

Geospatial differentiation of the Banjaluka region environment

Dušica Pešević¹

¹Faculty of Natural Sciences, University of Banjaluka, the Republic of Srpska, BiH

Corresponding author: Dušica Pešević, Faculty of Natural Sciences, University of Banjaluka, the Republic of Srpska, BiH,
e-mail: dusicapesevic@gmail.com

Abstract. Geospatial differentiation of the Banjaluka region environment, which is a result of symbiosis between man and natural environment, is performed on the basis of its individual elements (air, water, soil, ecosystem preservation, etc.) the changes of which affect the total condition of the environment. In addition, it is also performed on the basis of the dominant anthropogenic activities and interaction among the complex systems existing within a space, which have (or may have) a significant impact on the environment quality. The concept of geospatial differentiation of environment refers to the definition of protection measures and improvement of the target geospace, procedures and programs for the reconstruction of a degraded environment, and an investment planning in order to improve the existing environment. This article presents results of the research as map representation of a categorized environment, on the basis of production of GIS database, which helps determine priorities in order to stop further environment degradation, ranging from critically polluted urban, mining, and industrial centers, ecologically valuable areas to the total target geospace.

Key words: geospatial differentiation, environment, degradation, categorization

1. INTRODUCTION

The paper studies Banjaluka region, which encompasses eight municipalities as follows: Banjaluka, Laktaši, Prnjavor, Srbac, Gradiška, Čelinac, Kotor Varoš, and Kneževo. Thus, the defined region's borderline is the Sava River in north, the Ugar River in south, the Ukrina River in east (except the lower stream), and the Kozara and Prosara mountains in west. The relief is Peripannonian in its morphological structure – along the Vrbas river valley and its tributaries, in plains along the deltas, mountains, and finally karst. The main morphological feature of the north Banjaluka region, apart from Horst Mountains (Kozara, Prosara, Motajica) is the major macro fan of the region – Lijevče polje. The south part of the Banjaluka region covers the medium-sized mountains (Manjača, Čemernica, Uzlo mac) and the basins and river valleys. The geospace of the Banjaluka region is defined by the moderate continental climate that turns into Pannonian as we move northwards and northeastwards, and finally the climate is sub-mountain as we move southwards. The major river stream of the region is the Vrbas River, and its largest tributaries (with watershed surface larger than 100 km²) are Ugar (which is the southern borderline of the

region), Vrbanja (the longest Vrbas tributary), Svrakava, Turjanica, Povelich, and Osorna.

Banjaluka region covers the surface of 4 685 km², which is around 19 % of the Republic of Srpska territory. According to the preliminary results of the 2013 population census [14] the region has the population of 399,469 people, which makes it the most densely populated region inhabited by almost 30,1 % of the country's population.

Banjaluka also holds a crucial traffic position. The most frequent road line cuts the region in order to end at the Adriatic coastline in south and Posavina and Pounje in north. Nowadays, the crucial traffic issues to be addressed are the connection with European road network Vc, Banjaluka-Novigrad and Banjaluka-Doboj railways, and air traffic line at the Mahovljani airport.

According to ecological-vegetation regionalization of Bosnia and Herzegovina done by V. Stefanović [17] Banjaluka region mostly belongs to Peripannonian area, whereas its minor southern parts belong to inland Dinarides (several limestone and dolomite massive and plateaus).

Banjaluka region disposes of significant commercial potentials (natural, infrastructure, and human). Nevertheless, in modern days, due to general economic problems, system transition, and

consequences of the previous war, the region is still stagnant when it comes to the total commercial development. Many industrial facilities were devastated during the 1992-1995 war, and the decrease of industrial production, especially chemical and electric industries, is typical of the general condition of industry in both Banjaluka region and the Republic of Srpska.

The settlement network of our target region covers 354 settlements (singled out in eight municipalities), which are mainly dispersed and do not share a uniformed demographic, morphological, functional, and other features. Changes in the settlement network refer to the concentration along the major roads (particularly along Gradiška – Banjaluka road) and around the central towns. Key issues of the spatial development are illegal households and facilities, the lack of communal infrastructure, irrational usage of the city area, intensive construction of multistoried housing facilities, and inadequate proportion of green fields.

2. PRINCIPLES AND METHODS OF REGIONALIZATION OF THE BANJALUKA REGION GEOSPACE

The amount of scientific and professional papers best witnesses the importance of regionalization, which discusses the rational causes of regional classification. These papers usually address the principles and criteria of regionalization and (dis)balanced regional development. The world scientific bibliography constantly discusses problems of regionalism, which is treated as both an approach and principle of “scientific knowledge of spatial differentiation and integration, development management, planning, and arrangement of geographic space” [16], but a uniformed standard of regionalization still does not exist.

Geographical regions are relatively differentiated spatial units, which are different from other units by their total content, both natural and social. Unlike physiognomic regionalization of homogenous geographical spatial units, functional regionalization is primarily based upon the principle of regional spatial organization.

