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Natural Hazards and Earth System Sciences
Discussions
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Interactive comment on "Analysis of decadal land cover changes and salinization in Urmia Lake Basin using remote sensing techniques" *by* Yusuf Alizade Govarchin Ghale et al.

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Dear Dr. Rosa Lasaponara, Editor Journal of Natural Hazards and Earth System Sciences We would like to thank you and all the reviewers for the valuable comments that improved the quality of our paper. The paper has been thoroughly and carefully revised according to the reviewers' comments. Below are the responses given to the comments raised by the reviewer. Sincerely, ******** Reviewer #1: Comment 1- What are the novelties of paper in compare to these references? Please describe in the paper/ Fathian F, AD Prasad, Z Dehghan, S Eslamian 2015, Influence of land use/land cover change on land surface temperature using RS and GIS techniques, International

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Journal of Hydrology Science. 2- Fathian F, S Morid, E Kahya 2015 Identification of trends in hydrological and climatic variables in Urmia Lake basin, Iran, Theoretical and Applied Climatology. Author's Respond: Recent studies on Urmia Lake and its basin, mainly focused on the coastline, water surface area changes, and partial analysis while in this study temporal changes of different land cover types (such as salt, salty soil, and water body) were analyzed between 1975 and 2016. The area of irrigated lands in Urmia Lake Basin were determined between 1984 and 2016 to better understand how human activities have changed water consumption trends in the basin. Land field survey data have been used in order to improve the accuracy of the findings. Desertification progress in the ULB is determined after salinity changes, the area of salt, salty soil, and water classes in Urmia Lake were identified. The results of this research can play an important role in management of the northwest of Iran by providing accurate information on changes that have been happening in ULB in the last 41 years. We believe this study has the potential to be used as a reference study in related salinization and desertification studies. We have included the suggested references in the Introduction part (page 1, lines 29-30 and page 2, lines 11-17). Page 1, lines 29-30: Additionally, impact of increase in temperature and overuse of water resources on the drying Urmia Lake was investigated in a recent study (Fathian et al., 2015). Page 2, Lines 11-17 Fathian et al., (2015) used three Landsat images to analyze Land use/Land cover (LULC) changes and their impacts on Land Surface Temperature (LST) in the east part of Urmia Lake Basin (ULB) in 1989, 2002, and 2011. Results indicated that human activities and urbanization had affected the vegetation types and LST from the high temperature-sparse vegetation to the low temperature-dense vegetation during the period between 1989-2002 and from low temperature-dense vegetation to the high temperature-dense vegetation in period between 2002-2011. In previous studies a lot of valuable investigations have been conducted on Urmia Lake and its basin but there are no detailed studies in long term salinization progress and development of irrigated lands in all parts of ULB. We have explained the novelty of paper in compare to previous studies in page 2, in lines 15 to 25: In previous studies a lot of valuable

investigations have been conducted on Urmia Lake and its basin but there are no detailed studies in long term salinization progress and development of irrigated lands in all parts of ULB. Soil salinity research are crucial to understand the underlying causes and consequences of the drying Urmia Lake. Considering the lack of sampling data and limitations of field survey studies in Urmia Lake Basin, our aim is to use remote sensing technology and image processing techniques to detect temporal and spatial variability of salt body, salt affected lands, and development of irrigated lands to estimate the extend of salinization in terms of spectral response of satellite images for the ULB. Temporal changes of different land cover types including salt, salty soil, and water bodies were determined from 1975 to 2016. Normalized Difference Vegetation Index (NDVI), soil Salinity Index (SI) and Maximum likelihood classification methods were used to quantify the acceleration of salinization in the Urmia Lake Basin (ULB) for the study period.

Comment 2- In section 2, what is the lake area itself, and nor the basin area. Based on my knowledge the lake area is 5000 km2. Then how it is said in the abstract that the dried area is 5000 km2? All the lake area is dried? Reply: We have estimated the lake area as 5982 km2 for 1995, the maximum value for the period between 1972 and 2016. Similar number is given in the literature by Eimanifar and Mohebbi, 2007; Zarghami, 2011; Hasanzadeh et al., 2012. The following sentences were added to clarify this point on page 2 (lines 27-30), page 2 (lines . . .), and page 6 (lines . . .): Page 2, lines 27-30: Urmia Lake which has a surface area ranging between 5000 and 6000 km2 is located in the northwest of Iran (N 37.5°, E 45.5°) between West Azerbaijan and East Azerbaijan provinces with a catchment area of 51876 km^2. It is the largest inland lake of Iran and the second largest hypersaline lake in the world (Eimanifar and Mohebbi, 2007; Zarghami, 2011; Hasanzadeh et al., 2012). Page 6, lines 14-18: The results of this study indicate that salt and salty soil areas has increased dramatically from 1995 to 2014 and more than 5000 km^2 of Urmia Lake's water surface area was turned into salt or salty soil bodies during this period. The minimum water surface area was estimated for 2014 with a total value of 586 km2 whereas maximum water surface

