ГЕОГРАФИЧЕСКИЕ, ГЕОЛОГИЧЕСКИЕ И ПАЛЕОНТОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ

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ANALYZE OF DYNAMICS AND DEGREE OF ANTHROPOGENIC IMPACTS ON THE ECOGEOMORPHOLOGICAL CONDITIONS (CASE STUDY OF THE KURA-ARAZ LOWLAND AND SURROUNDING AREAS)

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Theoretical base of human effects on geomorphological environment, the evolution of anthropogenic impacts and modern situation of human activity were analyzed in the studied area. On the base of supervised and unsupervised classification of the Landsat images (1976–2017) Land use-Land cover map of the territory was compiled. The dynamic and transformation of land covers were determined with the change detection function. It was defined that the most increasing land cover in the area of transformation since 1976 to 2017 is the sown area. Due to the anthropogenic development of the study area, the largest decrease in the area of exposed (33,85%) and saline (25,43%) land cover occurred during this period.

Among the listed anthropogenic factors (oil and gas production, production of building materials, grazing, settlements, etc.), it is established that irrigation erosion has a wide radius of encirclement and a high degree of influence. With the application of Geographic Information System technologies, on the base of remote sensing data the density of the irrigation network has been computed and mapped. Ecogeomorphological assessment and zoning of the territory has been carried out. According to the comparative analysis of horizontal (stream network) and anthropogenic (irrigation network) fragmentation it was determined that the estimated maximum cost of anthropogenic fragmentation in the study area is 2,5 times higher than natural horizontal fragmentation.

Keywords: Anthropogenic factor, ecogeomorphological condition, land use-land cover map, Geographic Information System, remote sensing.

Introduction

Anthropogenic impacts along with the Earth's internal and external forces has gradually become an important agent in modern relief-forming processes (Timofeev et al., 1977; Kotlyakov, Komarova, 2007; Rozanov, 2013; Jialin et al., 2017). Being a part of nature, biosphere, human can influence any of the geomorphic processes by sculpting and transforming the landscape through the physical modification of the shape and properties of the ground in significant quantities and the relief is modified to the needs of urban development or for agricultural purposes (Meshcheryakov, 1972; Timofeev, 1981; Firsenkova, 1987; Szabó et al., 2010; Sofia et al., 2016; Xiang et al., 2019). Specially past five or six decades humans have become an increasingly important agent of geomorphological change through settlement and widespread industrialization and urbanization (Goudie, 2018; Xiang et al., 2019). The direct and indirect way of anthropogenic impact is also reflected in relief, as in other landscape components. Direct positive impacts include "conscious change" of the relief (including recultivation, prevention of harmful exogenous processes, slope terracing, phyto-melioration etc.), direct negative impacts include: transformation of the relief with modern technical means (oil and gas mining, quarrying, road building), alteration of fluvial systems, sedimentary record, etc., and the indirect adverse impacts caused by improper agricultural and tourism practices have been resulted in the development of harmful relief processes such as: soil and gully erosion, landslide, salinization, swamping etc. (Milkov, 1974; Kovalchuk, 2004; Tanriverdiyev, Safarov 2013; Migon, Latocha, 2018). Anthropogenic features may be symbolic, habitation, transport-exchange, subsistence, mining, water infrastructure, agricultural, irrigative, waste disposal, warfare, reliefoids (trench, embankment, dam, quarry, sand-pit, building) etc. (Bondarchuk, 1949; Likhacheva, 2011; Simonov, Simonova, 2012; Tarolli et al., 2019).

The human role in geomorphic change has significant value in better assessment and prediction of risk and management of potentially hazardous events. Anthropogenic impacts such as slope angle change, leaking pipes, increased loading or other alterations to drainage etc. may cause such geomorphic processes like land sliding and sinkhole formation etc. (Harden, 2014). Relationships between geomorphological environment and human may develop in two ways: a) geomorphological environment is mainly passive in relation to human (active). In other words, a geomorphological resource may be altered or destroyed by human activity (e.g., mining industry); b) geomorphological environment is mainly active in relation to human (passive). In other words, a hazard (e.g., earthquake, landslide, flooding) may damage or destroy buildings or infrastructures (Panizza, 1996).

Thus, most studies conducted in the field of anthropogenic effects on ecogeomorphological conditions express their theoretical provisions. However, studies on the evaluation of anthropogenic effects and quantitative comparative analysis and generally complex zoning for anthropogenic impacts, land use-land cover classification of the studied area with a geomorphological interpretation have not been conducted. From this point of view, the presented research work is of significant scientific and practical importance.