M. Lješević [6] claims that „in order to define a region as a part of geographical space with its typical environment, structure and system that differs from another part of geospace by its qualitative and quantitative features, we also have to address a spatial-qualitative hierarchy of that geosystem. “

A first step towards the regionalization of the Republic of Srpska was done by R. Gnjato [2], according to whom „on the basis of standard criteria of the nodal-

functional principle of geographical regionalization, the Republic of Srpska is conditionally differentiated into four regions, which make an integrated spatial-functional unit that is to some extent a sovereign state unit, due to logic and systematic actions of the factors of inter-regional integration. “ A final goal of one such concept of organization of geographical space and differentiation into geographical units (regions) was a uniformed and prosperous development based upon functions of the major development centers (nodes) – a trigger and medium of regional development [2]. The application of basic criteria within the Republic of Srpska regionalization in accordance with the nodal-functional principle, there are four conditional nodal-functional regions, among which Banjaluka region has the largest population and size, but there are also several subsystems, i.e. mesoregions singled out. Mesoregions are functional and gravitational areas of Prijedor and Mrkonjić Grad, and the subregion is the functional and gravitational area of Gradiška.

In his analysis of spatial structure of RS industry from the aspect of industrial commerce and gravitational relations within the Republic of Srpska, Đ. Marić [9] singled out ten areas, in which Banjaluka area fully matches the target geospace of this paper, i.e. it encompasses all eight municipalities. In addition, the 1996-2015 RS Spatial plan (step-by-step plan) took the borderline of the eight municipalities in order to determine the borderline of the region in which Banjaluka was the macro regional center. The Spatial plan up to 2015 defined six mesoregional units, in which Banjaluka covers Mrkonjić Grad subregion, which is being left out from our study. Hence, the defined area of Banjaluka region is approximately limited by the Sava River in north, the Ugar River in south, the Ukrina River in east (except the lower stream), and the Kozara and Prosara mountains in west.

3. CRITERIA OF GEOSPATIAL DIFFERENTIATION OF ENVIRONMENT

According to M. Radovanović [16] social development is manifested via „multiplex relations between society and natural environment through a fast multiplication of their mutual connections and parameters, deviations of a dynamic balance, regional and structural disproportions between natural systems on one side and intensity and nature of anthropogenic actions on the other...“, i.e. via the evident quantitative and qualitative changes within „the overall interaction between society and nature, man and his natural surroundings“. As we face the growing problems of the total social-economic development manifested through

the environment deterioration, the concept of regional differentiation of environment may be observed as a study of this macrosystem in all its complexity, dynamics, and variety in order to estimate the patterns and optimal possibilities of regulating relations between the human society and nature in accordance with differentiated spatial units [6]. In order to study the environment quality within a specific geographic space and apply the findings (starting with fundamental science all the way to spatial and social planning and construction), it is necessary to estimate the specific differences among separate parts of a unit.

Differentiation of environment, the integral part of general geographical regionalization and theoretical-methodological and theoretical-gnoseological ideas of region and regionalization clearly point out that regionalization of environment along with its phenomena and processes cannot be observed or interpreted separately but only within a larger system, i.e. the general geographical system. Hence, a regular definition of the term environment region is closely connected with features of general geographical region and issues of general geographical regionalization.

Lješević and Miljanović [6] claim that „it is difficult to perform a spatial-regional differentiation of environment and integrate the issues of environment per different regions because the environment is not physically bordered“ and that „some features are impossible to express quantitatively“. An additional problem is the fact that there is no unique system of monitoring and no uniformed environmental IT system, which might help us perform a thorough spatial-regional differentiation of environment within a specific geospace.

Environmental issues are also in connection with specific circumstances and they reflect the interaction among complex systems existing within a space. The procedure of spatial-regional differentiation of environment is based upon principles of ecological regionalization (hierarchy principle, genetic single gender, and complex typicality) and regionalization criteria, which might help perform a spatial-regional differentiation of environment, and according to M. Lješević and D. Miljanović [6] these are as follows: condition of environment (water, air, soil, vegetation), criterion of potential endangerment, criterion of population density, criterion of commercial activity division, and criterion of functional connection (infrastructure and assets). The basis of a conditional ecological regionalization, according to these authors, is the differentiation of geographic (life) environment, which takes into account interrelations and

interdependency between environment and its social-economic surrounding.

The population density criterion, i.e. anthropo-pressure of a space, is taken as one of criteria for geospatial differentiation of environment because environment is most degraded within areas of „poorly controlled processes of industrialization, urbanization, and usage of chemicals in agriculture“ [7].

The cross section of environment condition is a priority criterion although geospatial differentiation of environment may be performed on the basis of its individual elements (air, water, soil, ecosystem preservation, etc.), whose alterations affect the total environment. In addition, there are dominant anthropogenic activities existing within a space that also may largely affect the environment quality. The concept of geospatial differentiation of environment targets at measures of protection and improvement of a studied space, procedures and programs for the reconstruction of the degraded environment, and uses the differentiation in order to plan investments in improvement of the existing environment condition.

