq and Saudi Arabia created those dust storms and their movement towards Iran (Amanollahi et al., 2011d) caused severe community health and potential environmental concerns. Usually, air qualities have been measured by ground air quality monitoring stations (AQMS). AQMS entail a high budget for installation and maintenance, and interpolation of their data to other area with different geographical position is not more reliable. Regarding high variability of air quality, the reliability of the AQMS data is for few meters around their station. On the other hand, they have scarcely distribution, and as a result, they cannot investigate the movement pattern of pollution like suspended particulate matter (SPM) and land surface temperature (LST). In last decades, development and advances in remote sensing has opened a new corridor to studying particulate matter (PM) during the dust storms (Amanollahi et al., 2011a, b, c) and LST. Remote sensing has offered a new, cost-effective, efficient and accurate method to measure LST. One of the important sensors used in studying LST by many researchers is moderate resolution imaging spectroradiometer (MODIS) which is able to provide the LST with a power resolution of 1 km (Wang and Liang, 2009;

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Vancutsem et al., 2010; Imhoff et al., 2010). Landsat satellite is another satellite which has been utilized to study LST. However, in comparison with MODIS, Landsat satellite has a higher resolution and a high image accuracy of estimating LST. It has been shown that this satellite is very appropriate for such investigations (Vancutsem et al., 2010). Therefore, today researchers prefer to use Landsat 5 Thematic Mapper (TM) Satellite imaging which has a high resolution (120 m) for studying LST variation (Amiri et al., 2009; Li et al., 2009). The novel of this study was to determine one of the main factors which affect the creation of dust storms in vast area using remote sensing. The objective of this study was to investigate the changes in temperatures on the surface of the earth as well as the effect of it on the dust storms in deserts of Syria and Iraq as the origins of these storms.

MATERIALS AND METHODS

Study area

MODIS image of 1B called MODO21KM and three Landsat images were utilized to select the study area which is the origin of the dust storms. MODO21KM is used to identify dust as well as fire in vast area (Gupta et al., 2007; Amanollahi et al., 2011d). MODO21KM image on June 15, 2009 shows clearly the origins of the dust storms. These areas are the deserts near the Euphrates, in Syria and Iraq.

Image processing

Satellite images of Landsat TM5 on June 29, 2003 and June 29, 2009 for Syria desert, June 18, 1991 and May 20, 2007 for Boundary (Iraq and Syria, Area 2), and June 2, 2003 and June 28, 2009 for East of Bagdad deserts (Area 3) were used to compare the changes in soil surface temperatures. Images were rectified to the Universal Transverse Mercator (UTM) projection system (datum WGS84 zone 37, 38) and were geo-referenced based on the map (1:250000) (Sahebjalal and Heidari, 2011) that covered the lake near the Euphrates river from Syria to Iraq using 50 points ground control points. RMSE were less than one pixel for all bands. To preserve the brightness values of the pixels, the nearest neighbor resampling algorithm were utilized. The digital number of each pixel was converted to LST factor. For classification of heat in pixels, the supervised classification method with a minimum distance algorithm on the band 6 of the images were used. In order to investigate the lake shore changes, three bands of images consisting of bands 5, 4 and 3 were combined (Li et al., 2009).

Retrieval LST from Landsat TM

In this study, in order to convert digital numbers (DNs) of Landsat TM thermal bands into radiant temperature, a quadratic model was applied (Malaret et al., 1985) (Equation 1).

$$T_B = 209.831 + 0.834DN - 0.00133DN^2 \quad (1)$$

The effects of land surface emissivity on satellite measurement are the reduction of surface-emitted radiance, non-black surface radiance and decrease or increase in the total radiance from the surface (Prata, 1993). In this study, thick vegetation and light vegetation, built-up area, bare land and water were assigned the values of 0.940, 0.925, 0.923, 0920 and 0.992, respectively (Nichol, 1994; Masuda et al., 1988; Venkateswarlu et al., 2003). The emissivity corrected surface temperature was calculated using the following equation (Artis and Carnahan, 1982) (Equation 2).

$$T_S = T_B / 1 + (\lambda \times T_B / \alpha) \ln \varepsilon \quad (2)$$

where TS is the surface radiant temperature in Kelvin, TB is the black body temperature in Kelvin, and λ is the wavelength of emitted radiance. $\alpha = hc/K$ (1.438×10^{-2} mk), where h = Planck constant, c = velocity of light, K = Boltzman constant and ε = surface emissivity. For conversion from the Kelvin to Centigrade scale, the surface radiant temperature should be subtracted from 273.15 (Xu and Chen, 2004).