The Kura-Araz lowland and surrounding areas (The Eastern Kura depression), which is an important agricultural region and constitutes more than 30% of the territory of the Azerbaijan Republic, with a number of international and regional transport corridors (International Silk Road, North-Southern corridor, Baku-Tbilisi-Jeyhan oil pipeline, TANAP gas pipeline, etc.), communication lines, Kura-Baku drinking water pipeline require detailed ecogeomorphological researches here. Various types of endogenous (mud volcanism, modern tectonic movements, seismicity) and exogenous (fluvial, arid-denudation, thalassogenic, swampy and salinity) relief formation processes, including anthropogenic factors (irrigation erosion, intensive grazing, exploitation of oil and gas deposits, construction materials, etc.) create more complicated ecogeomorphological conditions and increase the relevance of the research (Tanriverdiyev, Safarov, 2002; Tanriverdiyev, Safarov 2004a; Tanriverdiyev, Safarov 2004b; Tanriverdiyev, Safarov, 2009; Tanriverdiyev, Safarov 2010; Tanriverdiyev, Safarov 2011; Tanriverdiyev, Safarov, Gasimov, 2015; Khalilov, Gasimov, 2017).

The object of the study, methods and data

The study area lies in the northern hemisphere between latitudes 38°49'09" – 40°51'48,71" N and longitudes 46°40'53,61" – 49°35'23,41" E in the east of Greenwich (Fig. 1). According to the scheme of the geomorphological division of the territory of Azerbaijan Republic, the studied area consists of Shirvan, Southeastern Shirvan, plains along Kura river, Mugan, Salyan geomorphological districts of the sub region of Kur-Araz lowlands and the districts of Alat, Harami of the sub region of Jeyranchol-Ajinohur range and the Mil, Garabagh district of the Lesser Caucasus sloping plains sub region of the region of the Kura depression of the South Caucasus province (Alizade et al., 2014).

Supervised (Maximum-likelihood algorithm) and unsupervised (ISODATA clustering) classification methods have been applied using corrected Landsat 2 MSS (1976) and Landsat 8 OLI & TIRS (2017) images with a band combination (RGB) of near-infrared (0,7–0,8 mkm), red (0,6–0,7 mkm) and green (0,5–0,6 mkm) wavelengths and multitemporal LULC maps were composed (Fig. 2). Change detection of 1976 and 2017 LULC maps was conducted (Fig. 3).

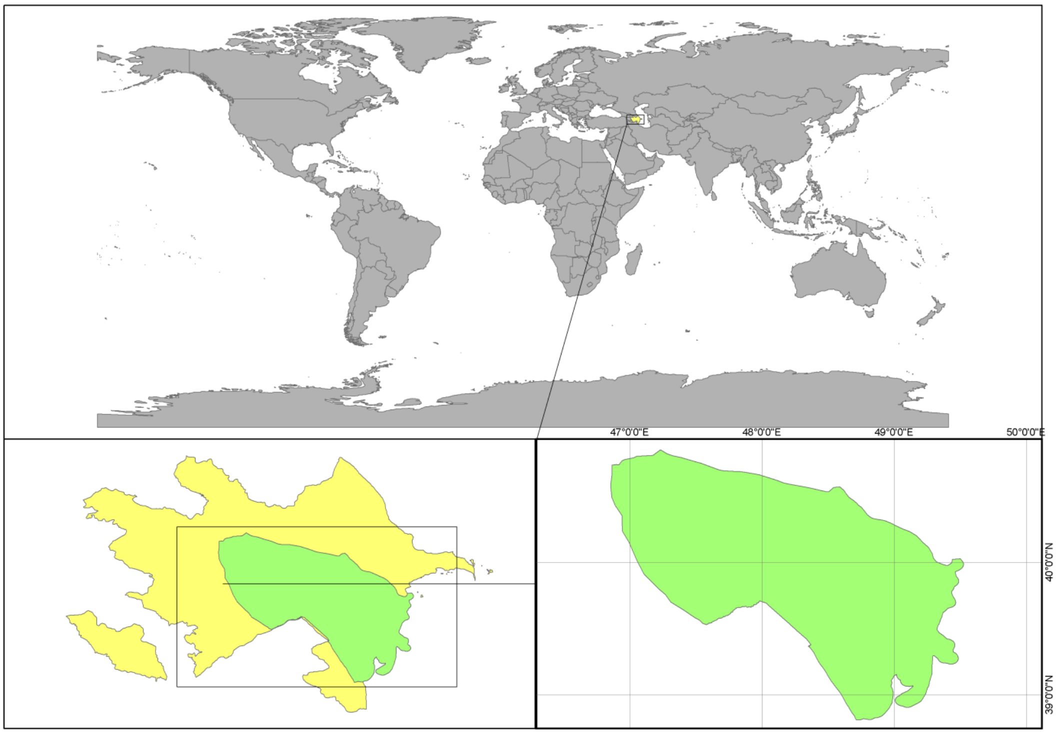
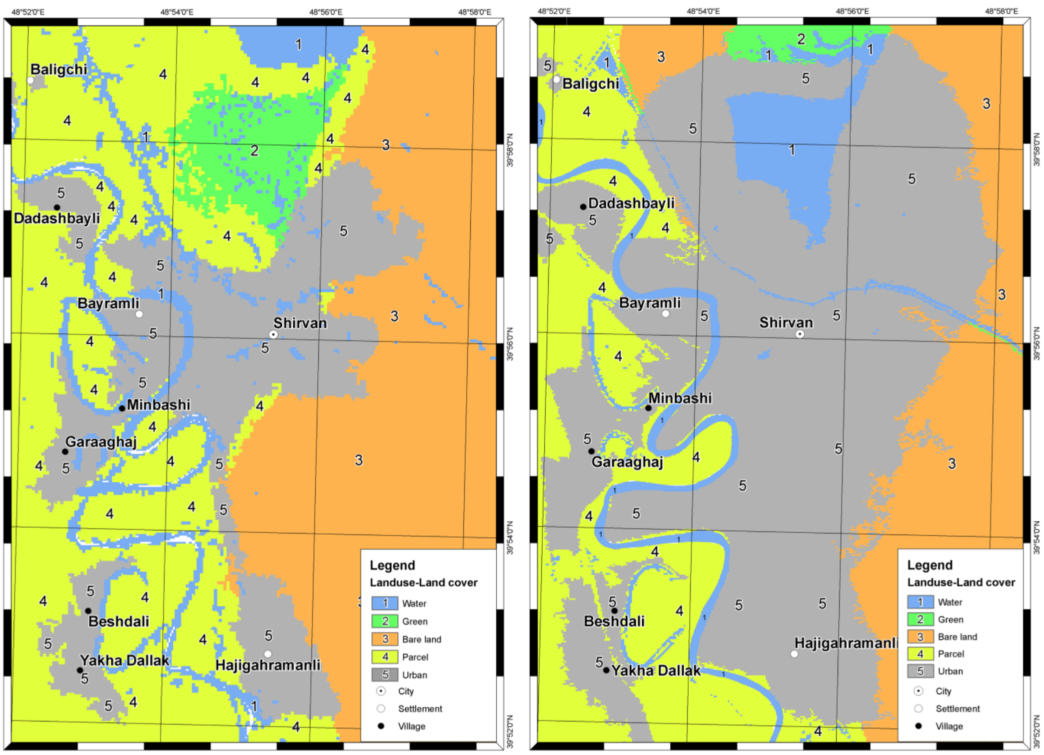


