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Development of landscape structure of Kežmarok cadastral area during the years (1769 - 2007) as an example of residential development around the Tatra Mountains (Western Carpathians)

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Abstract. On the basis of landscape structure we analyzed landscape changes and selected indicators of the assessment landscape as ecological stability and atrophic influence from eight time horizons. Landscape forms, changes in land use intensity, unchanged areas and relative unchanged areas were analyzed in relation to selected abiotic characteristics of the environment. The greatest changes occurred in the group of agricultural fields, where the abandonment of traditional management (1957) and the decline of agriculture in the 90's 20th century led to 25% decline in size of agricultural fields converted to grasslands and urban areas. Extensification was observed especially in areas of higher slopes and higher altitudes. Results at the local level reflect the general (global) trends in land use across Europe.

Key words: Landscape structure, GIS, Tatra and Subtatra region

Introduction

Culturing process of landscape is mainly determined by three basic conditions: - the level of cultural and social development of society, its economic situation and natural conditions (Ružička 2000).

The main aim of this study is to analyse the landscape structure in the Tatras region in the Western Carpathians in Slovakia. Model area is Kežmarok cadastral area assessed in selected time frames and on the basis of available historical materials. Other objectives were to assess land use and its changes related with development of society as well as its relationship to selected abiotic characteristics and land use. Using digital technologies, human activities in space and time provide interesting illustrations of the country, its present and historical use. Study area is in the Tatras region with rich history and considerably anthropic influence on the landscape from since Neolithic times.

Material and Methods

To create compilation synthesis, landscape features data from following studies were used: Oťaheľ (1994), Ružička (2000), Boltižiar (2004, 2007), Petrovič (2005), Forman and Gordon (1993), Mikloš and Izakovičová (1997), Ružička and Mišovičová (2006), Pucherová *et al.* (2007). Landscape structure is analyzed and defined according to Pucherová *et al.* 2007, and analyses of landscape stucture change and history of the landscape exploitation was evaluated according to the studies by Boltižiar (2003, 2004, 2006, 2007), Petrovič (2005) and Olah *et al.* (2006). Some historical data was obtained from Baráthová (1989, 1990, 1996).

Maps of landscape structure were created in ArcView GIS 3.2 and in ArcGIS 9.2. Digitization was standard procedure for input spatial data to GIS, which can´ t be avoided by existence of analog data. By using of "on screen" method based on analog (visual) interpretation of aerial orthophotographs relevant informations were extacted and recorded into separate vector layers (Boltižiar 2007).

By processing of landscape structure of 1769 were used maps of the first military mapping (from 1763 to 1785 in a scale of 1: 28,800) in Austrian Monarchy. For the landscape structure map of 1822 was used second military mapping (from 1806 to 1869 in a scale of 1: 28,800). The landscape structure of 1870 was taken from historical cadastral maps of State Regional Archives collection in Spisska Sobota town, followed by finishing in ArcGIS 9.2 Landscape structure of 1957 was created from topographic maps (1: 25,000). For the landscape structure of 1988 were used maps in the form of declassified military topographic maps (1: 25,000). AutoCad (dxf) layer format removed from Cadastral Portal SR in 1995 was used by creating the landscape structure of 1995. Landscape structure of 2002 was created on basis of orthophotos as well as the landscape structure of 2007, which was followed by a field survey of areas with potential changes since 2002, when orthophoto maps were taken.

Mapping units of landscape structure, landscape features, are spatial units earmarked mainly by characteristic method of land use and physiognomy. In principle, we can divide the mapping units into 6-8 groups. This way, field and its different units are easily mapped (Ružička and Ružičková 1973). Mapping units are:

1. Group of forest and nonforest vegetation (forests,

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small-scale vegetation, small-scale shrubs vegetation, liner woody vegetation, streamside stands of woods of watercourses, disturbed vegetation areas)
2. Group of permanent grasslands (pastures, meadows, permanent grasslands, non-used permanent grassland, non-productive grasslands, liner herbaceous vegetation)
3. Group of agricultural fields (fields, arable land, mosaic structure)
4. Group of the bedrock and substratum (bedrock bedrock, natural rock formations)
5. Group of the watercourses and water areas (water flows, water areas)
6. Group of the residential features and recreational areas (Continuous urban fabric, Gardens by the houses, historic buildings, sports and recreational facilities, administrative buildings, urban vegetation, cottages, recreational areas)
7. Group technical features (industrial production and service facilities, agricultural buildings, field dunghills, construction and technical objects in open country)
8. Group of the features of transport (roads, railways, paved areas).

Assessment of ecological stability and anthropic impact on the landscape

The coefficient of ecological stability Kes_2, defined by Miklós (1986) was used for the assessment of ecological stability of the studied area.

$Kes_2=(\Sigma\ pi.ki)/p$

(p_i - surface of i-form of land use, k_i - weight coefficient of the i-form, p-total surface area).

Human impact on the landscape was evaluated using the coefficient of landscape human impact Kao proposed by Kupková (2001).

$Kao = V/ N$

(V – areas with higher intensity of use; N – areas with lower intensity of use).

Relative intensity of land use change

For visual assessment of relative changes that occurred between two consecutive years was used Olah *et al.* (2006) methodology, evaluated the changes of land use intensity. The authors merged individual forms of land use and they assigned them coefficients from scale 1 to 5, given by the amount of subsidiary (additional) energy needed to change (or maintain against succession pressure) one form to another. The relative intensity of land use change was calculated according to the following formula: $I_R = i_1 + i_2 + ...$ in (I_R - relative intensity of land use change, i_1 - partial intensity of change between the 1. and 2. time horizon).

Selected abiotic conditions of the landscape

Geological conditions were obtained by vectorization of geological maps 1:50,000 (Janočko 2000). For height segmentation was necessary to create a TIN from contours 1: 10,000, and then create the underlying GRID 5 x 5 m for the other abiotic conditions. The basic GRID was reclassified in 10m and converted into vector form. Slope was created from the basic GRID using the function Slope and reclassification of 5 degrees. The resulting grid was converted into vector form. For orientation to cardinal was used the function Aspect, with following conversion to a vector in 9 groups (flat, north, northeast, east, southeast, south, southwest, west, northwest).

For making further analysis was necessary to create the superposition of the abiotic conditions maps called abiokomplex.