RESULTS AND DISCUSSION

The Syria deserts in the South West of Dayr az Zawr city is the first area where the dust storms originate. Figure 2 a and b shows the change in the LST of this area during 2003 to 2009. In Figure 2 a, b, c, d, e and f, the LST changes in the first, second and third areas, respectively. In Figure 2a and b, the areas with high range of LST (in dark red and red) have increased by June 26th, 2009 as compared to the same day in 2003. Moreover, the areas with 37.5 to 40 LST that ranges in Figure 2a (in yellow) have disappeared in Figure 2b. Figure 2c and d indicates the amount of heat variations in the area between June 18, 1991 and May 20, 2007. This area comprises the Northern and Southern parts of the Euphrates in the border between Iraq and Syria. A comparison between the LST of the area between June, 1991 and May, 2007 shows an increase in the size of the areas with high LST ranges (40 to 50°C), while the size of the areas with low LST ranges (25 to 37°C) decreased. Figure 2e to f illustrates the LST changes in the third area in the West of Bagdad (capital of Iraq). As Figure 2e to f showed, high LST ranges (46 to 52°C) have decreased by June 28th, 2009 as compared to LST ranges on June 2, 2003. The LST changes in the study area are as shown in Table 1.

According to the table for area 1, increased levels ranging between 43.5 and 46°C and 46.5 and 49°C can be observed for high percentages. No temperature range of 49.5 to 50 can be observed in the image of 2003 for the area, as a result of a rise in temperatures on June 26, 2009. However, the Figure 1e and f shows the decrease in temperature in the highest level, but the middle range of temperature that is enough to scorch the vegetation cover increased. The deserts around the Euphrates in Syria and Iraq play a significant role in the emergence of dust storms affecting Western parts of Iran. The study area in this study requires more attention when compared with other areas, because soil or sand particles that the wind transfers from this region to others area can weaken the soil surface and reduce soil resistance against wind erosion. High temperature ranges in these regions also show a significant increase. This situation reveals the upward trend of land surface temperature and the changes in climatic conditions in this region.

Water changes in the Euphrates banks and the lake shores. The banks of Euphrates before the Sammera dam were studied in order to determine any changes in these banks. Figure 3a and b shows the changes in