Fig. 1. The location map of the Eastern Kura depression



a) b)

Fig. 2. LULC map of Shirvan city and surrounding areas in the Eastern Kura depression: a) 1976; b) 2017

Due to the quantitative estimation of the anthropogenic factors affecting the ecogeomorphological conditions of the Eastern Kura depression, the horizontal fragmentation density of the irrigation network was calculated. For this purpose, a geodatabase of main, inter-farm and intra-farm irrigation canals and collector-drainage network has been created. As a source of information, satellite images and 1:100000 scale topographic maps were used. At the next stage, the geodatabase was statistically analyzed with the application of ArcGIS 10.5, and ecogeomorphological assessment with an evaluation of 8 points and an ecogeomorphological zoning of Kura-Araz lowland and surrounding areas was carried out.

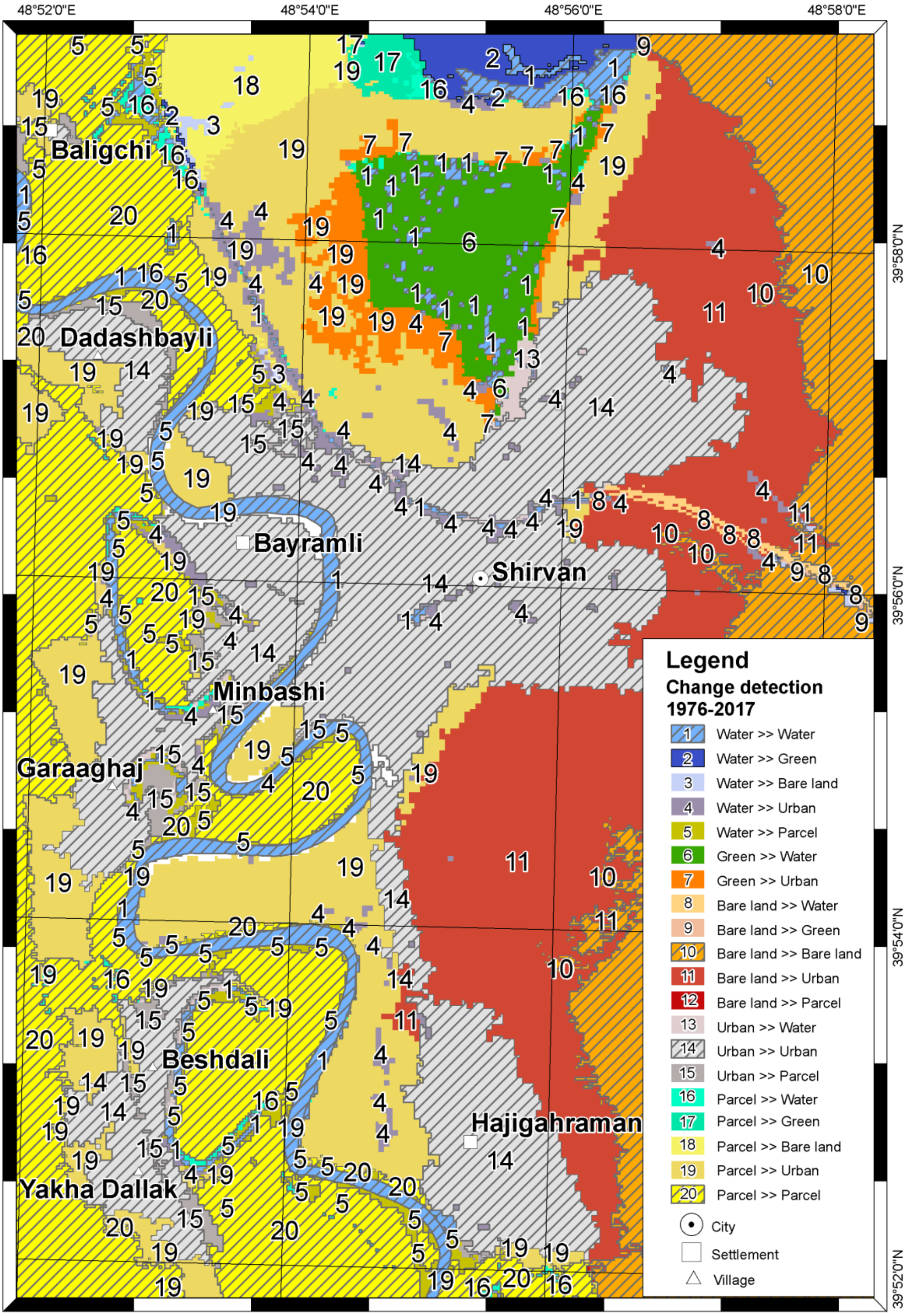


Fig. 3. Change detection map of LULC in Shirvan city and surrounding areas in the Eastern Kura depression since 1976 to 2017 year

Results and discussion

Anthropogenic factors affecting the ecogeomorphological conditions of the Eastern Kura depression in the modern era include man-caused activities (oil and gas extraction, building materials production, construction and exploitation of irrigation systems), artificial irrigation, pasture-cattle breeding, settlements and etc. The Eastern Kura depression is an important agricultural region but also an area of international importance, where the Silk Road, the North-South transport corridors pass. In addition to it, the highways of national importance in the depression, local and rural, urban and interurban roads, with asphalt and ground cover, and railways of international importance have some influence on the environmental conditions of the studied area (Eminov, 2015).

The Eastern Kura depression is the second region in the country after the Absheron peninsula for oil and gas reserves on land. In the Yevlakh-Agjabedi and Lower Kura districts located in the Eastern Kura depression, oil and gas deposits were found in the Maykop, Eocene and Upper Chalk sediments except for the Productive layer. In the lower Kura basin, the area of Muradkhanli (1971), Jafarli (1981) and Zardab (1984) (Imishli district), Mollakend (Kurdamir district), Kurovdag (1955), Kursengi (1962), Garabaghli (1962) (Salyan region), Mishovdag (1956) and Kalamaddin (Shirvan city), Neftchala, Durovdag-Babazan (Neftchala district) are being exploited. 1451,7 sq. km in the blocks of oil fields Neftchala and Durovdag-Babazan, 446 sq.km in Mishovdag and Kalamaddin oil and gas blocks have been polluted with various types of crude oil and mining waters (Fig. 4, d).