Relationship of land use forms to selected abiotic characteristics

To express the relationship of land use forms to abiotic conditions, map of the abiokomplex was overlaid with a map of landscape structure for each time horizon. Contingent tables for each abiotic conditions (slope, exposure, hypsography, geology) and forms of land use were created from generated data in the table. Further, graphs were created by the use of eight contingent tables. Consolidation of a settlements and recreational areas with a group of technical features and transport features was needed by the graphs creating. Problematic was also representation of the bedrock and the substrate features because of their negligible areas, therefore this group was excluded.

Study area

Area of interest is the cadastral territory of Kežmarok town. In the year 2007, it covered an area of 24.8 square kilometers. The area is located in the northeastern part of the Slovak Republic in the submountain area of the High Tatra Mountains.

The city center is at altitude 626m a.s.l. (49° 10' and 20° 25').

Results

Development of land use

Analysis of landscape structure of the current state (2007) verified the knowledge that the country with urban settlements is a richly structured in terms of land use, but also greatly influenced by natural and socio-economic conditions.

Land use was characterized not only in terms of size and presence but we also described changes in the last 238 years. Illustrations of landscape structure can be observed on eight maps (Appendix 1) and its proportion to the percentage is shown in Fig.1.

Group of forest and nonforest vegetation

In response to the socio-economic conditions in 1769, it is evident that the forests were out of interest of people and their Lords. Cadastre of the Kežmarok town achieved much bigger area ended in the High Tatras in area of Kežmarok White Water. This meant that the city itself had with increasing distance from the city more coherent forest area. Areas closer to the residential features were cultivated on agricultural land. In the year 1769 we registered discontinuous forests in the northeast of the cadastral territory. In 1822 the significant majority of this group represent the production forests in the northeastern part of the cadastral territory. Liner woody vegetation along streams is found sporadically.

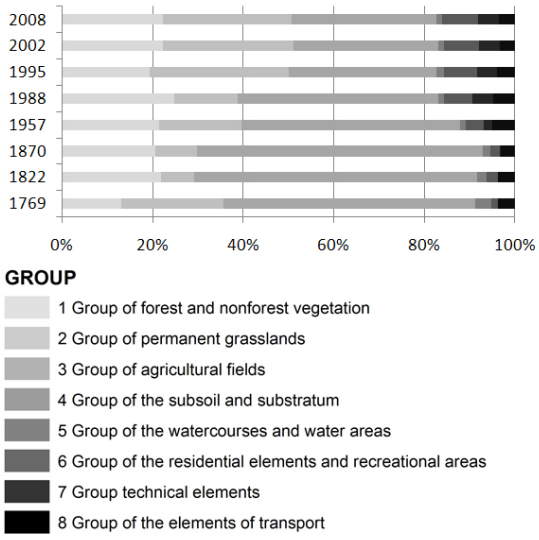

Fig. 1. Percentuage proportion of group features

Increase in area of woody vegetation in 1957, consists of newly arising areas representing parks. Percentage increase of 3.26% in 1988 was reflected in the progressive afforestation of northeastern part of the cadastral territory and in increased economic activities in the forests production. In the analysis of 1995 we observe significant decrease in 136.42 ha (5.43%) area of forest and nonforest vegetation in the northeastern part of the cadastral territory due to excessive logging. Since 1990, extraction, mainly coniferous forest was increased due to economic use, increasing inflation and increasing prices of wood.

Forests represent the most abundant feature in the group of forest and nonforest vegetation. The largest part is currently located in the eastern part. Forests are created by spruce-fir forest with dominant species of spruce (*Picea abies*). Small-area vegetation is poorly represented feature. They are found diffused throughout the cadastral territory on meadow and field edge as a solitaires, groups of woody plants but also wee-forests, smaller than 1 ha. In the past, small-area vegetation was absent; due to felling on firewood and wrong understanding of its role, when they thought that they represent potential refuge for pests. Liner woody vegetation is also represented by a few continuous and discontinuous tree lines on the edge of the fields and main roads, which serve on the various functions as wind-barrier, noise barriers etc. Streamside stands of woods of watercourses represent various species of willows (*Salix*) and poplars (*Populus*). They are located nearby water features without regulated waterside. Intersection, clearings, fields (disturbed forests) are only one important area in forest nurseries. Sometimes occur disturbed vegetation, broken trees and trees damaged by vandalism.

Group of permanent grasslands

In 1769, permanent grasslands, with proportion of 22.6%, covered the area, mainly along watercourses, in discontinuous forest vegetation and in surrounding urban areas. In 1822 we registered the smallest percentage proportion of this group of features in all the horizons, probably due to missing of marks on maps. Single features of this group are located between the adjacent forest and streams but especially in the confluence of the rivers between their branches. In 1870 we localized only meadows and liner herbaceous vegetation along all watercourses. Meadows were around the city roads and also near to watercourses.

In 1957, we recorded double increase (218.5 hectares) of permanent grasslands area, due to increase of extensive comprehensive pastures for large breeding of the cattle. Next decrease (3.93%), in 1988, was not only due to afforestation, but also because of the total spatial changes and formation of new areas as a substitute for meadow vegetation found in forests, hardly available for use The main reason was the way of farming and creation the large-block fields and construction of urban and technical buildings.

In 1995, an increase 16.6% (414.5 hectares) is the largest increase in this group of features from all the time horizons. The reason is reduction of the agricultural production and deforestation of the parts associated with forest management in forest.

In present times, extensive and intensive pastures with woods and without woods mainly occur near to agricultural cooperatives, firms and associations. Extensive meadows, intensive and extensive meadows with woody plants create the largest area in the group of permanent grassland. We can also find them in the group of the forest features and in the group of the agricultural fields. In the south of the cadastral territory there are meadows, which were in the period of socialism pastures but due to less intensive agriculture are now as meadows mown ones or twice per year.

Permanent grassland and unused permanent grassland with trees and without trees create abandoned pastures and unused meadows, privately owned. They are mainly situated near to industrial buildings.

Group of agricultural land

In this group, we determined the fields, arable and mosaic structure with narrow zone of arable land and permanent grassland.

Agricultural land covers the largest surface in the study area. We can found them mainly on the western side of the cadastral territory. Mosaic structure can be observed close to residential and technical buildings.