In order to take adequate measures of protection, preservation, and improvement of Banjaluka region environment quality, it is necessary to have large knowledge of the causes and evaluation criteria as well as the basic processes of environment degradation of the aforementioned geospace.

4. CRITERIA FOR CONDITION OF BANJALUKA REGION ENVIRONMENT

From the environmental aspect, Banjaluka region is a complex and partly degraded environment characterized by the following problems: pollution of surface and underground waters, air pollution, partial soil pollution by agrochemicals and hard waste, and degradation of space via illegal constructions followed by a lack of adequate communal infrastructure.

Air pollution. Within Banjaluka region, there are no major pre-war industrial pollutants that might threaten the air quality. The most significant air pollutants within the city area are wood industry, metal industry, leather industry, waste disposal, and local solid fuel boilers. Most of the pollution emission originates from the fossil fuel burning from energetics and traffic, and the city heating systems, both general and individual. Part of the pollution is due to the air transfer of air pollutants coming from the neighboring countries within the bordering areas. In order to talk about the portions of pollutants within the total pollution, it is necessary to keep records of pollutant cadaster and emission cadaster in order to keep track

of pollution sources per amount and type, along with both short-term and long-term programs for air pollution protection.

Continuous measurements and monitoring of air quality is currently performed at five urban sites in Banjaluka (Borik, Paprikovac, Obilicevo, and Centar) which are all under the authority of Banjaluka City Hall and make a local network together with Lazarevo site which is under the jurisdiction of the Republic Weather Institute. At a stationary ecological laboratory, currently the emission concentration of SO₂, NO, NO₂, NO_x, CO, O₃, PM₁₀ and grime are being measured in Banjaluka. In addition, the air quality station regularly measures all the meteorological measurements of atmospheric condition and pollution as well as the spreading of pollutants in air. As we analyzed the data collected for 2005-2010 period in Banjaluka for mean annual concentrations of air pollutants (SO₂, NO, NO₂, NO_x, CO, O₃ и PM₁₀) (PXM3 PC, 2011) we may infer that the amounts were within the defined limitations as regulated by the Rulebook on limiting values of air quality (RS Official Gazette, No. 39/05). The excess of daily limited value for PM₁₀, which according to the Directive on air quality values [18] was 50 µg/m³, was registered at almost all sites in Banjaluka in 2013 (except at Obilicevo site). In 2013, there was also the excess of maximum daily concentration of carbon monoxide, which was 5 mg/m³, at two city sites (Center and Borik) [19]. The air quality is worsened during winter due to emission from stationary sources (small boilers). The reason is the poor quality fuels from the City heating center, i.e. the coal was being enriched for the purpose of small heating boilers. Another crucial air pollutant, especially in city center, is the inadequately regulated traffic, which often comes to a halt and causes high emission of product of incomplete combustion.

The valley-located city limited in south due to relief causes the lack of strong winds that could help ventilate, which further causes high amounts of air pollutants in lower atmosphere. This is typical of wintertime because temperature inversion disables vertical air flow. Nevertheless, starting with the defined tolerable values [18] and taking into account the measurement results for 2012 and 2013, Banjaluka air was within the first category (clear and poorly polluted) because no defined value was exceeded. In 2013, we monitored the acidity of precipitation at Lazarevo meteorological station. Of the total number of days, the analysis was performed for 83% of rain samples, of which 2.18% had mild Ph acidity values [19].

In other Banjaluka municipalities, no continuous monitoring is being run. In Gradiska, monitoring is

performed occasionally at only one site. An additional problem is the fact that the air quality measurement network does not include measurement of the most harmful traffic pollutants, such as gas, hovering particles (PM 2,5), and polyaromatic carbon hydroxides. As we observe the general situation of Banjaluka region, and the Republic of Srpska, we may infer that monitoring is generally poor and it is necessary to improve it, first by installing new and modern equipment, stations, sizers, and a national referential laboratory.

Noise. Measurement of noise level at city center locations implies that the noise level exceeds the designated values and the noise ranges from 5 to 17 dB (A) during the day and from 4 to 12 dB (A) during the night. During the day, the noise is most affected by traffic and many coffee shops. Measurement along the main roads imply that noise is above the limit, both during the day and night, and the excess ranges from 5 to 14 dB (A) during the day, and from 4 to 12 dB (A) during the night. We should pay attention to the fact that noise limit was exceeded near hospitals, schools, recreational centers, and public surfaces [5].

Water pollution. One of the indicators of city environment condition is the drainage and treatment of waste water and protection of high quality water. According to statistics, in Banjaluka region municipality centers 70% of population drains water into public sewerage, and 30% into private sewerage. Speaking of sewerage system in municipal centers, we found the following properties in common:

- Waste water drainage is performed in mixed systems, except in Srbac and Celinac, where there are incomplete separation systems (mostly collecting only feces);
- Waste water is being drained directly into water systems without refinement (in Celinac, there is a facility for water refinement, but usually it is out of order);
- Only few industrial users, who use public sewerage, is equipped with pretreatment system of used water;
- In cases of heavy rain, waste water often overflows the roads, which makes us infer that the sewerage capacities are insufficient.