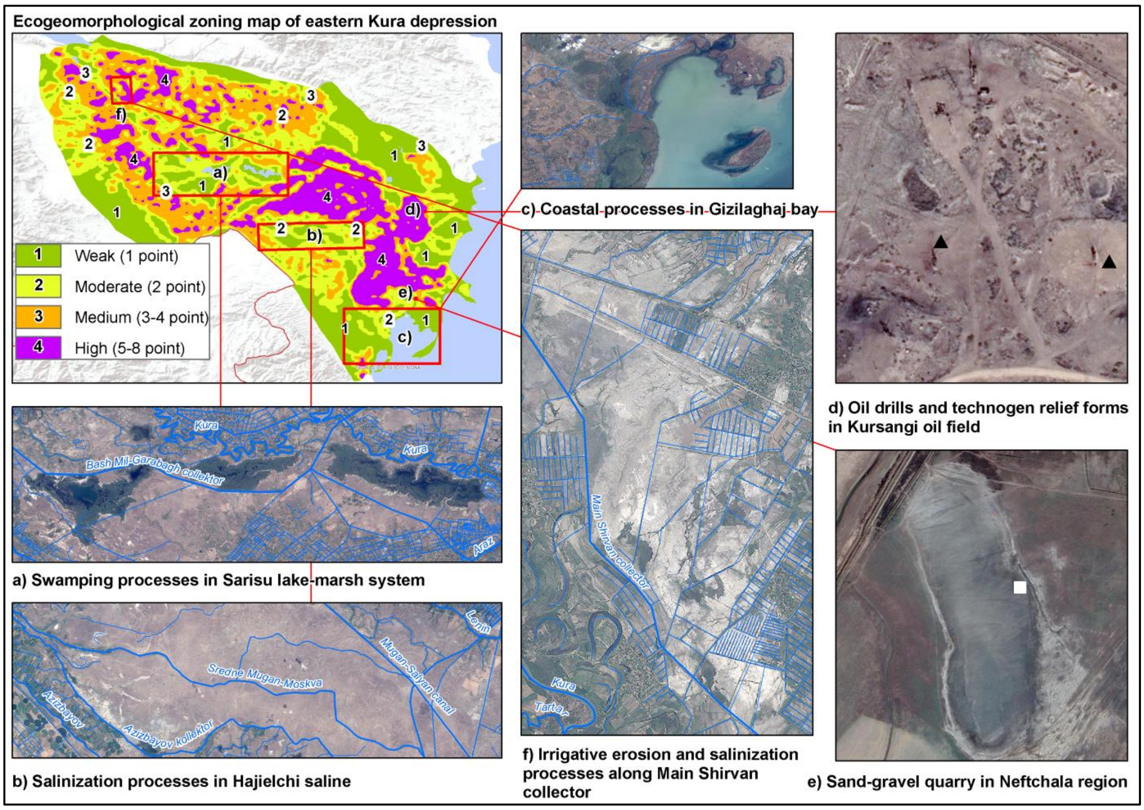


Fig. 4. Natural and anthropogenic impacts influencing ecogeomorphological conditions of the Eastern Kura depression

The wide spread of sediments also influences the availability of raw materials for the construction industry in these areas. In general, up to 13% of the construction materials produced in the country due to Kura depression. In Mingachevir and Shirvan cities, Bilasuvar, Sabirabad, Imishli, Neftchala regions (Fig. 4, e) and etc. construction materials production plants, sand and gravel quarries have led to the contamination of surrounding areas by spillage materials, deflation, erosion, and waste banks (Eminov, 2015).

The hydrological regime and environmental conditions of the Eastern Kura depression have been significantly altered through irrigation systems such as Mingachevir Reservoir, Upper Shirvan (123 km) and Upper Karabakh (172,4 km) canals, Bahramtapa hydropower station (6–7 m height of dump) and the Rasularkh (51 km, irrigating 18,3 thousand ha), the main Mugan (34 km, irrigating 65 thousand ha), Azizbeyov (46 km, irrigating 37 thousand ha) canals, the Mil-Mugan hydropower station (40 m height of concrete dump, with length of 1026 m) and the main Mil canal (37,1 km), etc. Along the main canals there are large settlement and planting areas, orchards, intra-farm and inter-farm distribution channels, a dense network of drainage and collectors, and other anthropogenic complexes. Perennial irrigation and melioration measures caused generating of anthropogenic relief forms here (Pashayev, Hasanov, 2013).

On the base of LULC analyze it was determined that the sown areas were less transformed land cover (11,25%) during the years 1976–2017 and most transformed land covers were erosion-accumulation areas (47,62%). The largest quantitative transformation was between the areas of erosion-accumulation and sown areas (Fig. 3). 1828,487 sq. km (33,85%) of erosion-accumulative areas have changed into sown areas (Table 1).

Table 1

Transformation of land cover in the Eastern Kura depression

Land cover, sq. km (%)	Water (2017) – 1657,29	Green (2017) – 847,84	Bare land (2017) – 3552,63	Salinity (2017) – 3475,2	Settlement areas (2017) – 2520,19	Sown areas (2017) – 15287,09
Water (1976) –1854,95 (100)	1259,1 (68)	156,7 (8,4)	39,18 (2,1)	74,84 (4)	41,67 (2,2)	283,79 (15,3)
Green (1976) –891,45 (100)	99,8 (11,2)	549,42 (61,63)	36,38 (4)	100,02 (11,22)	3,06 (0,34)	102,76 (11,52)
Bare land (1976) – 5401,544 (100)	211,01 (3,9)	88,04 (1,6)	2829,16 (52,38)	377,73 (6,99)	67,1 (1,24)	1828,49 (33,85)
Salinity (1976) – 4222,289 (100)	30,28 (0,72)	20,42 (0,48)	302,91 (7,17)	2766,13 (65,51)	32,43 (0,77)	1070,11 (25,34)
Settlement areas (1976) – 2196,23 (100)	6,70 (0,3)	2,92 (0,13)	14,31 (0,65)	11,22 (0,5)	1654,36 (75,)	506,72 (23,07)
Sown areas (1976) – 12830,3712 (100)	75,77 (0,59)	34,83 (0,27)	330,70 (2,58)	151,19 (1,18)	722,65 (5,63)	11515,22 (89,75)