Agricultural land in 1769 is located almost everywhere near to urban area (except the northeastern part of the cadastral territory) and is almost constant in subsequent periods. According to the maps of 1769 (where the white areas represent agricultural use), we can not exactly say whether the percentage 55.6% is of the total group, because pastures and meadows could not be identified in the maps.

The largest percentage (63.1%) of agricultural land in comparison to other time horizons we register in 1870. Total area was 1573.41 hectares. Cadastral territory of the Kežmarok was in this time very highly actively in agriculture.

Percentage difference (14.82%) between 1870 and 1957 presenting decrease 369.6 hectares of ag-

ricultural land and represent the greatest decrease of the percentage of agricultural land features in all time horizons due to developed of urbanization, formation of the new agricultural cooperatives and firms but also of the industrial firms. This difference was caused change of use of agricultural land associated with development of agriculture and the creation of large-block fields.

In 1988 one of the main reasons for decrease of this group is a change of use of agricultural land in the eastern part of the cadastral territory. This area was almost whole grassed due to terrain which is significantly rugged. Decrease was of course caused by development of urbanization and of building of technical features.

Decrease in 1995, in this group of features was 11.71% (293.89 hectares) and that reflects the reduction of farm production and the overall decline of agriculture after the change of social system in 1989. Currently the state of the use do not changed and has about 710 ha.

Group of the bedrock and substratum

From this group is dominated the uncovered bedrock, which is in the study area located in dispersed form. The largest uncover bedrock we can found on the side of rivers and their meanders. The largest feature in this group is the artificial rock wall, 5 m high and about 24 m long. It was created due to construction of railways and railway station around the year 1890.

Natural rock formations and represents the only one place on the right riverside of the Poprad River. Wall Is high 6-7 m and 400 m long, which was created by process of the water erosion of the river Poprad.

Group of the watercourses and water areas

This group of features representing the majority of natural water flows with the original riverbed. In 1769, Poprad River is regulated in part, that were near by the castle walls and artificial water ditches constructed for defense of the city. Generally missing water surface, except water reservoir at the bridge over the Poprad river.

Sporadic flows look like today but with compare to 1769, we can see loss of their entire length. Until 1870, the state of watercourses and water area was unchanging and we sporadically observed an artificial channel which is needed for run water mill.

In 1957, we registered 0.3% decrease in area, which shows the regulation and removal same of the watercourses. For example, removal of artificial water ditches and right branch of the Poprad River in the urban center. Regulated was also the Kežmarská biela water in the part from the Poprad River to the end of the city. Main reason was flood protection but also due to flows through the industrial areal and the newly established residential area on the right branch of the Kežmarok biela Water, where the small dam occurs.

On the maps from 1988 we localize Kežmarska dam, which is associated with general regulation of the Poprad River from the dam to the start of the intravilan. This regulation involves the removal of the right branch of the Poprad River. The regulation also affected other watercourses, one branch of which was removed. These changes have been performed not only with the intention of preventing flooding but also the city itself needed new residential areas and infrastructure. However two dams were created, the percentage cover of water areas increases only 0.04% due to regulation and elimination of same of the flow parts.

In present time in this group of the features dominate streams over water areas. All streams flow into the Poprad River. In the city are all flows artificially corrected, but outside the urban area they have character of the natural water flows.

There are three water areas in the cadastral territory. Kežmarok lake is the largest (4.78 ha) in the most southern part of cadastral territory. And the next is Zlatná dam (4.56 hectares), 3km away from the city center.

Group of the residential features and recreational areas

Not only in the city behind walls but also outside them already in 1769 we see the rows of houses from 13th to 14th Century. In front of the southern gate nearby road from Poprad to Kežmarok occur homes with surrounding gardens. We can also see the wooden evangelical church (1717) there. In the center of the town is the Church of the Saint Cross (St. Cross Basilica since 1997). Its oldest parts are from the mid 13th century and not far from here is original Gothic town hall (1461). In the northern part of town is the castle, with the first written record from the year 1463. Town cemetery was in the southwestern part of the town nearby the castle.

In 1822, building of individual houses continued outside the central part of town. In 1822 we can localize some historical objects such as Redoute, which was rebuilt in 1818 from the Book Printer building. In the years 1774-1776 was established Lyceum.

In 1870, the central part of the town is similar to the current situation. Downtown is formed with the burgess houses and at the edge of settlements are rural houses. In the city center nearby the Church of the Saint Cross was Catholic featureary school.

Development of the industry and agriculture after the Second World War largely influenced this group of features. New urban buildings represent increase of 1.98%. New residential buildings were built along the railway and along the adjacent roads to neighbouring settlements. We register new constructions of two streets on the place of the old cemetery as well as row houses and housing in place of the removed branches rivers, where the town built the hospital.

We recorded all schools and administrative buildings in 1988 and also the expansion in all urban areas by one or two streets most. On the place of the old slaughterhouse behind the Castle were built new housing estates as well as in southern cadastral territory. On opposite side of Lyceum we can find a new hospital. Nearby the football stadium is new ice hockey arena and new cemetery. In this period we have registered the first gardens for the purposes of residents from housing estates.

In 1995, an increase of 1.1% of urban area represents cbuilding of houses, the block of flats and new garden areas.

In 2002, an increase of 0.42% is due to building the new houses.

Gardens by the houses are now the largest part of this group of the features. City center create a historically important buildings and two-floor rural houses. Most from them have a primary function of houses with secondary use in trade and services. Residential buildings outside the urban area are isolated houses on the edge of the northern forest features of the cadastral territory.

Sports and recreational facilities and areas are represented by ice hockey arena and football stadium, the town's cultural center, an amphitheater, a ski resort with lifts on the west side of the Jerusalem hill and tennis courts.

Urban vegetation is the second largest subgroup of this group of the features. It consists of the parks near by castle and green areas within the town.

Parts of the residential and recreational areas are cottages, recreational facilities, garden colonies and settlements, which are located on the banks of rivers and in close proximity to forest features.

Part of the group of the residential features and recreational areas are cottages, recreational areas, garden colonies and settlements, which are located on the branches of rivers and in close proximity to group of the forest features.

Group of technical features

In 1769, this group represented only three objects, one in an unspecified area of today's bus station and the other two are the mills, where the first was located on the Poprad River in the western part and the second was on flow Kežmarská Biela Voda River. In 1715 was in Kežmarok 263 craft guilds and craft production, canceled in 1872.