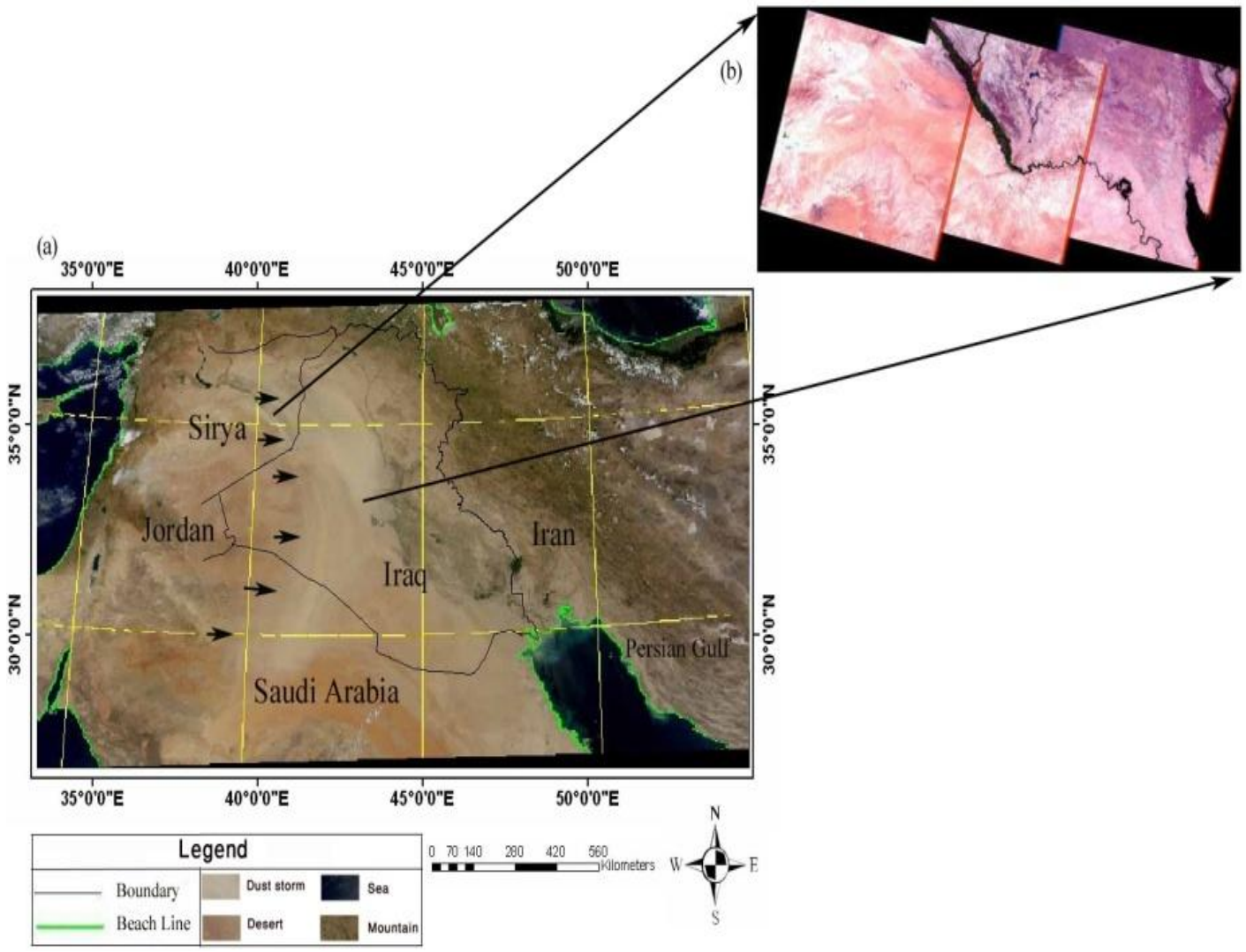

Figure 1. (a) The MODO21KM illustrating the establishment areas of dust storms in Syria, Iraq and Saudi Arabia (indicated by arrows) and (b) Landsate images of first, second and third areas.

Sammera dam and the Euphrates banks from June, 2003 to June, 2009. Figure 3 shows that the dam and Euphrates banks have dramatically decreased in June, 2009 as compared to June, 2003. The land areas that appeared in Figure 3b as the farm lands (indicated by green colors) had been covered by water in Figure 3a. Some parts of these lands have converted to desert due to lack of water for irrigation and they are shown by white color around the farm lands in Figure 3b. In order to investigate the changes in the lake shores, three lakes around the Euphrates were studied (Figure 4).

The water capacity in the lakes around Euphrates decrease in the whole study areas during the images of recent years as compared to the past. Varying depths of water have been indicated in different colors in Figures 3 and 4. In Figure 3, the Sammera dam bank as a considerably deep range of water is indicated by black color as compared to the blue color showing the low depths in Figure 4. Figure 4b shows that the lake shores and the vegetation cover surrounding them (indicated by green color) have decreased as compared to Figure 4b. The vegetation cover in the north decreased, while it completely disappeared in the west, and south parts of the image in Figure 4b, as compared to Figure 4a. In Figure 4b, the lake shores have clearly decreased in the west and north of the image as compared to Figure 4a. A comparison of Figure 4c and d shows that lakes and their surrounding vegetation covers disappeared in 2007 as compared to 1991. Lake shores and wetland in June 2003 were converted to wetlands and deserts in the third area, respectively in June 2009. The earth surface temperature has an indirect effect on the creation of dust storms. Temperature can affect the soil moisture that plays an important role in the growth of plants. On the of