The irrigation network, which creates an ecogeomorphological tension in the studied area and is the main anthropogenic factor has a large impact scale (Gasimov, 2017). The researches show that in the Eastern Kura depression agro-aggregate sediments with a thickness of 1-1,5 m were collected from irrigation since ancient times (Yunusov, 1998). Anthropogenic horizontally fragmentation indicators were calculated and mapped based on the created geodatabase of irrigation network. The density of the irrigation network ranging from 0 to 7,23 km/sq.km is estimated at 1–8 points (Table 2). Four ecogeomorphological districts were distinguished in the study area based on tension prices: weak (1 point), moderate (2 points), medium (3–4 points) and high (5–8 points) tension regions. An ecogeomorphological map for the anthropogenic impact of the Eastern Kura depression has been compiled using the ArcGIS 10.5 / ArcMap application (Fig. 5).

The weak-tension (1 point) regions compose 28,222% of the total area (7394,359 sq. km), include inner depression uplands, ridges that are unfavorable, unappropriated and poorly adapted for economic activity. The southeastern Shirvan, Salyan plains, Hajiyolchu salinity, Sarisu lake-marsh system, where intensively developed deflation, eolian accumulation and salinization, swamping processes, and Caspian Sea shore zone where abrasion is observed, constitute this region (Fig. 4, a, b).

Table 2

Fragmentation degree of irrigation network in the eastern Kura depression

Irrigation network density, km/sq.km	Area		Fragmentation degree	Area		Tension, point
	sq.km	%		sq.km	%	
0–0,2	7394,359	28,222	weak	7394,359	28,222	1
0,2–1	7789,135	29,729	moderate	7789,135	29,729	2
1–1,5	3461,947	13,213	medium	6266,749	23,918	3
1,5–2	2804,802	10,705				4
2–3	2642,534	10,086	high	4750,603	18,132	5
3–4	1372,57	5,239				6
4–5	536,866	2,049				7
5–7,5	198,633	0,758				8
Total area	**26200,845**	**100**		**26200,845**	**100**	

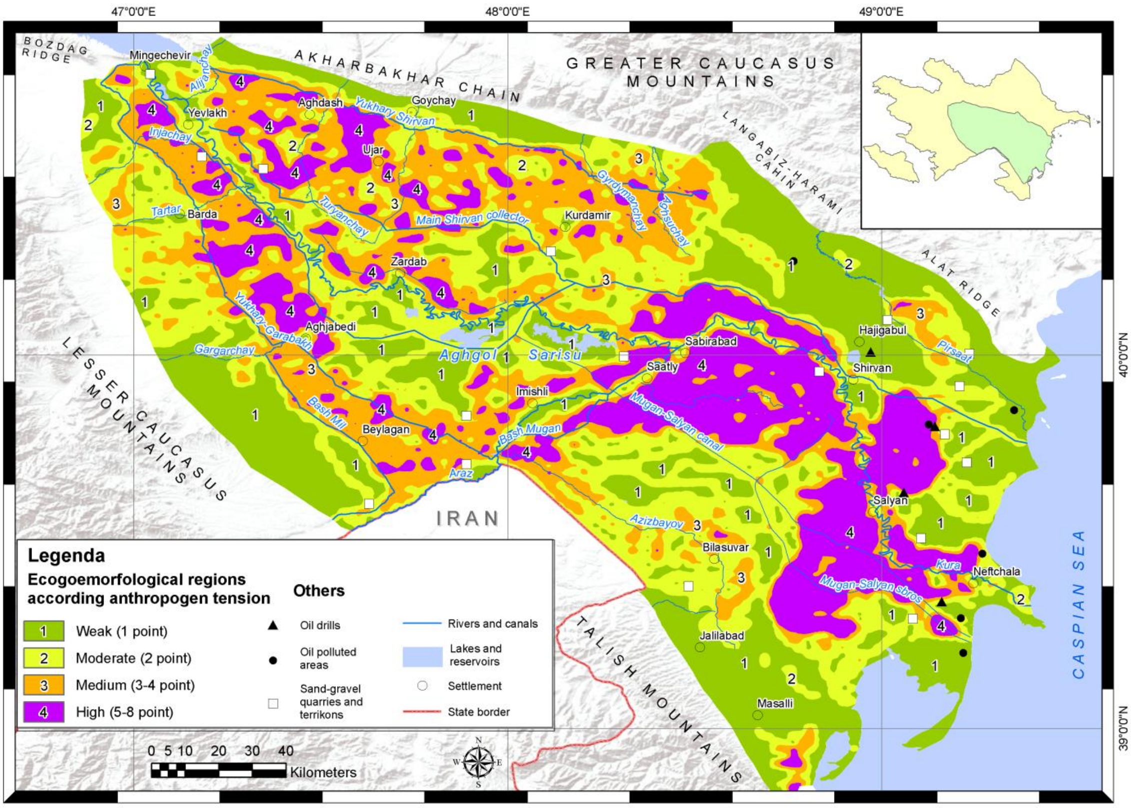


Fig. 5. Distribution Map for Anthropogenic Tension in the Eastern Kura depression