In 1822 there were more technical features, which are difficult to distinguish from the residential features because every house was a small manufacture and also living space for they owners.

Generally, the second smallest group of features are consists of farmyards with the first industrial buildings. In 1870 was built an industrial area outside the city. It was associated with the first mechanical spinning and weaving flax factory in Slovakia. In this period, among other factories in the town there were distillery and starch factory nearby castle.

Increase the share in 1957 to 1.78% reflects the industrial and agricultural development of the city, extending the areas of existing enterprises and creation of new industrial areas along the railway and agricultural buildings on the edge of the town. We record agricultural objects (slaughterhouse) also in the town. We localize state farms in the urban district Pradiareň. New industrial buildings are found mainly along the railways and roads to neighboring villages.

In the coming period in 1988, the total percentage increase of this group is 2.7%. This increase represents new industrial areas for processing of the agricultural products as well as the agricultural areas and cooperatives. Also we can observe enlargement area of the timber mill. In its neighborhood was built the Building Company along railway and the sewage plant.

Recession in the economy after a change in the social system in 1989 did not change this group of features. Some companies fall into disrepair and in 1995 we registered some decrease about 0.20% of the area. Population activities should focus on business in trade and services.

At present times, industrial production and storage areas and service are the most represented in this group. They are mainly localized on the edge of the urban areas of Kežmarok town nearby larger industrial complexes.

Agricultural objects are farm, farmyards and warehouses.

Different construction and technical objects in landscape are represented by a transmitter and Water pumping station in the most southern part of the cadastral territory.

Group of the features of transport

Road network represents the shortest way to surrounding urban areas. Some roads still exist, many from theirs became local streets of urban areas, and others stud in the form of a hollow way overgrown with vegetation, now only sporadically used.

Between 1870 and 1957 the largest increase of 1.75% area of the group of features was mainly due to construction of the railway, new roads within the city and roads to new industrial and agricultural buildings.

Between 1957 and 1988 was many field roads destroyed and replaced by new roads along large-block fields formed during the agricultural development in 1959. The decrease is only 0.14% whereas arose new roads in the city due to urban development. Changed was also main road Poprad - Spisska Bela which led cross the city center, declared as conservation area in 1950.

In 1995, the decline of agriculture activities decreases large-fields and thereby also increasing the number of field roads. These roads don't have permanent character and in subsequent periods were frequently changed.

Currently, the largest proportion of this group of the features is represented by roads, main roads, roads in the urban area, paved and unpaved roads such as forest and field roads. Major roads have three lines: Poprad – Kežmarok, Kežmarok – Ľubica a Kežmarok – Stará Ľubovňa.

Subgroup railways contain railways and railway stations. Railway direction Poprad Tatry - Plaveč goes from southwest to northeast cadastral territory and has one historical valuable train station, located 600m west from city center.

Paved traffic areas are represented by bus stations, gas stations and parking areas diffused in the urban area around technical and residential buildings.

Analysis of selected indicators of the landscape

Development of ecological stability and the anthropic affecting of the landscape

Calculated of ecological stability shows that the study area is a little stable territory. According to Fig. 3b ecological stability in the first three time horizons slightly decreased to the level of 0.36. In the years from 1957 to 1988 was the value 0.41, represented an increase of ecological stability. Since 1995, the ecological stability

has slightly increased to a value of 0.47 which is identical to the present.

Development of anthropic affecting (Fig. 3a) refers to the year 1822, when was the greatest pressure on the landscape. After 1870, the anthropogenic affecting of landscape decreased with increasing time to the year 1995, where the value is identical with the present.

Cadastral territory represents only a small segment of Podtatranska valley. Largest part of the landscape was used for agriculture. Figures 3a, b reflect the decrease of human activities and increase of ecological stability. This change was mainly due to decline of agricultural land use in more than 20%. Agricultural land covered more than 60% of the cadastral territory and these figures rather reflect a reduction of agricultural activity.

Relative changes in land use according to annual data are shown on the Appendix. 2. The detailed description and reasons of the changes were described above.

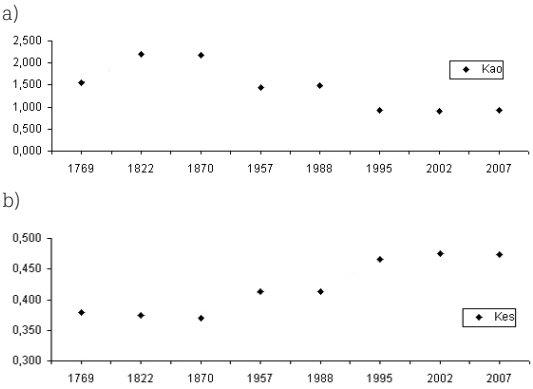

Fig. 2. a) Development of the coefficient of anthropic affecting of the landscape; b) Development of the coefficient of ecological stability of the landscape.

Analysis of selected abiotics conditions

In the cadastral territory Kežmarok dominate mainly smaller slopes (Fig. 3c) in categories from 0 to 5 degrees with 54.9%. In the category of the slope from 5 to 10 degrees is 22.2% of the area, the slopes from 10 to 15 degrees occupies 14.6% of the area and slopes from 15 to 20 degrees 6.2% from the total area.

Altitudinal range in the Kežmarok cadastral territory is from 600m to 810m a.s.l. The total difference in altitude is 210m. Fig. 3.a shows that the largest surface area is occupied by range of altitudes from 640 to 650m with 12.3%. With proportions from 11.3% to 11.1% are categories of 630-640m, 620-630m, 610 to 620m. Altitudinal intervals between 650 to 660m (9.8%) occupied more than 5% of surface area same as intervals between 660 to 670m (9.4%) and 670 to 680m (5.9%). Below 1% of the surface area covere ranges of altitudes from 760 to 770m, 770-780m, 780-790m, 790-800m and from 800 to 810m.

In terms of orientation to cardinal (Fig.3.b) flat (flat) with 20.4% is covering the largest surface area. East (V), southeast (SE) and northeast (NE) slopes occupy from 12.3% to 11.7% of the area. They are followed by northwest (NW) and west (W) with 9.6%, southwestern (SW) with 84%, south (J) with 7.9% and north (S) with 7.4%.