Disposal of waste water in rural settlement is done mostly through private sewerage or the water is drained directly into nearby water streams. The Vrbanja River is the final recipient of 1.500 sewerage pipes 45 kilometers long.

Most waste water from the urban settlements (including waste water from industrial systems) is

drained into water streams (around 92,8%), and the rest is drained into groundwater without refinement. Other industries do the same thing and drain their water into the Vrbas River (around 97,1%). According to available data, Banjaluka as the largest city in the Republic of Srpska, has 25 locations of waste water drainage into the Vrbas River. The total load of the Vrbas River in Banjaluka city territory is 400000 EPN (equivalent to population number) with 250000 EPN sanitary water and 150000 EPN industrial waste water [3]. The amount of waste water is around 2,5 m³/s. In the city of Banjaluka, there is no central system for refinement of waste water. Some industrial waste water is treated within their facilities but most of the water is being drained directly into the recipient. The existing industrial waste water system is out-of-date and does not work, so the technology they have does not meet specific criteria.

The outlets of mixed sewerage, which partly collect industrial waste water, are introduced into the Vrbas ranging from Novoselija to Lazarevo settlements without refinement. Some parts of the city have no sewerage. The collection of sanitary waste water is performed in inappropriate private sewerage or they are directly drained into the neighboring water streams. In addition, there is no precipitation water drainage in some parts of the city as well. Most settlements drain the precipitation water into fecal collectors, which is a large problem for the future introduction of fecal water treatment in central facilities.

The systematic monitoring of water quality is performed by the Republic Weather Institute in Banjaluka via the authorized Water institute Bijeljina. The Vrbas River assessment is done four times a year at three locations (Novoselija, Delinasino selo, and Razboj). The report results over the last five years indicate that the Vrbas water quality upstream from Banjaluka is the 2nd class water quality, and downstream from Banjaluka it is the 3rd class quality water (among five possible categories), which is a direct consequence of high amounts of non-refined waste waters both communal and industrial. Microbiological indicators suggest that the Vrbas is most affected at Delibasino selo location (the point where the Vrbas River leaves Banjaluka) where the values of total colimorph bacteria belong to the worse, 5th category [19]. Downstream from Banjaluka, the Vrbas has some uncontrolled pollutants, especially artificial compost and pesticides that come from drainage from the neighboring agricultural surfaces and play a significant role in the amount of general pollution. Drainage potholes and stable compost depots, along with the waste water, largely affect the water quality in Lijeve

polje. Rural areas of Lijeve polje have no connected sewerage system, so there is a potential threat of polluting underground water and agricultural soils of the whole region. This is extremely important because most villages use underground water for drinking so the inadequately treated sewerage potholes may pollute well water. An additional problem is the uncontrolled surface exploitation of pebbles and sand in Laktasi-Kukulje-Nova Topola region, which may affect the protective soil layer and the locations of exploitation become local waste depots (pesticide containers, animal waste, etc.) which directly pollute underground waters. Such activities permanently destroy the cultivated soil (usually 1st and 2nd categories) and devastate the surrounding area.

In most settlement, there is an evident lack of high quality drinking water along with the poor protection of water sources and installations. We lack the preventive protection measures, which often causes incidents of polluted water sources. In some water systems, the drinking water quality is already poor which causes frequent epidemics (e.g. some Prnjavor settlements). The old and neglected pipelines, uncontrolled chlorine usage, great losses of water, inadequate maintenance, etc. are only some of issues that consequently might cause different types of pollution.

During high water streams, low soil along the middle and upper Vrbas stream are susceptible to floods. The lower Vrbas stream is exposed to the Sava River stream, which also causes frequent floods. We witness recurrent Vrbas outflows in Lijeve polje. In May 2014, there was a major Vrbas outflow in Banjaluka region and the flood officially caused damages worth around 70 million BAM, and in August the same year floods devastated more than 300 housing facilities. Over the last years, the Vrbas outflows are also frequent, particularly in Celinac area.

We may infer that the existing flood protection system in Banjaluka region does not provide the designated protection level. The reasons are as follows: the lack of major accumulation areas for transformation of flood waves, incomplete systems, poor project documentation, and poor maintenance of constructions and uncontrolled inhabitation of the river banks. The inadequate water management and the poor distribution of water increase the risk of floods. In the year to come, it is necessary to minimize the risk of floods and other natural disasters.

In northeast Banjaluka region, there is Bardaca natural reservation which is a marsh wetland ecosystem located in the vicinity of Vrbas delta into Sava. Specific hydrogeological conditions brought to this marsh

wetland ecosystem, with all its specific Eco climate, phyto, and zoogeographical features. Therefore, World Ramsar Committee made this area a place of global importance in 2007. Nevertheless, over the last few years, Bardaca wetland has been threatened by drainage of the wetland, intensive agricultural production, hunting and fishing, etc. all of this caused the impairment of the ecosystem and the decrease of the biodiversity.