area was determined for 1995 with a total area of 5982 km2. The water surface area has increased to 1490 km2 and salt body has decreased about 348 km2 in 2016.

Comment 3- Beneath the formulas 1 and 2, describe the parameters uses in them. Reply: We have described the formulas 1 and 2 on page 3, lines 12-16: SI= (Green+ Red)/2 (1) where, Green and Red are ground surface reflectance values of green and red bands respectively.

NDVI=(NIR- Red)/(NIR+ Red) (2) where, NIR and Red are ground surface reflectance values of Near Infrared and red bands respectively.

Comment 4- The flowchart in figure 1 is not clear. Please enlarge the fonts and improve the graphics. Reply: We have improved the quality of Figure 1.

Comment 5- In table 2, the population is for the part of each province which falls in the Urmia lake basin area? Or it is the total population? In the first case some part of the Kurdistan province also falls in the lake basin and it should also mentioned. Reply: Table 2 includes the total population of just West Azerbaijan and East Azerbaijan (Population in West Azerbaijan + Population in East Azerbaijan). We have used the data of these provinces because about 90% of Urmia Lake Basin is located in these provinces and they are located in neighboring of Urmia Lake.

Comment 6- What is the reference for Table 1. Reply: The references are given in the text (on page 3, lines 29-30): Anderson et al., 2003; Ritter, 2006; Rawashdeh, 2012, USGS, 2016).

We have cited 4 references (3 references in last version) about NDVI, in page 3, lines 30-31. The fourths references is related to the USGS (https://phenology.cr.usgs.gov/ndvi_foundation.php). For more information you can visit this URL too. http://www.pvts.net/pdfs/ndvi/3_3_ndvi.PDF

Comment 7- The graphics of the figures 3 and 5 has problem in black and white print. Reply: We have improved the quality of these figures.

Comment 8- The figures 6-7 are provided in a very small sizes and then difficult to understand. Reply: We have improved the quality of these figures.

Comment 9- Page 11, line 10, the names of ministries should be written by capitals. Reply: We have revised the names of ministries.

Comment 10- In conclusion, first line, please revise accordingly: management of water resources in Urmia Lake basin: : :. Reply: We have revised this part accordingly.

Comment 11- The English of the paper should be polished. Reply: English of the paper has been improved. Repetitive parts are removed, and general flow of the manuscript has been improved.

Comment 12- In discussion I could not find clearly on the causes/drivers of expanding agriculture around the lake. In addition I do not see any citation from the Urmia Lake Restoration Program. What are their interactive responses to the findings of this valuable study? Reply: The question asked by the reviewer is beyond the scope of this study. Possible logical reasons behind the expansion of agricultural areas are the increasing population and their needs and agricultural policies. Unfortunately, our objectives do not include finding the reasons behind the increasing trend in agricultural activities. We don't have enough scientific and technical information about the plans and activities "Urmia Lake Restoration Program". However, it is possible that the increase after 2014 might be contributed to these restoration programs. We follow this program through: http://ulrp.sharif.ir/en. We have plan to share our findings with them through publication of this paper.

We have added the revised paper to the supplement part.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-212/nhess-2017-212-AC2-supplement.pdf

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2017-212, 2017.

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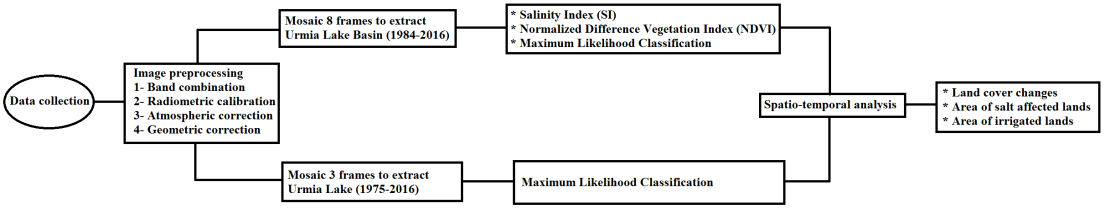

Fig. 1. Figure 1: Image processing steps of quantifying salt affected areas in Urmia Lake Basin

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Fig. 2. Figure 2: Photos of land cover changes in the northwest part of Urmia Lake. (a) Urmia Lake in 2005. (b) Urmia Lake in 2012. (c) Urmia Lake in 2005. (d) Urmia Lake in 2010.