In terms of geological bedrock we use numeric code in Fig.3d. In cadastral territory of Kežmarok the most prevailing layers of rocks are Kežmarok layers of flysch with the presence of sandstone layers of Bielopotocky type (positions of conglomerate flysch) (38) with 17.9%, followed by fluvial floodplain sediments (1) with 14% and sandstones in ab-

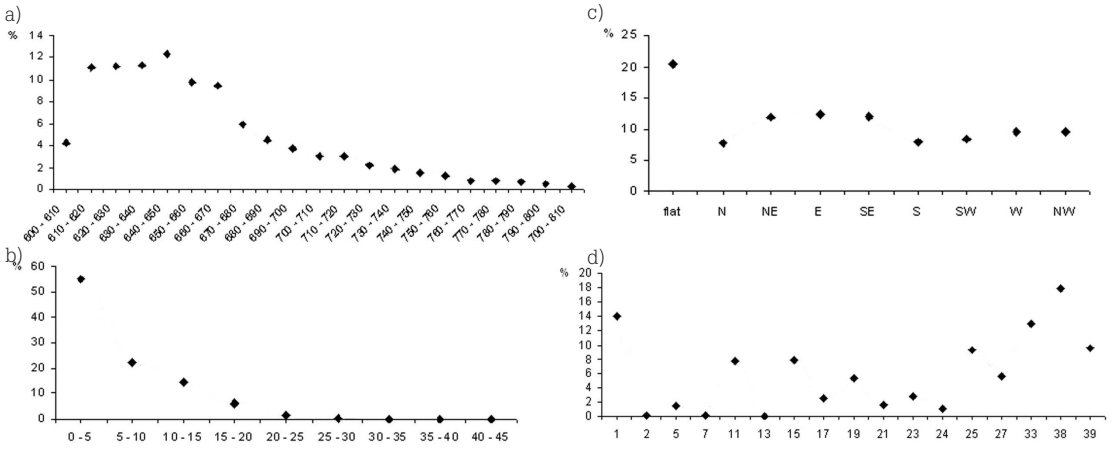

Fig. 3. a) Percentage proportion of altitude categories; b) Percentage proportion of orientation categories; c) Percentage proportion of slope categories; d) Percentage proportion of geology bedrock categories (1 - fluvial floodplain sediments (mostly loamy or laomy-gravel); 2 - proluvial floodplain loams; 5 - fluvial sandy gravel, sandy gravels and loams of bottom accumulation; 7 - glacial-fluvial loamy-sandy gravels coarse to bouldery; 11 - fluvial sandy gravels and gravels; 13 - glacial-fluvial sandy gravels, mostly coarse; 15 - fluvial sandy gravels and gravels; 17 - glacial-fluvial gravel and sandy gravel, coarse to bouldery; 19 - glacial-fluvial gravels, coarse to bouldery; 21 - Gerlach-východnianske and hybianske layers: glacial-fluvial, strongly weathered gravels, sands and placers; 23 - deluvial-fluvial flushed loams, sandy loams, sometimes with fragments; 24 - loamy-rocky, sandy. sandy-rocky and rocky debris; 25 - loams of slopes (polygenetic) sporadically with a debris; 27 - colluvium - litofacial uncategorized (undifferentiated loams of slopes and debris); 33 - sandstones in absolute predominance over non-carbonate claystone; 38 - Kežmarok layers of flysch with the presence of sandstone layers of Bielopotocky type (positions of conglomerate flysch); 39 - typical flysch: sandstone. claystones in a ratio of 2: 1 a) position of conglomerate flysch).

solute predominance over non-carbonate claystone (33) with 13%. Other layers (5%-10%) are typical flysch: sandstones, claystones in a ratio of 2:1 (39) with 9.5%, loams of slopes (polygenetic) sporadically with a debris (25) with 9.3%, fluvial gravels and sandy gravels (15) with 7.9%, fluvial sandy gravels and gravels (11) with 7.7%, colluvium - litofacial uncategorized (undifferentiated loams of slopes and debris) (27) with 5.6%, glacial-fluvial gravels, coarse to bouldery (19) with 5.3%.

Relationship of land use forms to abiotic conditions

In each reporting period (Fig.4.) in slope of 10° and more dominate group of forest and nonforest vegetation. Construction, in slopes larger than 5° has evidently extended after 1957. After 1995, in slopes between 5-10° permanent grasslands outweigh the agricultural land due to decline of agriculture.

Dependence between altitude and group of the features of forest and nonforest vegetation can be seen mainly in 1988 (Fig. 5), where in the height above 680m a.s.l. we can observe its predominance above the agricultural land. From this relationship we can conclude that decreased agricultural activities are dependent on increase of the height. Development of urbanization after the World War II is seen in 1957 in categories from 10 to 620m a.s.l. and in the year 1988 the urban areas dominate in the area over the other groups of the features and in categories 620-630m a.s.l. Change in the area represented by grassland and agricultural land occurred in 1988 in the height over 690m a.s.l. and in 1995 in the height of 680m a.s.l.

Relationship of exposition is strongly expressed (Fig.6) with group of features of agricultural fields, which is mostly found in sunny exposed areas as flat, E, SE, NE, S, SW. Areas oriented to NW, W and N are dominated by group of forest and nonforest vegetation.

Relation of geological bedrock (Fig.7) is evident in the group of features of forest and nonforest woody vegetation, which is localized mainly on the sandstones in absolute predominance above non-carbonate claystone (33) and loamy-rocky, sandy. sandy-rocky and rocky debris (24).

Group of features of agricultural fields is found mainly on loams of slopes (polygentlic) sporadically with a debris (25), fluvial gravels and gravels of sand (15) and glacial-fluvial gravels, coarse to bouldery (19). In 1957 agricultural field on fluvial sandy gravels and gravels (11) were replaced by rural settlements, also on fluvial sandy gravel, sandy gravels and loams of bottom accumulation (5) in 1988.

Discussion

Time demands is the biggest handicap of landscape structure analysis, together with individual identification of land use forms and maps of lower quality.