Soil condition. Soil and terrain of Banjaluka region are characterized by multiple system units due to diversity of conditions under which the terrain was formed and developed. The southern highland part of the region is dominated by automorphic soil, whereas the northern lowland part is mainly covered by hydromorphic soil (valleys of the Sava and Vrbas rivers and their tributaries). The natural conditions of the lowland region favor the sustainable agricultural production and modern market commerce. Terrains, the quality of which ranges from I-IV quality categories, are located in the river valleys of the Sava and Vrbas rivers where it is possible to achieve sustainable crop production (wheat, barley, soybean, and corn), fruit production (plums, apples, and pears), and finally production of vegetable, herbs, and industrial plants. In the highland area of Banjaluka region, the soil quality is somewhat poorer and cattle breeding and the adequate agricultural production are dominant.

The major agricultural terrain is located in Lijeve polje, Srbac-Nozicko plain, and the Turjanica river valley. The highland area of Banjaluka region is characterized by shallow, automorphic soil, and the vegetation is either pasture (with intensive cattle breeding) or forests.

The main pollution sources in Banjaluka region are industry, traffic, settlements, agriculture, and waste material. The main problem with soil pollution, unlike with water and air, is that the soil is capable of absorbing harmful substances and they may remain there for a long time, which may in turn increase their harmful effect. Depending on the soil accumulation and exposure to pollution, harmful substances may reach surface and underground water or even plant roots, which further threaten both human and animal food chain. All these reasons make soil pollution the most dangerous type of soil degradation because it directly affects humans.

Lijeve polje is the location of most intensive agricultural production of Banjaluka region where most agrochemicals are being used. In addition, favorable natural conditions make this area a traditional location of successful agricultural production. Direct sources of pollution of Lijeve polje region are the inadequate

application of mineral compost and pesticides, and indirect ones are Sava and Vrbas water streams, sewerage potholes, stable waste depots, individual waste depots, industrial facilities, boilers, and furnaces. Although ten times less artificial compost and pesticides are being used in comparison with developed countries [4], there is an evident problem of non-professional usage which causes higher chemical concentration in food and water. Hence, we lack an educational system that might train individual agricultural producers for the usage of these chemicals. This problem is crucial in the most arable part of the region with traditional intensive agricultural production (Lijeve polje), which has been confirmed by the analyses of drainage and underground waters from the area as they have indicated higher concentrations of pesticides, nitrates, heavy metals, and other pollutants [10]. The drainage water samples collected by the Agricultural Institute of the Republic of Srpska at Liman site down the Sava River (municipality of Gradiska) confirmed the remains of the tested parameters (nitrogen, phosphorus, and pesticides). The limiting values designated by the Rulebook on conditions of waste water outlet into surface water [15] indicate that nitrate content in all drainage outlets was above the limited value; which only confirmed that drainage water contains dangerous and harmful substances that originate from agricultural production. The marked nitrate concentration ranged from 16,6 to 27,7 mg/l. The nitrate content was above the allowed concentration in water that flew into the Sava river (10,1 mg/l). They also discovered organochloride pesticides and herbicides. Of total 22 compounds, 6 compounds were singled out as follows: insecticides (beta HCH, gamma HCH, and permethrin) and herbicides (atrazine, alachlorine, and metolachlorine). The maximum allowed pesticide remains in EU for surface water are 1-3 µg/l, but in some samples we detected the total concentration above 4 µg/l [13].

The results confirmed that chemical substances used for plant protection (pesticides) and mineral compost used within the system of intensive agricultural production remained in soil, and to some extent, during rainfall, they were being drained into canals after which they finally reached water streams.

Waste management. The process of communal waste disposal in all municipalities of Banjaluka region covers collection of waste, transport to the depots, and waste disposal. Urban parts of municipalities and suburban areas are well-covered by the waste disposal system despite the lack of modern vehicles and insufficient containers and financing. Nevertheless, problems of waste collection are extreme in rural parts of municipalities due to inadequate infrastructure,

organization, and insufficient finances, which fact makes us infer that waste collection coverage is generally poor. Therefore, rural areas of Banjaluka region are characterized by a large number of uncontrolled waste depots, i.e. "wild depots". Currently, the uncontrolled waste disposal threatens rivers and water streams that run through settlements or in their vicinity. The disposed materials are singled out as follows: communal and bulky (cars, trucks, housing machines, car tires), and organic and medical waste for which there is no evidence of being non-harmful. In municipalities the area of which is covered by forests, the waste disposal problem is crucial (e.g. sawdust disposal). In addition, in municipalities with lowland terrain the major problem are waste from slaughterhouses and poultry farms, plastic waste, different types of poison, pesticides, and herbicides used in agriculture.