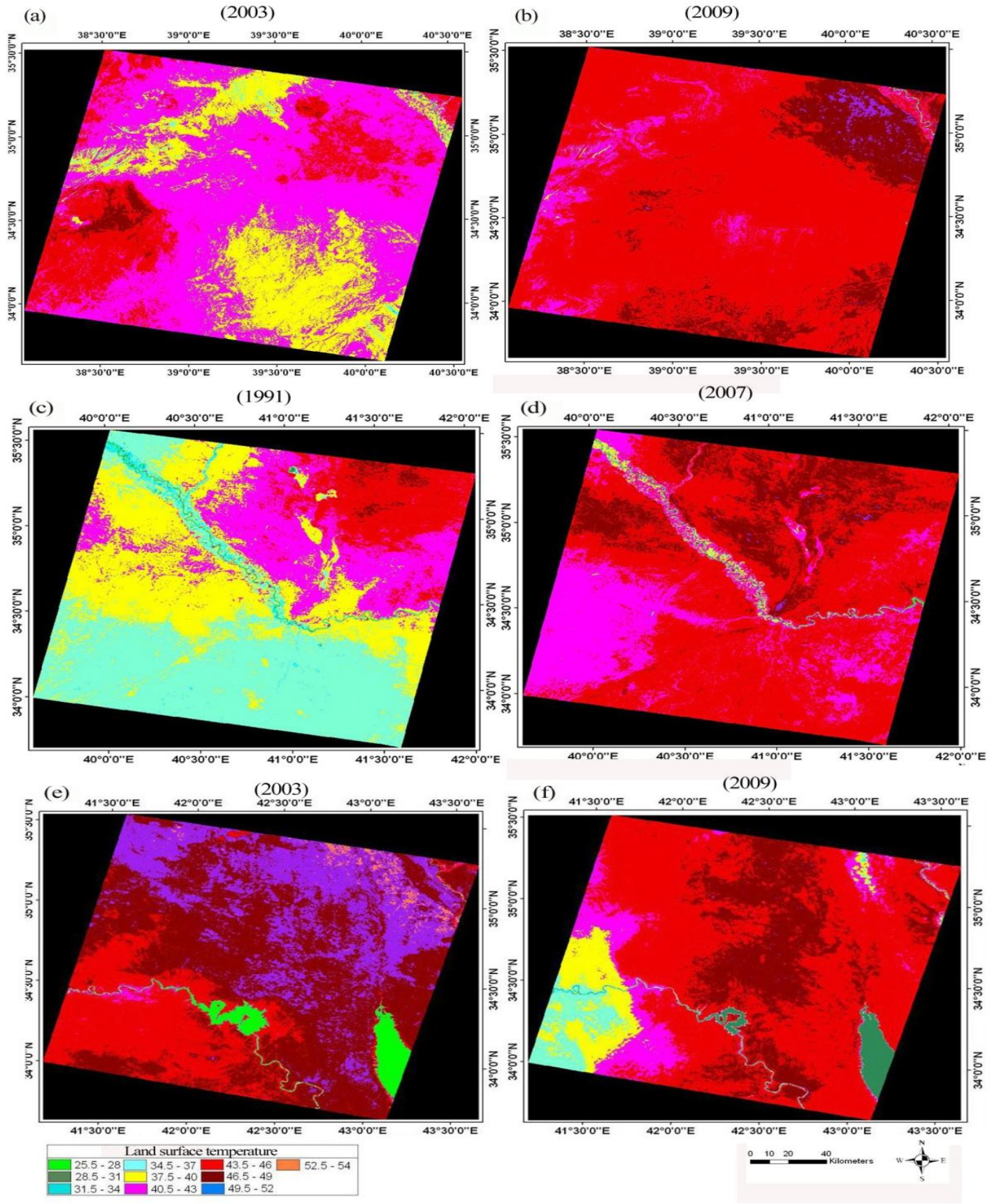

Figure 2. (a, b, c, d, e and f) the LST changes in the first, second and third areas, respectively.

Table 1. Changes in thermal ranges in the study area around the Euphrates in Syria and Iraq.

LST (°C)	Area 1 (ha)	Area 1 (%)	Area 2 (ha)	Area 2 (%)	Area 3 (ha)	Area 3 (%)
25.5 - 28	-18945	-1.08	-9548	-50.21	-192112	-100
28.5 - 31	250	13.75	-3791	-41.21	154480	2744.14
31.5 - 34	-1571	-49.09	-36250	-87.79	4773	90.79
34.5 - 37	-26751	-92.55	-1267512	-99.15	162750	3095.14
37.5 - 40	-816935	-99.01	-983809	-95.92	2229385	3361.06
40.5 - 43	-1618227	-89.26	111215	16.67	255650	850.99
43.5 - 46	2068452	308.89	1730310	438.6	1246370	170.47
46.5 - 49	470384	746.17	508028	1402.86	-962869	-56.66
49.5 - 50	8165	100	5338	100	-859901	-99.79
52.5 - 54	-	-	-	-	-99.79	-100