Digitalization is significantly affecting the qual-

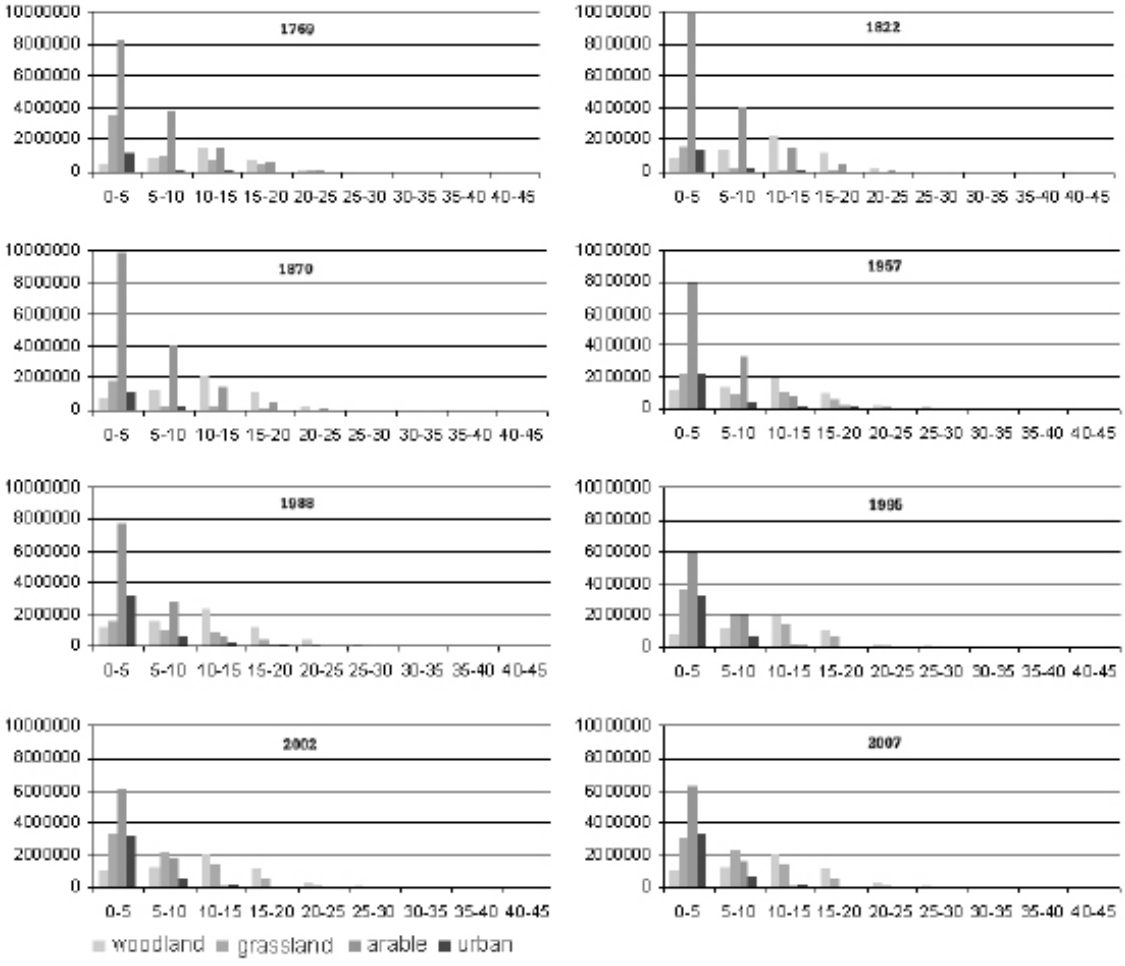

Fig. 4. Percentage proportion of land use areas to categories of slope.