The collected waste from Banjaluka region is disposed of at Ramici location, which has been used as the major city depot since 1970s. In the beginning, the depot was used for all types of waste, including industrial and other hazardous waste. Since it did not meet the terms of sanitary waste disposal (there was no waterproof floor nor the water refinement equipment) it caused a whole range of hazardous events [11]. Incompliance with the Strategy of hard waste management in Bosnia and Herzegovina (2000), a regional waste management concept was accepted, which meant the construction of a sanitary waste depot and its accompanying facilities in order to meet the needs of the whole region and become self-sustainable. „Dep-ot“ Banjaluka public company was founded in 2003 with an aim to improve the existing and build a new regional sanitary depot in Ramici. The company founders are the Banjaluka City Hall and municipalities of Banjaluka region (Gradiska, Prnjavor, Laktasi, Srbac, Kotor Varos, Celinac, and Knezevo). The foundation of this company was a first step towards a solution of waste disposal problem, which later helped minimize the issue of waste collection, transport, and disposal. There was a whole range of measures taken at the depot in order to minimize its environmental impact: old waste was relocated, the canyon drainage was improved, a plateau with a lagoon absorbing the rainfall water was built, a reservoir for filtrates was completed, and new facilities for treatment of depot water were installed. Still, locations of old municipal depots were not reconstructed (except in Knezevo) so they remain the source of environmental pollution.

The only option for a final waste disposal management is the regional depot in Ramici, without any pre-treatment, and communal and hazardous

wastes are often disposed of jointly due to lack of storages. This waste disposal situation without an adequate management and hazardous waste disposal is harmful for the environment. Furthermore, no selection of reusable waste affects the population health as well as large commercial losses due to poor usage of material and energetic waste potential. Recycling of hard waste is also a process which has not started yet, and one of the reasons is the fact that there is no primary recycling or organized collection of communal hard waste.

In order to protect environment and reach sustainable development, it is necessary to set an integral hard waste management system which includes the following: minimal waste source, recycling, improvement of waste disposal services, recovery of material and energetic resources, functioning of sanitary depots for waste that cannot be reused.

5. CATEGORIZATION OF ENVIRONMENT IN BANJALUKA REGION

Based upon the quality of elements of environment it is possible to single out environmental spatial units (categories, zones) starting with areas of little natural alteration all the way to various consequences of anthropogenic activity in urban zones, or vice versa, from the most threatened zones to the least jeopardized ones. In compliance with the differentiation of technological and commercial prosperity, Banjaluka geospace is characterized with different stages of alterations of original conditions (formation of high population density zones, traffic and energetics, intensive agricultural zones). Furthermore, there are different levels of degradation and environmental pollution. In north Banjaluka region, there is an evident environmental pressure taking into account the population density and distribution, settlements, industry, infrastructure, and intensive agricultural production, which is geographically predisposed. There is also a strong conversion of arable land into non-arable one due to an uncontrolled settlement and infrastructural expansion, which often take place in the most arable zones. In the southern highland part of the region, environment is more preserved due to minor anthropogenic impact and higher pasture and forest coverage. In addition, industry is less developed, agriculture is not intensive, and population density (Knezevo, Kotor Varos) is four to five times lower in comparison with the administrative territory of Banjaluka city.

Banjaluka city is an administrative, commercial, health, educational, and cultural center, which makes it

economically appealing. Therefore, the city has high population density and faces issues of fast unplanned construction without the basic infrastructure, which affects both human health and environment. At first, illegal construction was present only in rural suburbs but it later expanded along the major roads. A planned construction is disabled and the road corridors turn into city streets (e.g. Banjaluka-Gradiska highway), which results in destruction of protection zones. Despite the fact that major industrial systems are out of order, their negative environmental impact has not been dealt with. The abandoned, old, and non-profitable facilities, depots, and technologies still threaten the ecological balance within our target geospace. There has been no estimation of dangers and possibilities of accidents caused by non-working facilities and factories, and corrosion of reservoirs, siloes, pipelines, or other chemical containers.

In compliance with EU standard and directives, environment conditions, and projected trends, the paper attempted to perform the geospatial differentiation, i.e. a categorization of environment in accordance with pollution and anthropogenic degradation – environmental threats in Banjaluka region. Bearing in mind environmental condition in Banjaluka region, we may single out seven categories of environmental quality (pollution and threats) in compliance with specificities of spatial units, in which:

- No location in Banjaluka region, according to these criteria, belongs to the first category (most polluted) and there are no critically polluted urban, mining-energetic, or industrial centers.
- Category two is Banjaluka urban zone with different industrial complexes, regional communal waste depot, unattended communal problems (especially waste water), huge traffic concentration, etc. A fast city expansion, i.e. the intensive unplanned housing construction in peripheral zones, is not accompanied by adequate infrastructure, particularly sewerage network and roads. The intensive traffic jam on urban and suburban roads indicates that the traffic infrastructure is not designed for a large number of vehicles, the gaseous emission and noise of which threaten environment. Unplanned city expansion has ecological consequences such as pollution of air, soil, and water, and degradation of arable land and forest vegetation.