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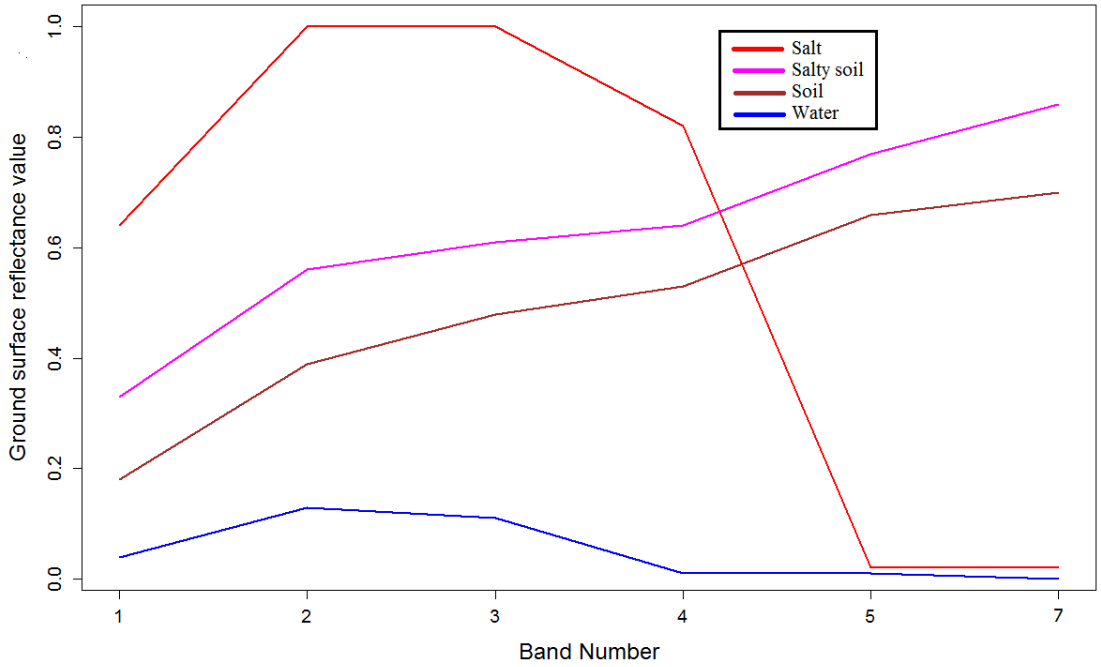

Fig. 3. Figure 3: Spectral profile of salt, salty soil, soil and water bodies in Landsat_5 TM for 2011-August.

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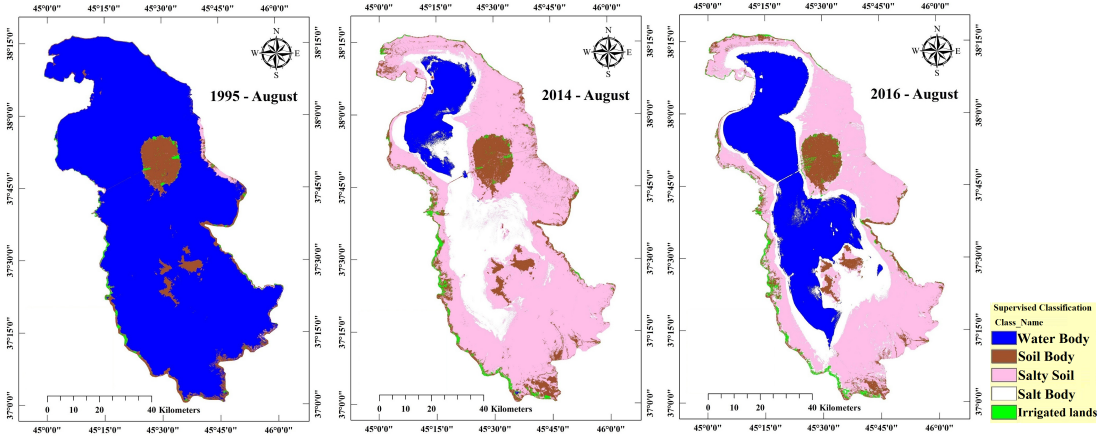

Fig. 4. Figure 4: Salinization and desertification progress in Urmia Lake (Classifications are shown for 1995, 2014, and 2016 August.)

