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Comparative character and monitoring of some parameters of the soil and vegetation by remote sensing in the zone of Zangilan

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Abstract

It is important to reveal a character, scale and development line of the change in order to determine a potential and future enlargement direction of ecosystem. The monitoring of the changes occurring in some parameters of soil and vegetation in the research zone by GIS has been performed and the consequences have been compared in the article. It was determined that the positive tendency was shown in some parameters of soil and vegetation, but negative tendency was shown in some parameters. An investigation of the changes by the remote sensing were given on the basis of different parameters (NDVI, LST, VHI) using the satellite images (Landsat 5 TM; Landsat 8 OLI) in the research zone. Change of the area of forest ecosystem under the negative and anthropogenic influences were compared on different years (1990-2022 years). It was determined that an area of the optimally developed forests decreased 84.5 % (10.838.05 h). At present the serious degradation has occurred in a negative direction of the available forest area. The Sentinel-2 satellite images have been used to evaluate changes occurring in soil use/ soil cover (LU/LC) in the active war phase (2016-2022 years). The soils of the plain and foothill regions in the district have been subjected to all the types of degradation (physical, chemical, biological) as a result of the military-technogenic effect.

1. Introduction

Concentration of the industry and growth temp of the population was a reason for important transformation of the geographical components within space and time. All the forms of the anthropogenic effect (urbanization, mining industry, war, etc.) negatively affect the environment.

The zone was historically important in development of the agricultural development. At present this region possesses a great potential in successful realization of the social-economical strategy related to agriculture of the country. But occupation of this region by the Armenia's military units for nearly 30 years and brutal plundering of the nature, including the soil and vegetation during the occupation led to violation of the ecological balance of the environment.

Although there has been no settlement in the research region in the last 30 years, every year extensively usage of the soils, burning of the pastures, subsurface soils after harvesting exposed the fertile soils to degradation. The other state is military-technogenic effect. Recently, at least in war-torn countries of the world, the research is being done in this direction. A main reason for this poor performance of these works is that the wars occur in economically weakened countries and are concentrated in developed countries as a result of the biological-technogenic effect.

From the 90s of the XX century to the 20s of the XXI century the soils in this zone were subjected to physical deformation, chemical contamination and degradation.

Until the beginning of the 90s of the XX century, although extensive soil researches were carried out covering individual regions, no soil researches were conducted in the last 30 years and the proposed problem wasn't studied at all, the perfect soil researches weren't performed. The soil researches , monitoring results carried out in the last century were important as a valuable source while assessing modern state of the soils.

The 30-year occupation period and repetition of the active war phase led to destruction of all the ecosystems and infrastructure. The scientific –research works were performed in different regions of the world in this direction [1-2]. But the scientific-research works implemented in this direction were dedicated to the ethical, social-economic and ethnic consequences of the war [3]. An effect of the war on surrounding ecosystems was poorly studied. Baumann [4] notes that more than 60% of Garabagh's agricultural land was left unused as a result of the war. 30% of these soils were also compensated at the expense of the new agricultural soils. As a result, loading grew in the surrounding regions, the pastures were turned into agricultural fields.

2. Study Area

The research covers a zone of the administrative region (70099.177h) in Zangilan. It is located between latitudes 39°14'30″ N - 38°51'30″ N and longitudes 46°25'30″ E - 46°52'30″ E. Description of the zone was mainly given according to the digital height model (Figure 1).