The moderate tension (2 points) region is observed in the Shirvan, Sabaduzu and Navahi plains, Southeastern Shirvan, Southern Salyan, Southern Mugan plains, Northern Lankaran lowland, Eastern Mil and Garabagh plains. The region has 7789,135 sq. km and is 29,729% of the total area. Moderate tension regions, which are partly favourable for economic activity, are characterized by alluvial, alluvial-proluvial, alluvial-lake-flow, alluvial-sea, alluvial-delta, proluvial-deluvial, deluvial exogenous processes, which have positive influence. Such negative exogenous processes like flood and erosion of banks along Kura and Araz river, gully and gorge erosion in Sabaduzu plain, eolian processes and salinization in Navahi, southeastern Shirvan and southern Mugan plains, intensive swampy processes in Gizilaghaj bay and Sarisu lake-marsh are observed (Fig. 4, a, c).

The medium tension (3–4 points) region covers 23,918% (6266,749 sq. km) of the total area. This region includes Shirvan plain, Navahi depression, parts of Mil and Garabagh plains located between Kura river and Upper Garabagh-Main Mil canals. The medium tension ecogeomorphological region is observed locally in the areas that is situated in the west of Upper Garabagh - Main Mil canal, also in southeastern Shirvan, Salyan, Northern Mugan plains, Lankaran lowland. Exemplary processes are characteristic of the meduim tension region, which is typical for moderate tension. Density of irrigation network within the district is 1–2 km / sq. km.

The high tension (5–8 points) region has 4750,603 sq. km area and constitutes 18,131% of the total area. High tension district covers the eastern part of Shirvan, Southeastern Shirvan, Salyan, Northern Mugan plains, Lankaran lowland, Mil and Garabagh plains, where intensive development of irrigation erosion occurs. The density of the irrigation network within the district varies from 2 to 7,2 km / sq. km. The positive exogenous processes in moderate and medium tension regions are also observed in high tension regions. This has created favorable conditions for the development of irrigation agriculture in the mentioned area. However, intrinsic anthropogenic effects within the high tension region resulted in a number of adverse exogeneous processes. Expiry of the main line, intra-farm and inter-farm canals, as well as poor irrigation and drenage have led to the infiltration of irrigation water in the irrigated areas, the increase in ground water levels, and the swamping and salinization processes (Fig. 4, f). For example, an area of 1660 sq. km along the Upper (Yukary) Shirvan Main Canal, commissioned in 1958, with a groundwater depth of up to 3 m, covered 29% of the total area in 1951, 61.9% in 1960, 87.6% in 1965, and in 1977 it was 91.3% (Mammadova, 2003).

Conclusions and proposals

During the 41-year period (1976–2017) as a result of the anthropogenic transformation of the area, irrigation erosion and accumulation of sown areas increased by 2456,72 sq. km (245672,28 ha) and settlement areas increased by 323,96 sq. km (32396,13 ha). The average annual increase in sown areas and settle areas during the mentioned period amounted to 59,92 sq. km (5992 ha) and 7,9 sq. km (790 ha) respectively. The most increasing land cover in the area of transformation since 1976 to 2017 is the sown area (3791,87 sq. km, 29,55%). In general, 15,3% of the water bodies (283,786 sq. km), 11,52% of vegetation cover (102,76 sq. km), 33,85% (1828,487 sq. km) of erosion-accumulation areas, 25,34% (1070,115 sq. km) of salines, 23,07% (506,719 sq. km) of settlement areas have turned into sown (cultivated) areas (Table 1).

A comparative analysis of natural and anthropogenic impacts on the ecogeomorphological conditions of the studied area was performed on the natural horizontal (stream network) and anthropogenic (irrigation network) fragmentation. As the amount of fragmantation increased, natural horizontal fragmentation showed a decrease in the same irradiation compared with anthropogenic fragmentation (Fig. 6).