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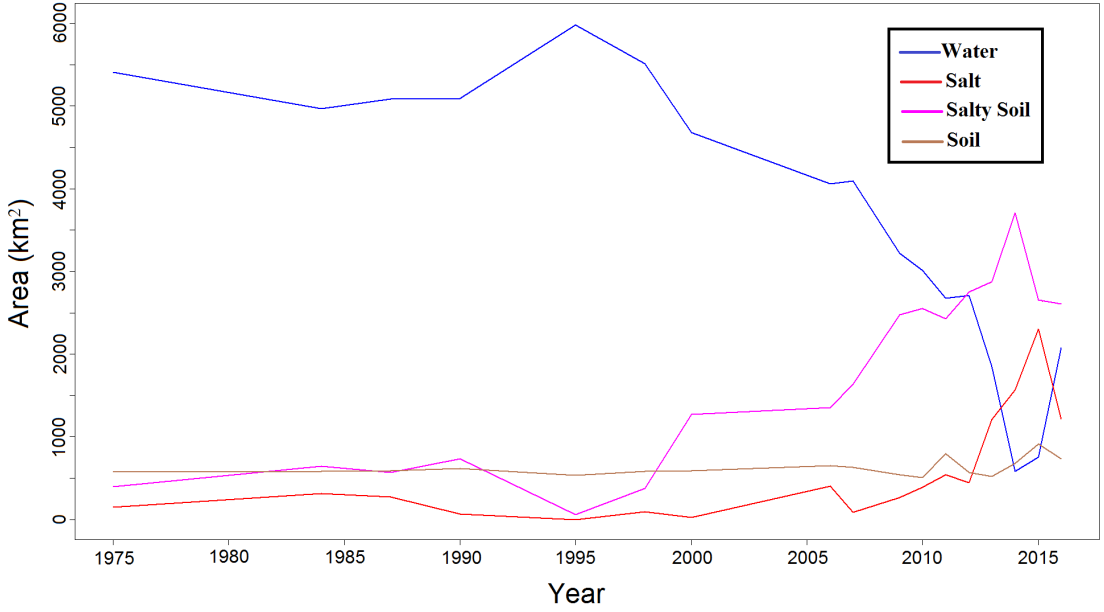

Fig. 5. Figure 5: Land cover changes trend in Summer seaons years from 1975 to 2016

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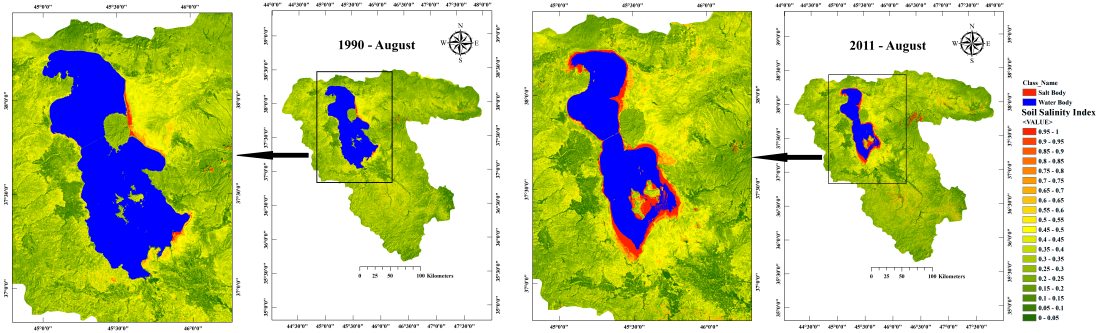

Fig. 6. Figure 6: Water body and Salinity changes in Urmia Lake throughout the years of 1990 – 2011

