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Investigating the Effect of Gold Mining on Land-Cover Trend at Pixel Scale Using a Combination of Remote Sensing Data and Mann-Kendall Test in Northwestern Iran Case Study: Andaryan Region, East Azerbaijan

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1-Introduction

Mining industry has almost negative and destructive effects on the environment and ecosystems of regions and can affect the health of humans and other living organisms including animals, plants, soil, water, and the entire biosystem of the region on a local and regional scale.

2-Methodology

The study area is located in East Azerbaijan and it belongs to the sub-basins of the western part of the Aras Basin.

2.1-Data

Landsat 5, 8 data available in July (1984-2019), monthly and annually value of temperature and precipitation data (1998-2017) in Varzeqan station.

2.2-Method

In the present study, land-cover density using Normalized Differential vegetation Index (NDVI) was extracted from satellite imagery of Landsat (Thematic Mapper and Operational Land Imager) as time series for the period of June 1984-2019. 27 images were analyzed after correction and NDVI extraction. See question 1:

$$NDVI = NIR - RED/NIR + RED \quad (1)$$

Where, NIR is reflectance value of near infrared and RED is reflectance value of red band.

To determine the trend in vegetation, first, the land-cover density extracted from satellite images were pre-whited in time series and then the trend analysis was done by Mann-Kendall (MK) method in each of the pixels, and also beginning of the trends were

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analyzed by Mann-Kendall sequence (SMK) in per case studies. SMK was used in MATLAB software (Ye et al., 2013; Moraes et al., 1998).

3-Results and Discussion

The average values of land-cover in all three case studies (i.e., case 1, case 2, and case 3) have increased in the period 1984-2019 and have almost had the same fluctuations over the period under study. Therefore, that linear regression was derived between the land-cover of cases 1 and 2, 1 and 3, and finally 2 and 3 with the average correlation coefficient of 96%, 96%, and 98%, respectively. The highest vegetation peak was in 1992, 2004, 2013, and 2018 to 2019, however, such an increase in the average occurred in all three study units. The peak of average land-cover density in different years is consistent with the peak of precipitation and decrease in temperature on an annual scale. According to the results, in studying the trend of vegetation changes, it is not possible to generalize the numerical average of vegetation for the whole region or analyze the trend. By emphasizing this result in each of the pixels as a time series, trend analysis was performed by MK method. Case 1 experienced the most fluctuation and case 3 (downstream of the mined area) experienced the least fluctuation trends. The significant decreasing trend in both levels of reliability, 95% and 99% has the highest level of the mining area (Fig. 1).

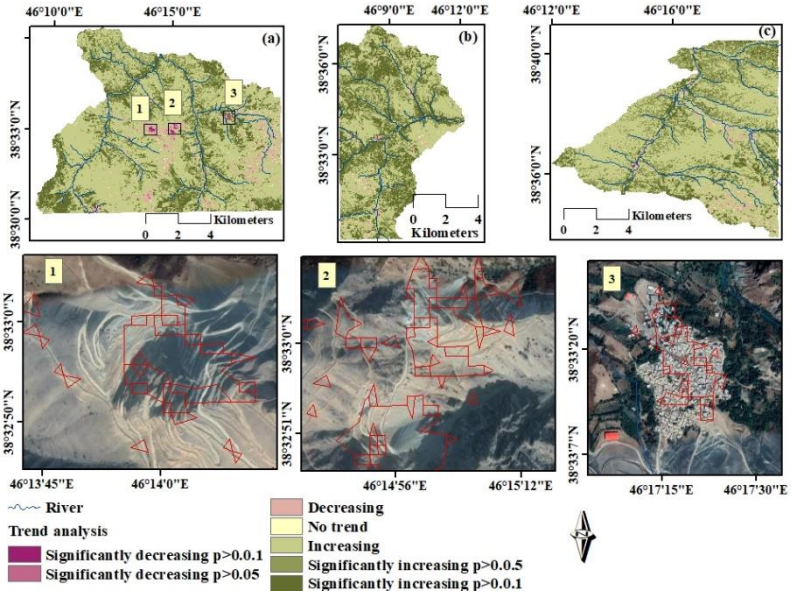

Fig. (1): Classification of trend analysis at 95% and 99% confidence levels, (a) case 1, (b) case 2 and (c) case 3. Figures 1-3, which have been resulted from Fig. 6 (a), indicate areas with significant decrease. Figs. 1 and 2 are the mining areas and Fig. 3 is the Andaryan village

0.48% of the case 1 area is under the significant decreasing trend, which is 0.18% and 0.22% in case 2 and 3, respectively. Therefore, there is a significant decrease in all three case studies. Approximately, 5%, 2%, and 3% of the area of cases 1, 2, and 3 have a decreasing trend, respectively. The percentage of areas with a significant increasing trend at both 95% and 99% confidence levels are equal to 35.5%, 54%, and 36.5% for each of the 1-3 case studies, respectively. According to Varzeqan station data, these areas have received good rainfall in the last decade, so the area of vegetation has increased significantly. The existence of 88% correlation between the area where the mining took place and the area that is untouched in terms of exploration operations shows the insignificant impact of exploration operations and smelting services on the vegetation of the area. Although most of land-cover of about 51 hectares has been lost due to road construction on steep slopes for mining and smelting services, based on sustainable development goals, the affected vegetation can be restored to the original state and at the same time to make the best use of existing minerals and consider future generations (Thenepalli et al., 2019).

4- Conclusion

The results show fluctuations in land-cover density; however, in general, high dense areas in terms of vegetation are observed in all three areas. The case studies 1- 2, 1 - 3, and 2 - 3 have a correlation of 96%, 96%, and 98% with each other, respectively. Therefore, using the Mann- Kendall statistical model, NDVI values were analyzed pixel by pixel as a time series. The results show a significant decrease in the vegetation of regions 1-3 equal to 0.48%, 0.19% of the area in all three regions, respectively. The results of the Mann-Kendall sequence and correlation in the areas with a significant reduction in vegetation and the considered various hypotheses showed no chemical leakage to downstream of the basin.

Keywords: Impact of mining, Land-cover, NDVI, Mann-Kendall Test, Varzegan, Northwestern Iran

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