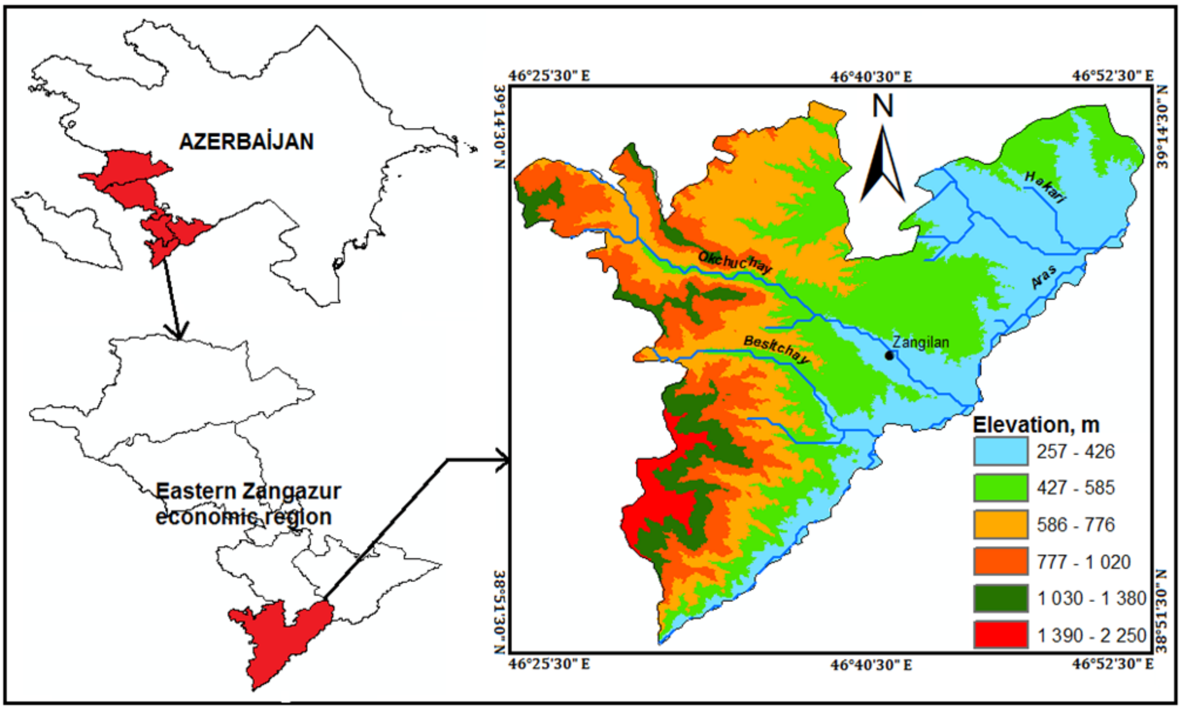

Figure 1. The geographic location of Zangilan district in Azerbaijan.

The Zangilan administrative region possesses complex relief and special geo-morphological character in the south –eastern part of the Little Caucasus and in terms of landscape-ecological assessment, it has been brutally anthropogenically affected compared to the pre-occupation situation. From this point of view, it is more dangerous than other neighboring regions due to the risk of erosion and degradation of the research soil. Enlargement of agro-landscape in the zone again and incorrect use of the soils can increase this risk.

The climate of the region is various according to the surface structure. The winter months are characterized by soft and short-lasting snow cover, and summer months are dry and hot. Therefore the certain time is required for restoration of the negative effects on nature of the region. The average yearly temperature is 14.2 °C, a quantity of the average yearly rainfall is 501.2 mm. An average yearly velocity of the wind decreases from the zone along the Araz towards the mountainous direction (4,1-3,6 m/san). The climate data covers average statistical indicators of 1990-2021 (Figure 2).

The human's incorrect farming and military-technogenic activity led to the change of the erosion intensity of soils depending on slope exposition, length, inclination degree.

The zone is divided into three sub-districts:

I – Arid-denudation mountains;

II – Accumulative-denudation plateau and plains;

III – Accumulative plains.

Arid denudation mountains are mainly located in the low and middle mountains, they occupy 85-90 % of the total zone of the research region. The forest landscape in the complex zones of the relief was destructed, and that's why the transit surface flows in the low mountainous regions eroded more soils and it was a reason for activation of the ravine and gorge net.