- Third category covers suburban and urban Banjaluka zones with minor ecological issues (minor anthropogenic pressure, smaller concentration of traffic and industry).
- Fourth category covers the zone of impact of urban and suburban settlements and largely burdened major roads: Banjaluka-Gradiska highway, Banjaluka-Gradiska route, Banjaluka-Doboj highway under construction, railways (increased air pollution, noise, and soil pollution by particles, ground water pollution, and waste disposal). In addition, zone of impact varies depending on the level of ecological threat in some settlements.
- Fifth category covers a large agricultural impact (intensive application of agrochemicals, irrigation systems) that is most expressed in Lijevece polje and Srbac-Nozicko plain, but also in some minor river valleys.
- Sixth category of threatened environment is minor rural and agricultural impacts (fruit growing, cattle breeding) in highland part of the region.
- Seventh category is meadows and pastures, wetlands (Bardaca), and areas with natural land degradation (eroded terrain, landslide).
- Eight category is forests and protected zones of nature.

Our analysis helps us infer that Banjaluka region environment is diverse, which is a result of technogenic impact and different natural factors, conditions, and resources. According to environment quality categorization, categories II, III, IV, and V are very to moderately polluted, whereas categories VI, VII, and VIII are those of little or no pollution. Based upon methodology of agro-ecological zoning and GIS modelling on the basis of GIS database (pedology, land use, potential erosion, settlement size and distribution, industry, waterstreams, infrastructure) in Figure 1., we display the categorization of environment quality in Banjaluka region geospace (based upon pollution and threats, i.e. anthropological degradation).

Based upon the provided methodology, it is possible to perform a detailed categorization of minor area environment (e.g. municipalities) in which case it would be possible to enter large number of data such as municipal and illegal depots, surface pits, mined surfaces, and other degraded and polluted surfaces [12].

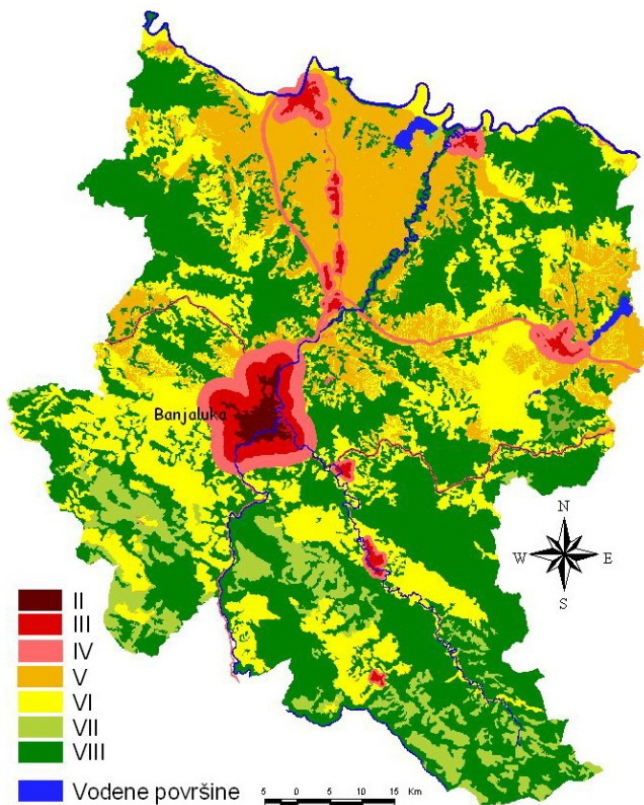


Figure 1. A lookup map of categorization of environment of Banjaluka region geospace (according to pollution and anthropogenic degradation)

6. CONCLUSION

From environmental point of view, Banjaluka region geospace is a complex structure. There is one major city core burdened by most ecological problems (Banjaluka), and a network of minor city suburbs with minor ecological problems. Some parts of the region have a different level of agricultural impact, and some parts have relatively preserved environment.

An extensive analysis of our target area pointed out some crucial environmental issues not only in urban areas and within the fields of agriculture and forestry. There are also problems of agricultural and forest soil degradation due to artificial surfaces (urban infrastructures), intensive soil erosion, natural resource exhaustion, and secondary negative effects in water resources. The watery and wetland soil (e.g. Lijeve polje, Bardaca wetland) is under pressure due to intensive agriculture and new infrastructural projects (highway construction, other roads, etc.). Revitalization of highland area is both vital and economically, ecologically and socially justified.

Speaking of water pollution, the key problem is the non-refined water drainage directly into surface water streams. It is necessary to repair the existing sewerage system and facilities for waste water treatment, and start a planned construction of new

systems in compliance with the sustainable development policy.

As the environmental hazard is not uniformed along the region, it ranges from high level danger zones (urban areas and industrial zones) to the high quality environment zones (forests). This paper attempted to categorize the environment in accordance with EU standards and practices, and determine the environmental condition and potential threats in times to come.