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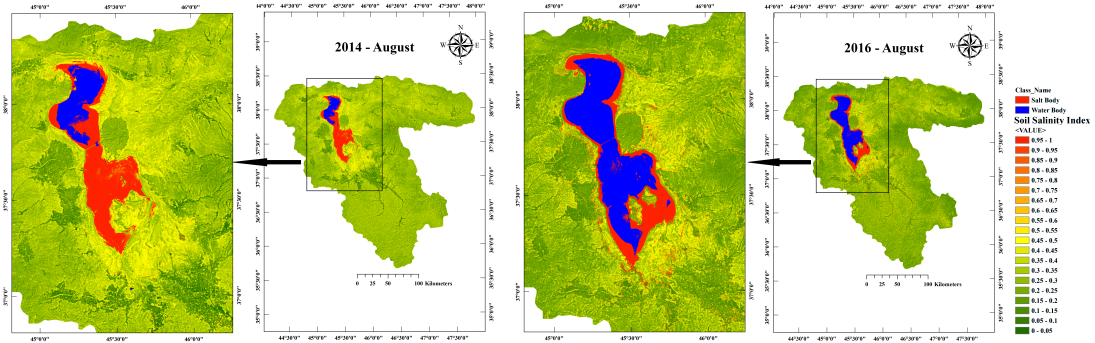

Fig. 7. Figure 7: Water body and Salinity changes in Urmia Lake throughout the years of 2014-2016

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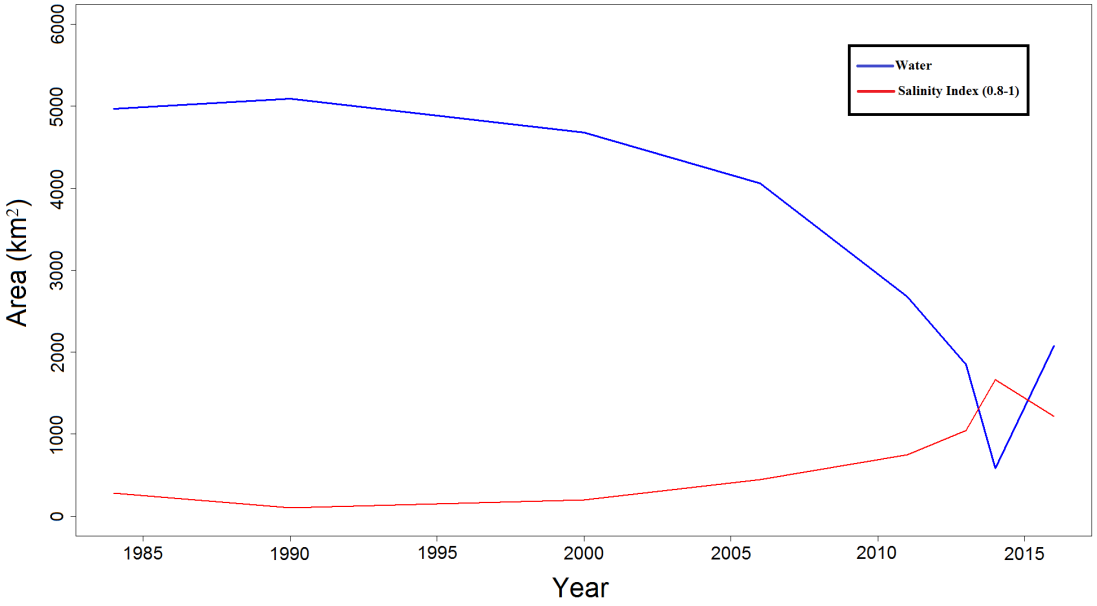

Fig. 8. Figure 8: Inverse correlation between water surface area and area of high salt affected lands.