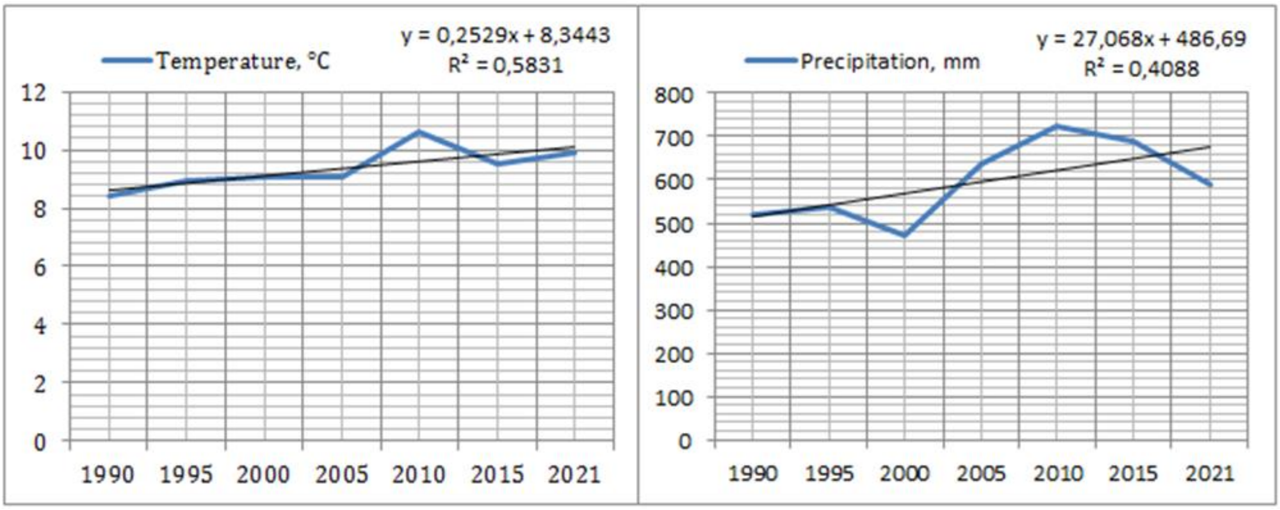

Figure 2. Climate data (Köppen-Geiger climate classification system).

Intensification of the relief in the arid-denudation condition in the south-eastern direction of the Bazarchay and Okhchuchay basins, especially deterioration of the natural ecological balance of the Asgulum, Susandagh monoclonal graben increased a risk of soil erosion. This led to erosion of the steppe-brown and grey-brown soils. A good condition was created for enlargement of the "U" –shaped valleys, terraces, erosion steps and ravines for the relief of this zone.

Diversity of the relief and climate of Zangilan is reflected in vegetation. There are three zones according to vegetation: 1. Broad-leaved arid sparse forest zones; 2. Mountain-xerophyte (firgana typical) zone; 3. The semi-desert zone with the dry steppe elements.

The forest landscape spreads in the middle mountain zone, it is not a large area. Though the hornbeam trees spread in the small areas on the north slopes, the dominant tree species Iberia oak (Quercus iberica) and eastern oak (Quercus macranthera) are replaced by arid sparse forests towards low-upland.

The arid sparse forests are situated below the broad-leaved forest zone and it is a large area. The main tree species are Araz oak (Quercus araxina) and juniper (Foetidissima). It is known from the comparative analysis of the perennial satellite images that the forest landscape was mostly damaged, the forests were more drawn up in the north-east, strong fragmentation occurred in the relief. The water-collecting basin mountain-xerophyte plants are intra-zonal in nature and cover foothill and middle mountain zone, the semi-desert zone with dry steppe elements foothill inclined plain. The soil and vegetation of this zone is agro-ecological zone which is under the military-technogenic effect.

Different taxonomic units of the Mountain-forest brown (Kastanozems), mountain grey-brown (Haplic Kastanozems), alluvial-meadow (Mollic Fluvisols) soil types developed in the Zangilan region.

The mountain-forest brown soils occupy a large zone in the research region and denudation middle mountain and foothill zone. The relief is strongly fragmented. The climate is different, increase of the precipitations towards height is noticed. The oak and hornbeam forests dominate in the upper part of the middle mountain zone. These forests are replaced by the oak forests in the north-east direction and they are small area. The soil-forming rocks are main volcanic and sedimentary rocks. The calcareous mountain –forest brown, steppe mountain-forest brown subtypes develop according to the genetic characters of the mountain-forest soils in the zone.

The alluvial-meadow soils spread in the floods of the mountain grey-brown (chestnut) , Hakari, Bargushad, Okhchu, Basit and Araz rivers in the low mountainous and foothill region. The soil cover possesses medium and heavy loamy mechanical composition in the complex complicated automorphic condition and it is subjected to leaching to a different degree. When these soils were under occupation , they were ploughed without considering modern farming culture and so, the soils were quickly degraded and turned into badland.

The zone more susceptible to degradation is steppe mountain-brown and grey-brown (chestnut) soil zone below the forest stripe. This zone was mostly evaluated as fragmented, degraded zone before occupation. A reason is explained with the human's farming activity, heat and dryness of the climate, strong fragmentation of the relief and weakness of the vegetation.

An aim of large description of the zone is correct evaluation of transformation of the zone ecosystems during the occupation.

2.1. Data

The changes occurring in the various parameters of the research zone were analyzed by the satellite images (Landsat 5 TM; Landsat 8 OLI) for 1990-2022. The Sentinel-2 satellite images were used during composition of the land use characteristic map. The sequence was followed during the course of the research process (Figure 3).