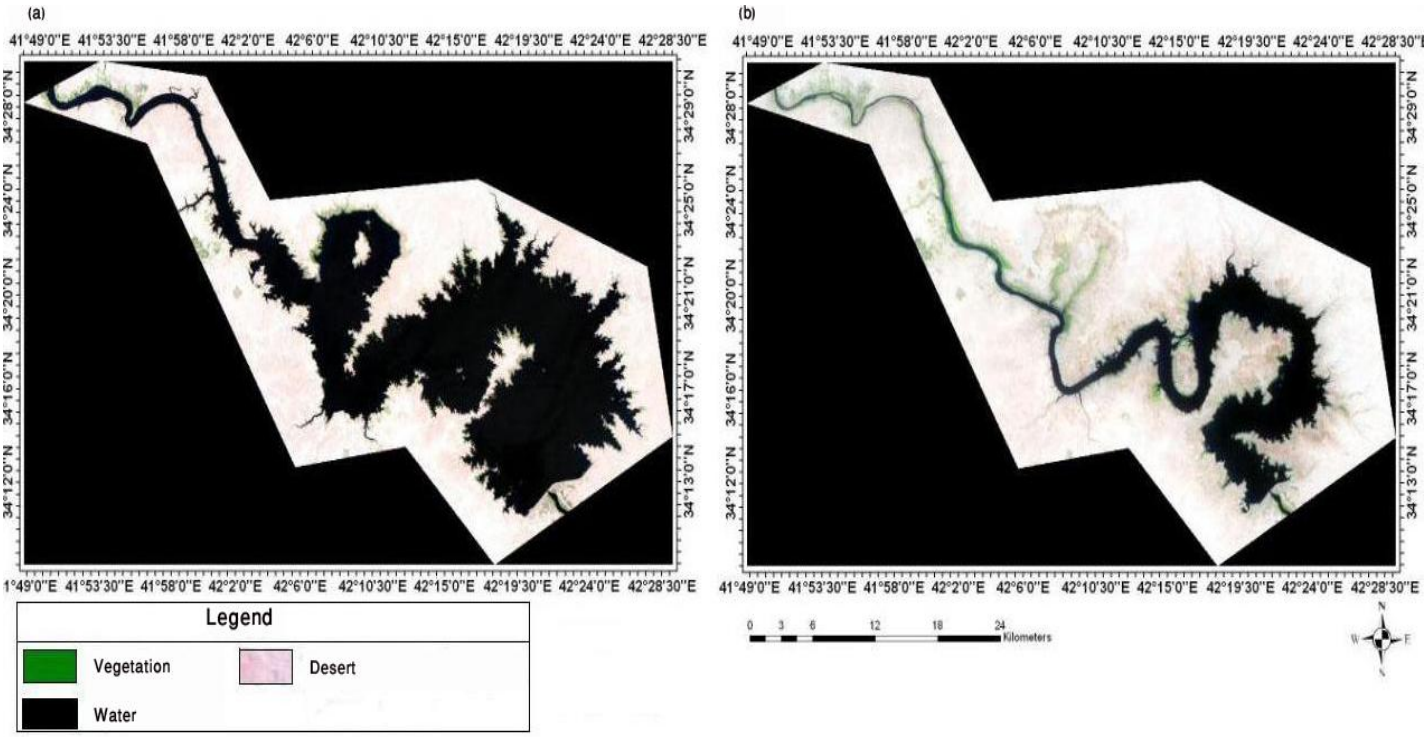

Figure 3. (a) and (b) shows the changes in Sammera dam and the Euphrates banks from June, 2003 to June, 2009.

other hand, a rise in the temperatures can increase the rate of plant transpiration and its need for water, and on the other hand, it can increase the intensity evaporation from soil surface. This, in turn, can reduce the relative humidity of soil that can decrease the vegetation cover (Latifah et al., 2011). Today, reduction in vegetation is known as the major cause of soil erosion and dust storms (Zhang et al., 2003; Gong et al., 2004). As the soil moisture decreases, the adhesion properties of soil particles are reduced, weakening the resistance of surface soil against wind erosion, the first stage of the formation of any dust storm (Hai et al., 2002).