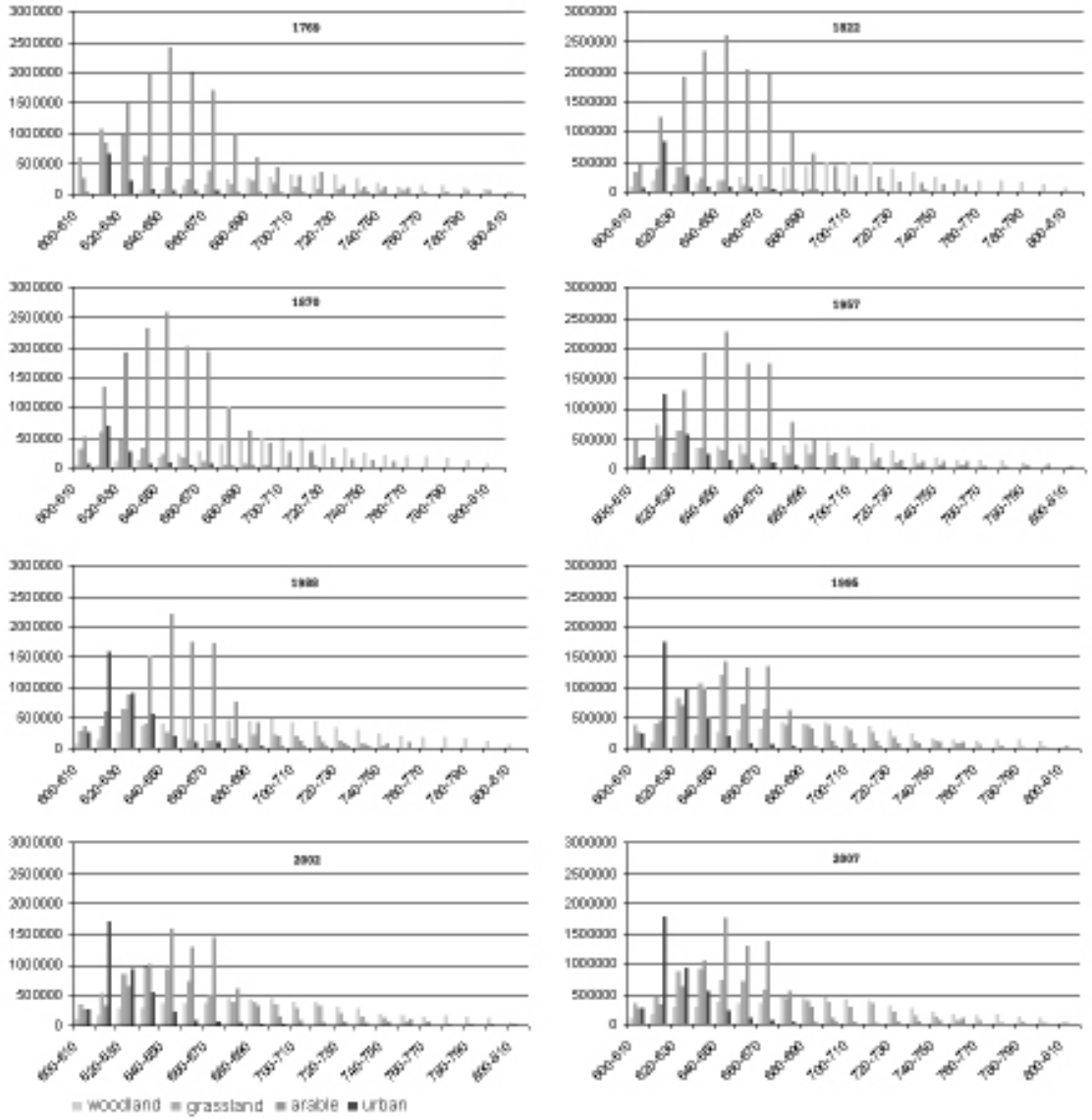

Fig. 5. Percentage proportion of land use areas to categories of altitude.

ity of data, because this process is sensitive to the accuracy. Unremoved errors and scale of accuracy are implicitly passed to all subsequent processes of treatment and in some cases can significantly distort the all results (Boltižiar 2007).

The best quality materials we used were orthophoto imagery. For vectorization process, materials from cadastral portal of the Slovak republic, were better due to their diginal form with accurate spatial position of the residential features, water and other features.

In study area we identified 32 landscape features which were classified into 8 groups. Their percentages proportions were changed over the time. The most significant changes were recorded in increasing proportion of permanent grassland and forest and nonforest vegetation features at the expense of agricultural fields. Analysis of landscape structure changes presents a significant dependence on social and economic changes but also on the natural factors.

In the study area was from 1769 to 2007 a total of 26.2% of the territory with relatively without changes. Bugár *et al.* (2006) evaluated in the case of Nitra and its surroundings similar situation in the years 1780 to 2000, where the land use was unchanged on 30% of the surface area. The biggest changes were recorded in intensification agricultural activities. In the Tatras region, this situation was reversed and we register almost 25% decrease of agricultural fields. This decrease is related not only with social changes, but also with deteriorating soil quality.

Boltižiar *et al.* (2007) found that with increasing of the slope continually increased also extensive areas and areas without changes. Intensification of use affected mainly lower situated places with lower slopes, and lower degree of altitude. Strong dependence between landscape changes and their intensity and properties of relief can be clearly seen. The same fact suggests also Mottet *et al.* (2006) in sub mountain area in French Pyrenees. Unchanged areas and extensive areas were found on higher slopes and at higher altitudes. Extensification of agricultural fields meant transition to pasture and meadows. Traditional heterogeneous mosaic structures used to grow crops were transferred to a large blocks of fields due to creation of the specialized farms with production of crops only for livestock feeding. Mottet *et al.*

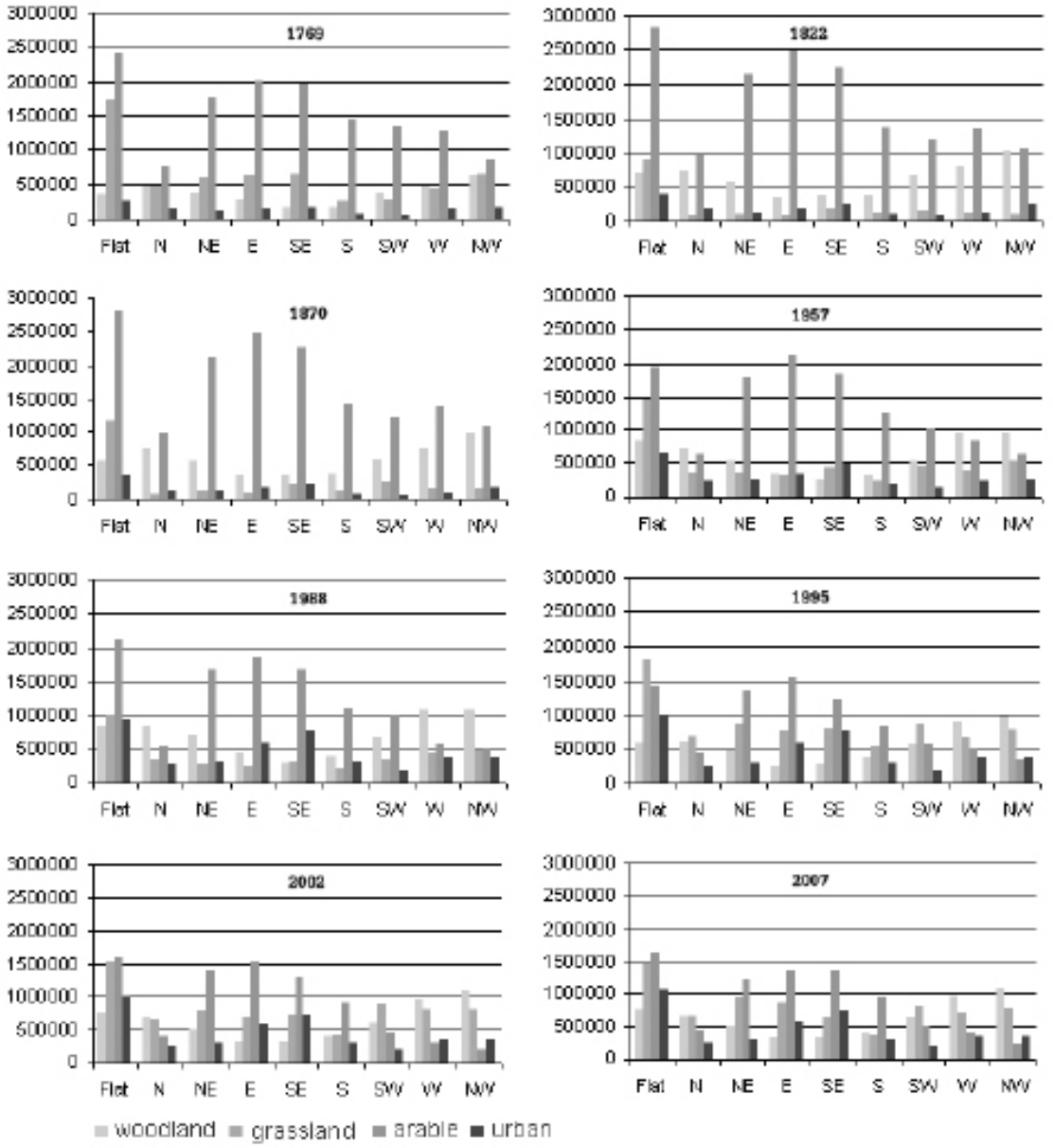

Fig. 6. Percentage proportion of land use areas to categories of exposition.