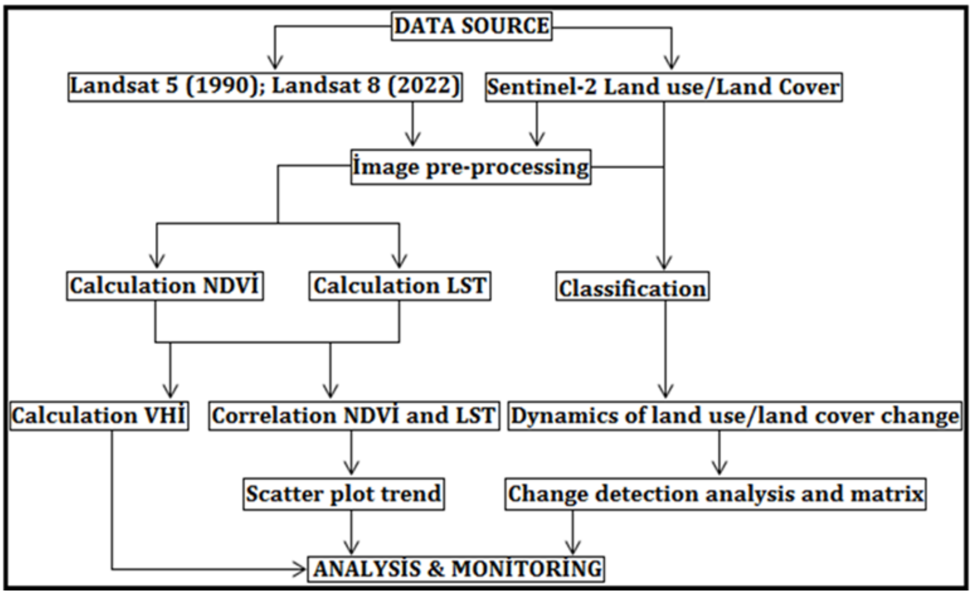

Figure 3. Methodology flowchart.

2.2. Description of the different parameters (NDVI, LST, VHI, LU/LC)

The changes occurring in vegetation are regularly performed by remote sensing on a local and global scale. The multispectral data are included in the research in a form of vegetative indices (NDVI, EVI, SAVI, etc.) [5-6]. Mainly, the normalized difference vegetation index (NDV) is used. NDVI values range from -1 to 1. Evaluation of the changes occurring in vegetation was performed on 5 categories (Table 1).

Table 1. NDVI classification.

NDVI class	NDVI value	Classification
1	<-0,03	non-vegetation area, open area, waterbody
2	-0,03-0,15	very low dense vegetation
3	0,15-0,25	low dense vegetation
4	0,26-0,35	moderately dense vegetation
5	>0,35	highly dense vegetation

During the measurement of the temperature of soil surface (LST), the satellite sensor data were processed, corresponding formula sequence was calculated taking account the corrections of the atmospheric indicators, vegetation. etc [7].

Monitoring of the ecosystem isn't rational over a wide period of time using from NDVI values. Therefore, the vegetation healthy index (VHI) was used in order to characterize and perform drought monitoring [8]. Minimum and maximum values of the vegetation state index (VCI) and thermal state index (TCI) were used for this. VCI characterizes a humidity condition in the visible and near infrared stripes, but TCI characterizes temperature condition on the basis of the heat balance [9]. According to the adopted method, the classification was conducted within the VHI <40 drought threshold and the evaluation was performed on five classes (Table 2).

Table 2. Drought severity classes for the vegetation health index.

VHI class	VHI value	Drought severity classes
1	0-10	extreme
2	10-20	severe
3	20-30	moderate
4	30-40	mild
5	>40	no drought

Some scientific-research works were performed in a direction of the ecosystem monitoring by the change dynamics of soil use/ soil cover (LU/LC) and analysis of the change investigation [10, 11].

As a result of repetition of the active war phase (2016-2022), monitoring of the changes occurring in ecosystem was conducted, mapped and matrix of variability was compiled.

3. Analysis and monitoring

According to NDVI, compared to 1990, the area of water ecosystems decreased by 0.19% (136.3148 h), the area of moderately dense vegetation by 17.14% (12016.072 h), the area of high-density vegetation by 18%

(12613.6432 h), and the area of very weak vegetation by 28.55% (20012.9 h), it was determined that the region of areas with poor vegetation increased by 6,77 % (4753,13 ha). According to NDVI, dynamics of the vegetation process was studied on categories and the areas of the zones with stable and changeable vegetation were calculated (Table 3).

Table 3. Direction of the vegetation process.

Changes	Area (ha)	Persentage of total (%)
No vegetation	37303,19	53,2
No vegetation - vegetation	2762,847	3,9
Vegetation - no vegetation	10838,05	15,5
Vegetation	19195,09	27,4
Total	70099,177	100

A temperature of the soil surface was 2.36-28.74 °C in 1990, 5.81-31.78° in 2022. Increase of the temperature is related to disturbing of the irrigation system, deforestation, burning of the pastures, sowing areas after occupation of the soils.