Lowland terrain has large human population, intensive agricultural production and commercial activity, which fact certainly does affect the higher degradation of environment in comparison with highlands, which are only partly threatened by natural resource exploitation, especially forests.

According to our analysis, we may infer that, in both our target region and the whole of the Republic of Srpska, there is no adequate information ecological system of control and monitoring of environment, except some individual approaches to measuring air pollutants in Banjaluka and water quality in major water streams. An additional problem is methodological diversity and insufficient measurements of environmental quality due to lack of technique and finances, and inadequate legislations within this field.

One such research tends to leave some questions open for further discussion because some problems demand an interdisciplinary research. The lack of monitoring prevents the adequate planning, reporting, and protection of environment whatsoever. A vast problem is that there is no pollutant cadaster and database. Furthermore, there is no continuous monitoring but we expect that a study of spatial regional differentiation of environment might be much more thorough after an integral environment information system is set.

References

- [1] Filipović, D., Obradović, D.: **Stanje životne sredine na teritoriji opštine Loznica – osnov integralne planske zaštite**. Glasnik srpskog geografskog društva. br. 87 (1), Beograd, pp. 163-172, 2007.
- [2] Gnjata, R. (1997): **Nodalno-funkcionalna regionalizacija Republike Srpske**. Glasnik Geografskog društva Republike Srpske. sv.2, Banjaluka, pp. 5-11, 1997.
- [3] **Izveštaj o zagađivačima rijeke Vrbas od područja zahvata za vodovod sa Programom sanacije zagađivača**. br. 09-333-sl./08
- [4] Janjić, V., Škundrić, B.: **Zaštita agroekosistema i biljna proizvodnja u Republici Srpskoj**. Naučni skup: Republika Srpska – petnaest godina postojanja i razvoja. Akademija nauka i umjetnosti Republike Srpske, Banjaluka, 2007.
- [5] **Lokalni ekološki akcioni plan Grada Banja Luka**. Institut za građevinarstvo „IG“, Banjaluka, 2009.
- [6] Lješević, M., Miljanović, D.: **Ekološki aspekti regionalizacije geografske sredine**. Geografska struktura i regionalizacija Srbije I.

Geografski institut „Jovan Cvijić“ SANU, knjiga 51, Beograd, pp. 71-84, **1997.**

[7] Lješević, M., Milašin, N.: **Informaciona osnova životne sredine u Prostornom planu Srbije.** Savez inženjera I tehničara Jugoslavije, Beograd, Kotor, **1995.**

[8] Lješević, M., Miljanović, D.: **Prostorno-regionalna diferencijacija životne sredine Srbije.** Geografska struktura i regionalizacija Srbije II. Geografski institut „Jovan Cvijić“ SANU, knjiga 53, Beograd, **1998.**

[9] Marić, Đ.: **Analiza prostorne strukture industrije u Republici Srpskoj,** Zbornik radova: Resursi Republike Srpske. Banjaluka, pp. 201-210, **1995.**

[10] Nedović, B., Janjić, V., Todorović, J., Mitrić, S., Kovačević, Z.: **Prisustvo teških metala (Pb, Hg, Cd, Cu) i pesticida (atrazin) u zemljištu i podzemnoj vodi Lijevča polja.** Agroznanje, god. IV, broj 3, pp. 164-179, Grafid, Banjaluka, **2003.**

[11] Pešević, D.: **Geografski faktori izbora lokacija deponija i centara za reciklažu komunalnog otpada Banjalučke regije.** Geografsko društvo Republike Srpske, Banjaluka, pp. 1-253, **2009.**

[12] Pešević, D.: **Geoprostorna diferencijacija životne sredine Banjalučke regije u funkciji planiranja održivog razvoja.** Geografski fakultet, Univerzitet u Beogradu, doktorska disertacija, pp. 1-247, **2010.**

[13] Predić, T., et al.: **Ispitivanje sadržaja ostataka pesticida i nitrata u drenažnim vodama poljoprivrednog zemljišta.** Poljoprivredni institut Republike Srpske, Banjaluka, **2009.**

[14] **Preliminarni rezultati popisa stanovništva, domaćinstava i stanova u Bosni i Hercegovini 2013.** Agencija za statistiku Bosne i Hercegovine, Sarajevo, 2013.

[15] **Pravilnik o uslovima ispuštanja otpadnih voda u površinske vode** (Sl. glasnik RS br. 10/98)

[16] Radovanović, M.: **Teorijsko-metodološke osnove i praktični ciljevi geografskog istraživanja životne sredine.** Zbornik X kongresa geografa Jugoslavije, Beograd, pp. 351-361, **1997.**

[17] Stefanović, V., et al.: **Ekološko-vegetacijska rejonizacija Bosne i Hercegovine.** Šumarski fakultet u Sarajevu, Sarajevo, pp.1-51, **1983.**

[18] Uredba o vrijednostima kvaliteta vazduha (Sl. glasnik RS br. 124/12)

[19] <http://rhmrzrs.com>