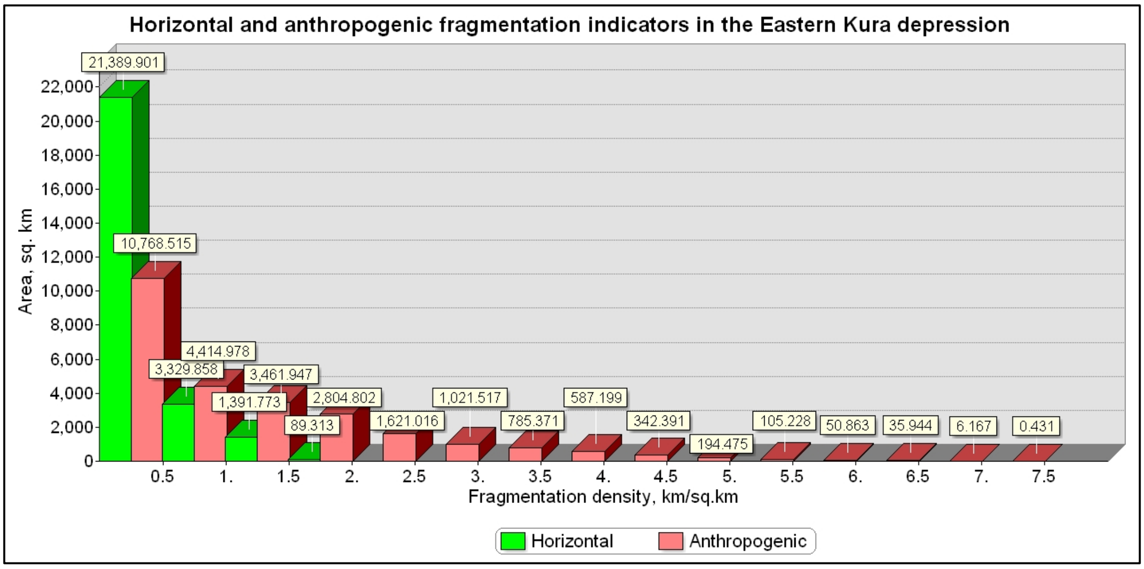


Fig. 6. Area indicators of natural and anthropogenous horizontal fragmentation in the Eastern Kura depression

The estimated maximum cost of anthropogenic fragmentation (7,23 km / sq. km) in the study area is 2,5 times higher than natural horizontal fragmentation (2,92 km / sq. km). This proportion also gives the total length of relief forms as a result of linear erosion (21,37% of the total length is natural, and 78,63% is the length of relief forms formed by the influence of anthropogenic factors). 7,19% of the total length of the irrigation network falls on trunk, 3,75% in intra-farm, and 89,06% in small inter-farm canals.

In order to prevent the development of swamping, saline and erosion processes along the trunk and intra-farm canals in the Eastern Kura depression, first of all, it is important deepening the bottom of these canals, and cover with concrete, asphalt-concrete, bitumen, special clay, etc. on the surface. It is important improvement of the taking irrigation water from the canals and to adhere to the irrigation norm. Also, the maximum and minimum levels of water in the canals and collectors should be strictly controlled not to exceed the intended scope of the project, and repairs should be carried out in a timely manner. It is necessary to pass from the classic method of irrigation to the modern drip irrigation method.

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АНАЛИЗ ДИНАМИКИ И СТЕПЕНИ АНТРОПОГЕННОГО ВОЗДЕЙСТВИЯ НА ЭКОГЕОМОРФОЛОГИЧЕСКИЕ УСЛОВИЯ (НА ПРИМЕРЕ КУРА-АРАЗСКОЙ НИЗМЕННОСТИ И ПРИЛЕГАЮЩИХ ТЕРРИТОРИЙ)

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Были ведены анализы воздействия человека на геоморфологическую среду и современного состояния результатов человеческой деятельности в исследуемом районе. На основе контролируемого и неконтролируемого дешифрирования многозональных снимков Ландсат (1976–2017 гг.), выполненных с применением Географических Информационных Систем была составлена карта землепользования и земельного покрова исследуемой территории. Шесть типов земельного покрова: вода, растительность, обнаженные земли, засоленность, посевные площади и селитебные территории были выделены при геоморфологической интерпретации, на основе дешифрирования. Была вычислена площадь и выявлено уменьшение и увеличение каждого типа земного покрова. Динамика и трансформация земного покрова определялись при помощи функции обнаружения изменений. Например, было выявлено, что наиболее увеличенной земельным покровом в зоне трансформации с 1976 по 2017 год является посевная площадь. За счет антропогенного освоения исследуемой территории произошло наибольшее уменьшение площади обнаженных (33,85%) и засоленных (25,43%) земельных покровов в течение указанного периода.

Среди перечисленных антропогенных факторов (добыча нефти и газа, производство стройматериалов, пастбищное скотоводство, поселения и др.) установлено, что ирригационная эрозия имеет наиболее широкий радиус и высокую степень влияния. С применением Географических Информационных Систем на основе данных дистанционного зондирования была рассчитана и закартирована плотность ирригационной сети. Проведена экогеоморфологическая оценка и районирование территории. Согласно сравнительному анализу горизонтальной (долинная сеть) и антропогенной (ирригационная сеть) плотности расчленения было установлено, что вычисленная максимальная стоимость антропогенной расчлененностей в исследуемой зоне в 2,5 раза выше, чем таковая естественная горизонтальная.

Ключевые слова: Антропогенный фактор, экогеоморфологическое состояние, карта землепользования и земельного покрова, географическая информационная система, дистанционное зондирование.

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