According to the vegetation healthy index, degree of exposure of plants to drought stress was studied. It was determined that 1.39 % (976.913 h) is very strong, 2.95% (2065.154 h)-strong, 24.07% (16875.71 h)-mild, 26.41 % (18510.02 h)-weak, 45.18 % (31671.38 h)-background in 1990, 3.77 % (2643.534 h)–very strong, 14.21 % (h)-strong, 56.01 % (39259.79 h)–mild, 14,96 % (10490.26 h)-weak, 11.05 % (7746.878 h)–background in 2022.

The ecosystem of the zone is unstable against an effect of sensitive and exo-dynamical processes. The ecosystems of the research zone were damaged and completeness of the ecosystem deteriorated as a result of the 30-year occupation period and 44-day war. So, the soil use/soil cover (LU/LC) map-scheme was composed in this context (Figure 4).

According to the change matrix, it was determined that the serious degradation (physical, chemical and biological) occurred in vegetation which provides occurrence of the natural restoration process (Table 4). A direction of the transformation reflected negative tendency in itself.

Table 4. Change detection analysis from 2016 to 2022 in study area.

	LU/LC classes 2022							
LU/LC classes 2016	Water	Trees	Flooded vegetation	Crops	Built area	Bare ground	Rangeland	Total (2016)
Water	308,12	35,30	75,95	65,75	0,007	113,92	183,13	782,177
Trees	5,54	10417,89	0,07	148,05	8,75	3,66	582,67	11166,63
Wetland	0,71	16,88	1,21	-	-	-	27,04	45,84
Crops	10,14	93,42	0,02	2955,81	147,75	199,45	4137,09	7543,68
Built area	-	32,84	-	30,02	233,88	5,81	72,48	375,03
Bare ground	0,07	4,42	6,87	2,68	-	14,80	76,19	105,03
Rangeland	13,05	2253,50	11,79	377,84	81,79	636,96	46737,2	50112,13
Total (2022)	337,63	12854,25	95,91	3580,15	472,177	974,6	51815,8	70099,177

A main problem is to restore forest landscape in the research region. Because the zones where the forest cover spreads are susceptible to erosion. During 30-year occupation 10838.05 hectares of the forest areas were cut, the natural restoration happened in the zone with 2762.847 hectares (Figure 5).

The correlation dependence between the parameters were calculated and scattering graphic of the linear tendency was compiled for the correct assessment of the circumstances necessary for optimal development of the ecosystems of the research zone.

As a result of the correlation an optimal temperature interval at which vegetation is formed has been determined. It was determined that the vegetation was formed at the highest temperature interval in 2022 compared to 1990.

Restoration of the vegetation characteristic for the zone is a main factor in provision of completeness of the ecosystem.

4. Conclusion

During the occupation compared to 1990, in 2022 the area of severely degraded areas increased by 14.55% (10202.76%), the area of degraded areas at the background level by 14.78% (10357.91 h). At present the works which will be realized in restoration of the ecological balance should be performed taking into account the balance between two classes.

Averagely 46m^3 of soil is washed from one hectare as a result of the rainfall effect on slopes with an inclination of more than 3^0. This index is 200 m^3/h in the extreme condition. This means 328 kg of humus and up to 184 kg of NPK till per hectare. From this point of view, as a result of disturbing the ecological balance in the low and medium mountainous areas of Zangilan, tons of humus and nitrogen, phosphorus, potassium are washed out from each hectare.

At the background of military–technogenic effect, as a result of multiple increases of the anthropogenic effect and loading the degradation velocity is multiple higher in the center of the research region, in the west and south-west parts compared to south-east parts. The extent of the damage to nature and farming should be specified during the occupation in order to use potential opportunities and to get high productivity from the soils of the zone. Therefore, there is a necessary need for conduction of the field researches in the zone.