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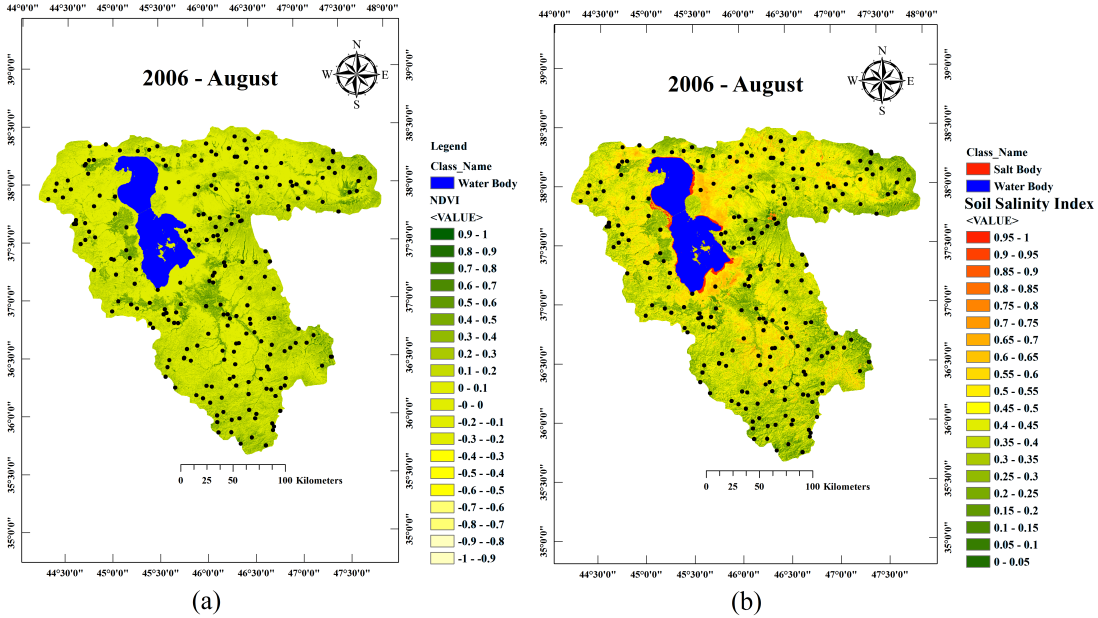

Fig. 9. Figure 9: Distribution of randomly selected sample pixels to indicate correlation between SI and NDVI changes in 2006

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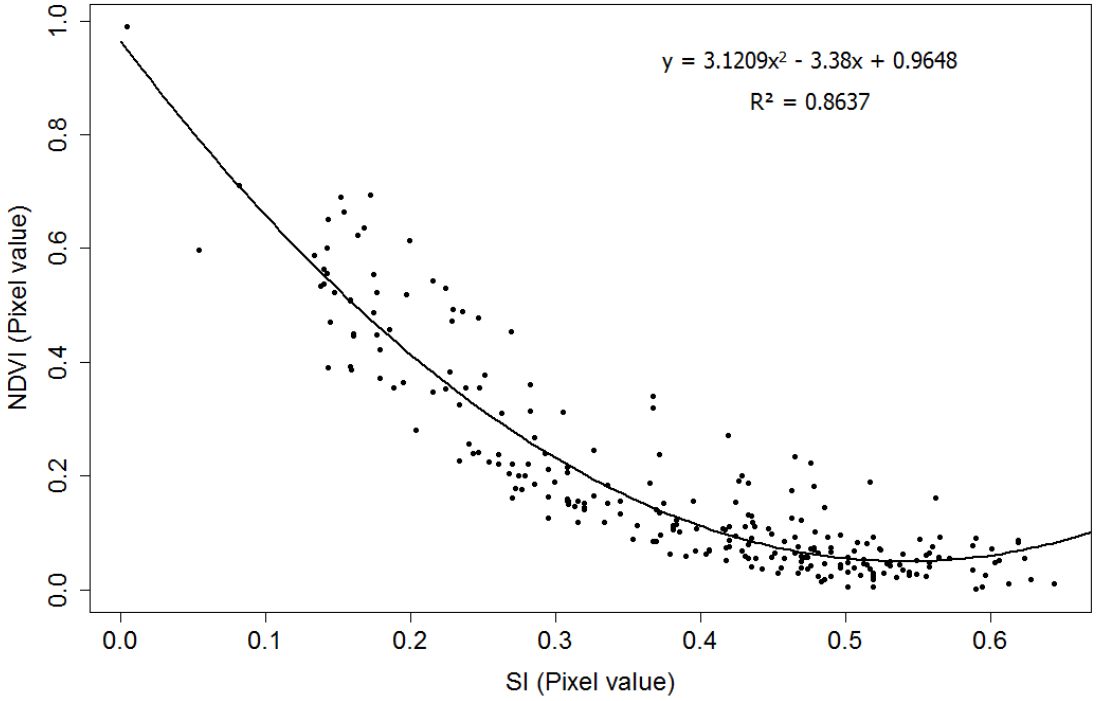

Fig. 10. Figure 10: Inverse correlation between SI and NDVI values of randomly sample pixels in 2006