Conclusion

Remote sensing has been increasingly used to study LST in last decade. In this study, the Landsat TM5 images of the different time were utilized to study LST in Syria, Boundary (Iraq and Syria) and East of Bagdad deserts that are one of the primarily places which creates dust storms. The result showed the increase of LST and consequently, decrease of water content in soil has an important effect on creation of dust storms. This study showed that remote sensing is a useful tool to study LST in international areas. Our research concludes that the

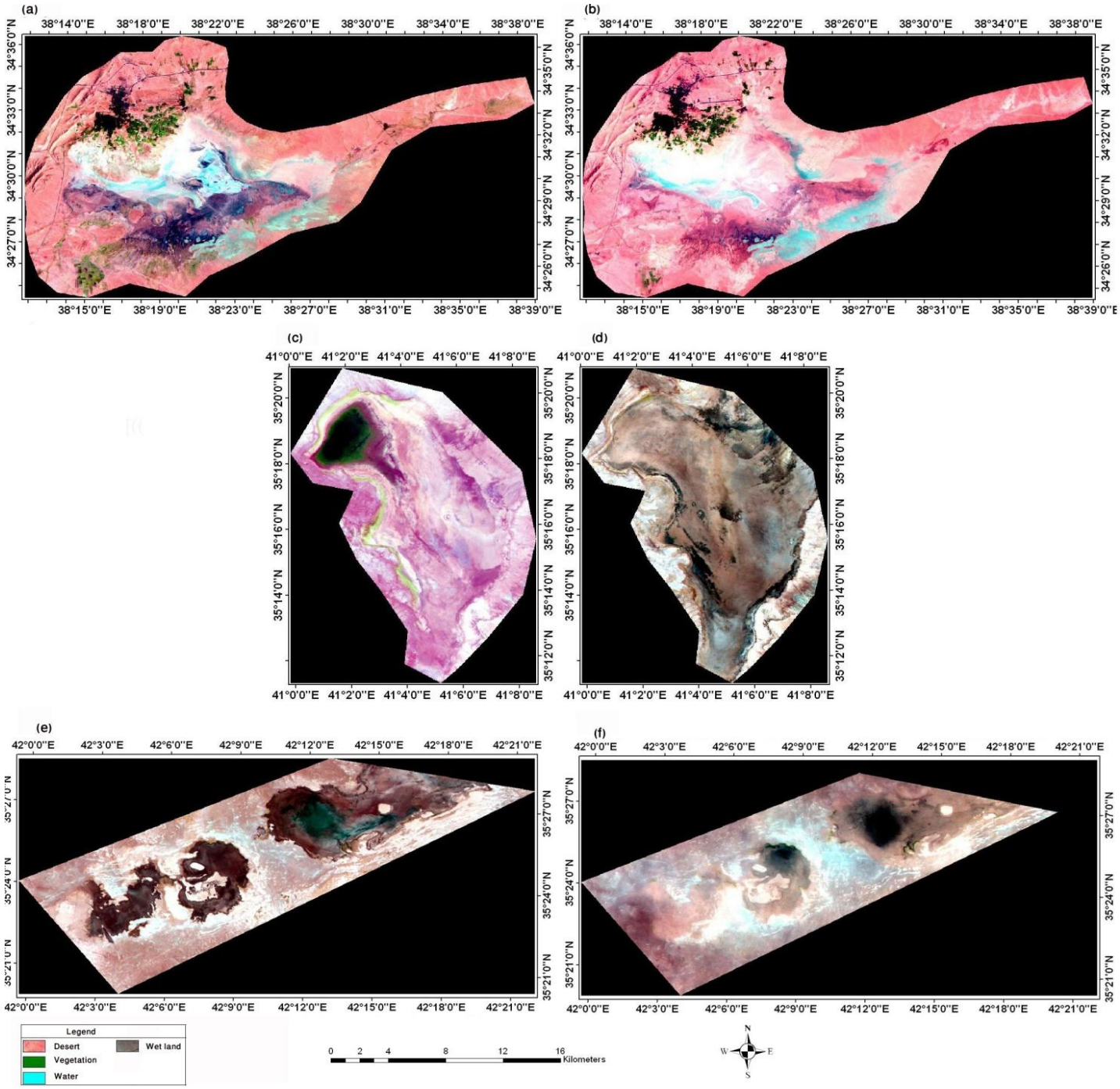

Figure 4. (a, b, c, d, e and f) The lake shore changes in the first, second and third areas, respectively.

main reason of dust storms creation is to increase LST.

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