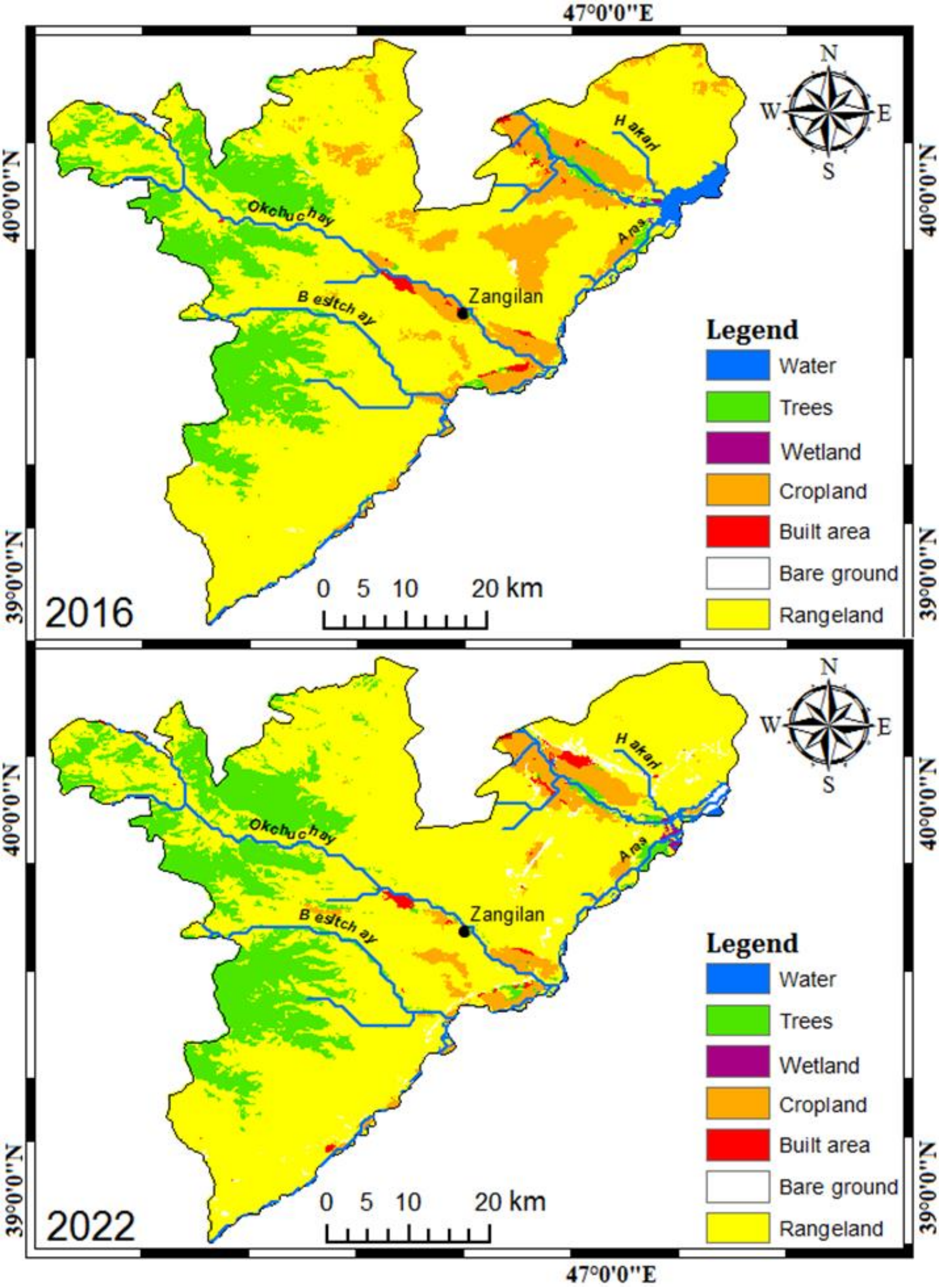

Figure 4. The LULC maps for the years 2016 and 2022 of district Zangilan.