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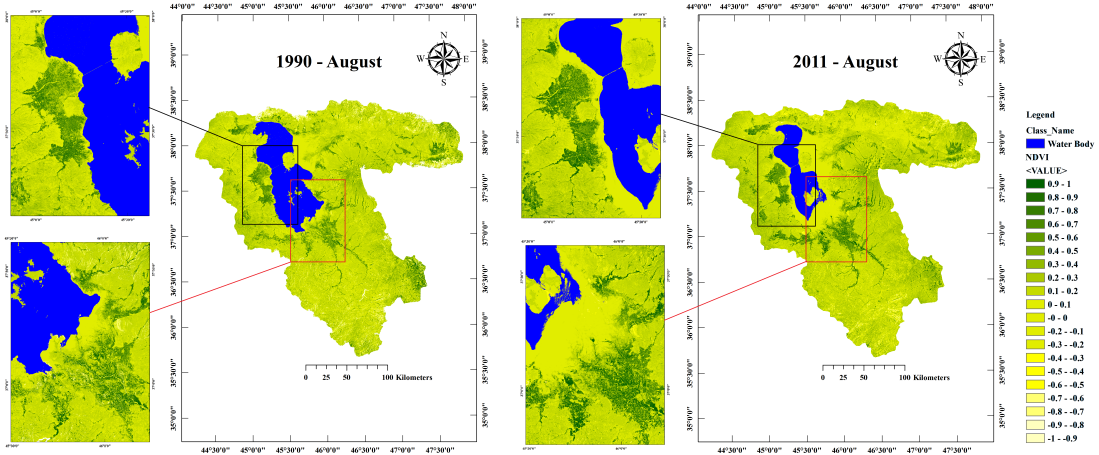

Fig. 11. Figure 11: Water body and NDVI changes in Urmia Lake throughout the years of 1990 – 2011

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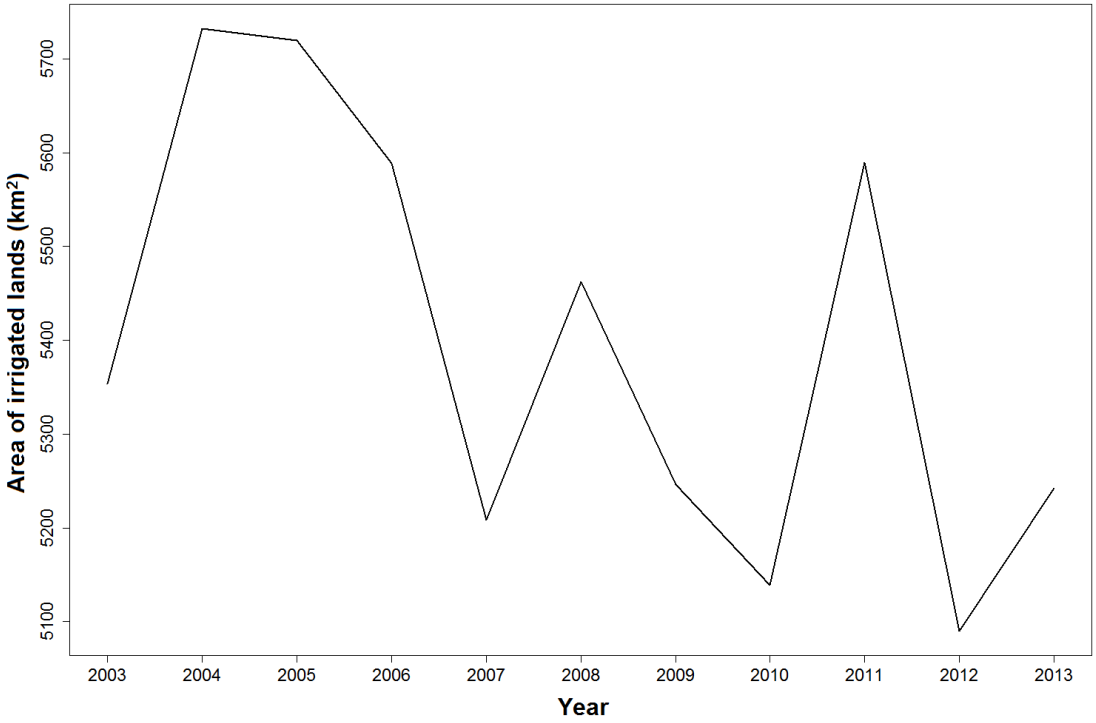

Fig. 12. Figure 12: Total area of irrigated lands in West Azerbaijan and East Azerbijan provinces

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