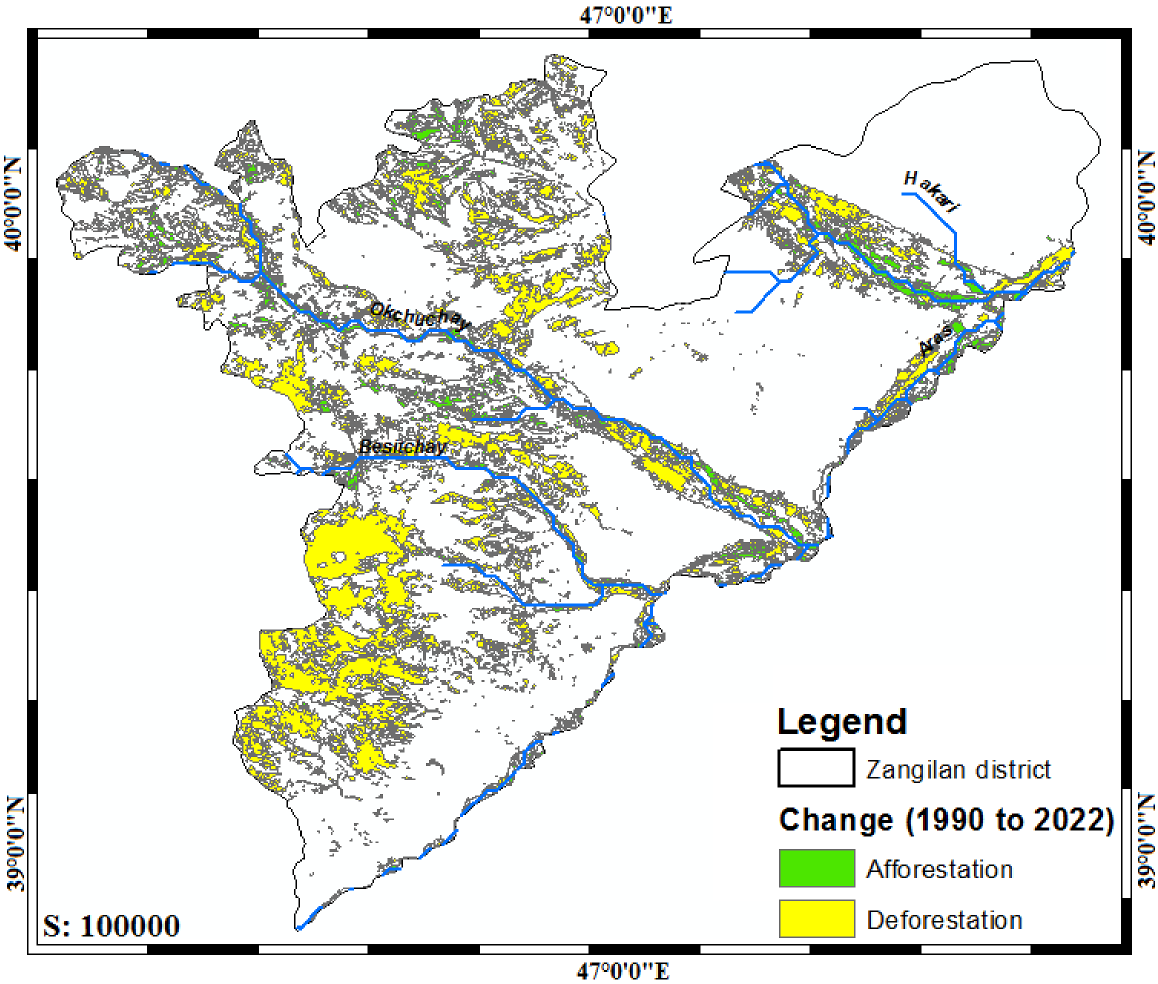

Figure 5. Afforestation & Deforestation (1990 – 2022).

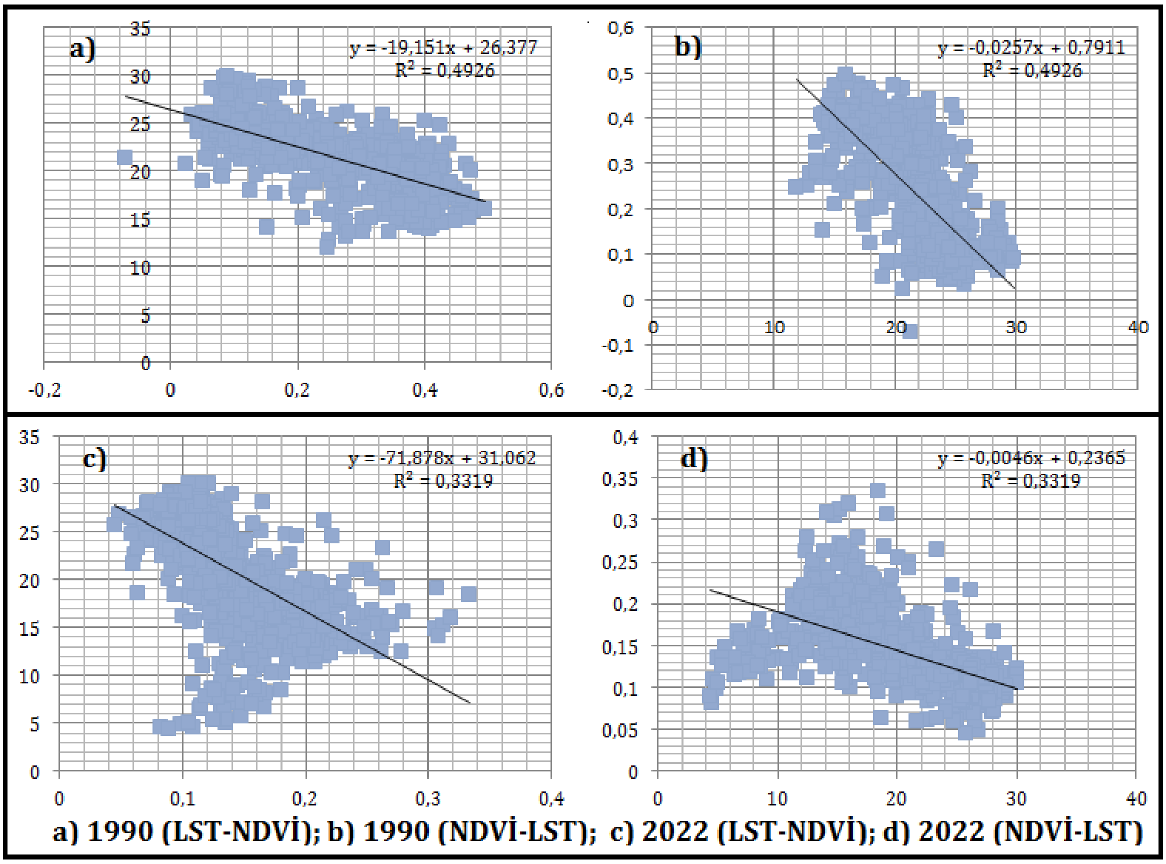

Figure 6. Correlation between NDVI & LST.

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Author contributions

İsmail Guliyev: Conceptualization, methodology, writing-original draft preparation, analysis, **Rauf Huseynov:** Software, validation, visualization, writing-reviewing

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Khrushch, O., Moskalets, V., Fedyk, O., Karpiuk, Y., Hasiuk, M., Ivantsev, N., ... & Aijjumend, H. (2023). Environmental and psychological effects of Russian war in Ukraine. Grassroots Journal of Natural Resources, 6(1), 37-84. https://doi.org/10.33002/nr2581.6853.060103
2. Ordway, E. M. (2015). Political shifts and changing forests: Effects of armed conflict on forest conservation in Rwanda. Global Ecology and Conservation, 3, 448-460. https://doi.org/10.1016/j.gecco.2015.01.013
3. Wirtz, P. H., & von Känel, R. (2017). Psychological stress, inflammation, and coronary heart disease. Current cardiology reports, 19, 1-10. https://doi.org/10.1007/s11886-017-0919-x
4. Baumann, M., Radeloff, V. C., Avedian, V., & Kuemmerle, T. (2015). Land-use change in the Caucasus during and after the Nagorno-Karabakh conflict. Regional Environmental Change, 15, 1703-1716. https://doi.org/10.1007/s10113-014-0728-3
5. Guha, S., Govil, H., Dey, A., & Gill, N. (2018). Analytical study of land surface temperature with NDVI and NDBI using Landsat 8 OLI and TIRS data in Florence and Naples city, Italy. European Journal of Remote Sensing, 51(1), 667-678. https://doi.org/10.1080/22797254.2018.1474494
6. Li, H., Liu, G., & Fu, B. (2011). Response of vegetation growth to climate change and human activities in the Three-River Headwaters based on NDVI. Chinese Journal of Applied Ecology, 31, 5495-5504.
7. Ahmed, Y. A. (2013). Potential Impacts of Climate Change on Waste Management in Ilorin City, Nigeria. AFRREV STECH: An International Journal of Science and Technology, 2(1), 45-63.
8. Arshad, S., Morid, S., Mobasheri, M. R., & Alikhani, M. A. (2008). Development of agricultural drought risk assessment model for Kermanshah province (Iran), using satellite data and intelligent methods. The First International Conference on Drought Management, 303-310.
9. Pei, F., Wu, C., Liu, X., Li, X., Yang, K., Zhou, Y., ... & Xia, G. (2018). Monitoring the vegetation activity in China using vegetation health indices. Agricultural and Forest Meteorology, 248, 215-227. https://doi.org/10.1016/j.agrformet.2017.10.001
10. Gidado, K. A., Kamarudin, M. K. A., Firdaus, N. A., Nalado, A. M., Saudi, A. S. M., Saad, M. H. M., & Ibrahim, S. (2018). Analysis of spatiotemporal land use and land cover changes using remote sensing and GIS: a review. International Journal of Engineering & Technology, 7(4.34), 159-162.
11. Rwanga S. S., Ndambuki J. M. (2017). Accuracy assessment of land use/land cover (LU/LC) classification using remote sensing and GIS. International Journal of Geosciences, 8(4), 611-622. https://do.iorg/10.4236/ijg.2017.84033
12. Oghlu, G. İ. A., & Oghlu, H. R. A. (2023). Comprehensive soil erosion risk assessment using remote sensing (on the example of Zangilan region). Intercontinental Geoinformation Days, 6, 357-359.