(2006) points out that such a phenomenon changes in agricultural fields on grasslands is widely observed throughout the Mediterranean. Further pointed out on the spatial land use mainly agricultural fields, which were dependent on the distance from the farms and barns as we confirmed also in our studied area.

Feranec *et al.* (2000) investigate major changes in land use in the Czech Republic, Slovakia, Hungary and Romania between the years 1970 and 1990. They confirmed the general trends that land use changes generally reflect the socio-economic and political development of the state. The greatest changes were due to industrialization, urbanization and anthropogenic pressure on arable land, forests and wetlands. They indicate extensification of agricultural fields as a source of the largest changes in the landscape. Area of agricultural fields decreased by 24% in the Slovakia and 26% in the Romania, what is comparable with the situation in the Kežmarok cadastre territory. The main reason for this changes was return of arable land to the original owners, as well as the changes of arable land with low production capacity to the meadows and pastures, especially on higher and steeper slopes.

Krausmann *et al.* (2003) showed the spatial changes in landscape structure and stable trend of converting arable land to grassland and meadow in Austria since 1950. The mainly reason was segregation of arable land to forage production for livestock. It led to a concentration of agriculture activities and arable lands in the fertile lowlands (for example Nitra and its surroundings) and to concetration of grassland to the lower mountain regions (for example Podtatranská area).

Since cultural landscape change entails serious ecological consequences, such as fragmentation and loss of habitats, specific knowledge about the background of disadvantageous processes is fundamental for the success of nature conservation measures. Particularly conservation concepts for endangered species and communities that are supported by traditional land-use systems (e.g., sheep grazing) have to consider the historical distribution of suitable habitats (Boehmer *et al.* 2005).

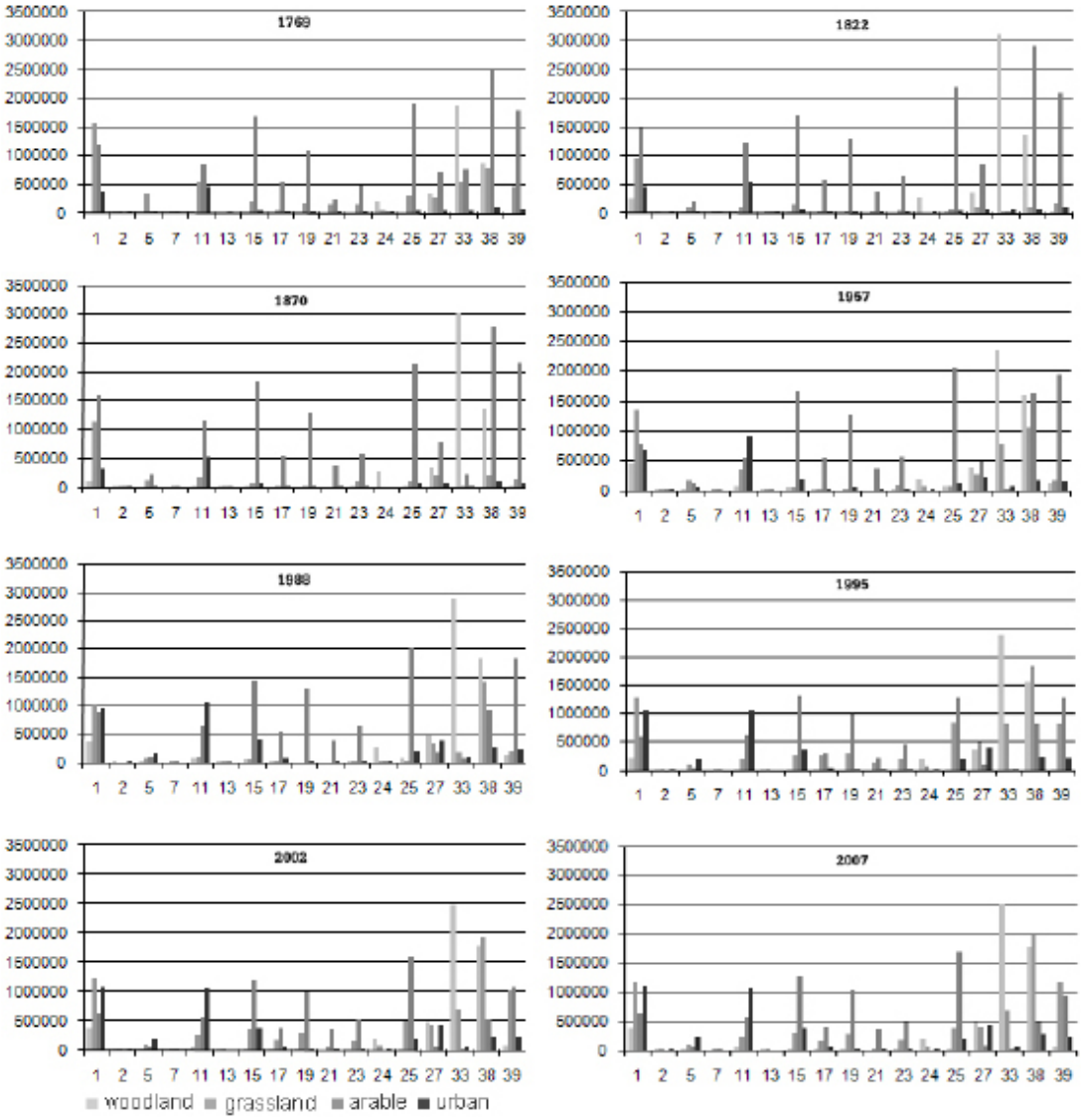

Fig. 7. Percentage proportion of land use areas to categories of geological bedrock.

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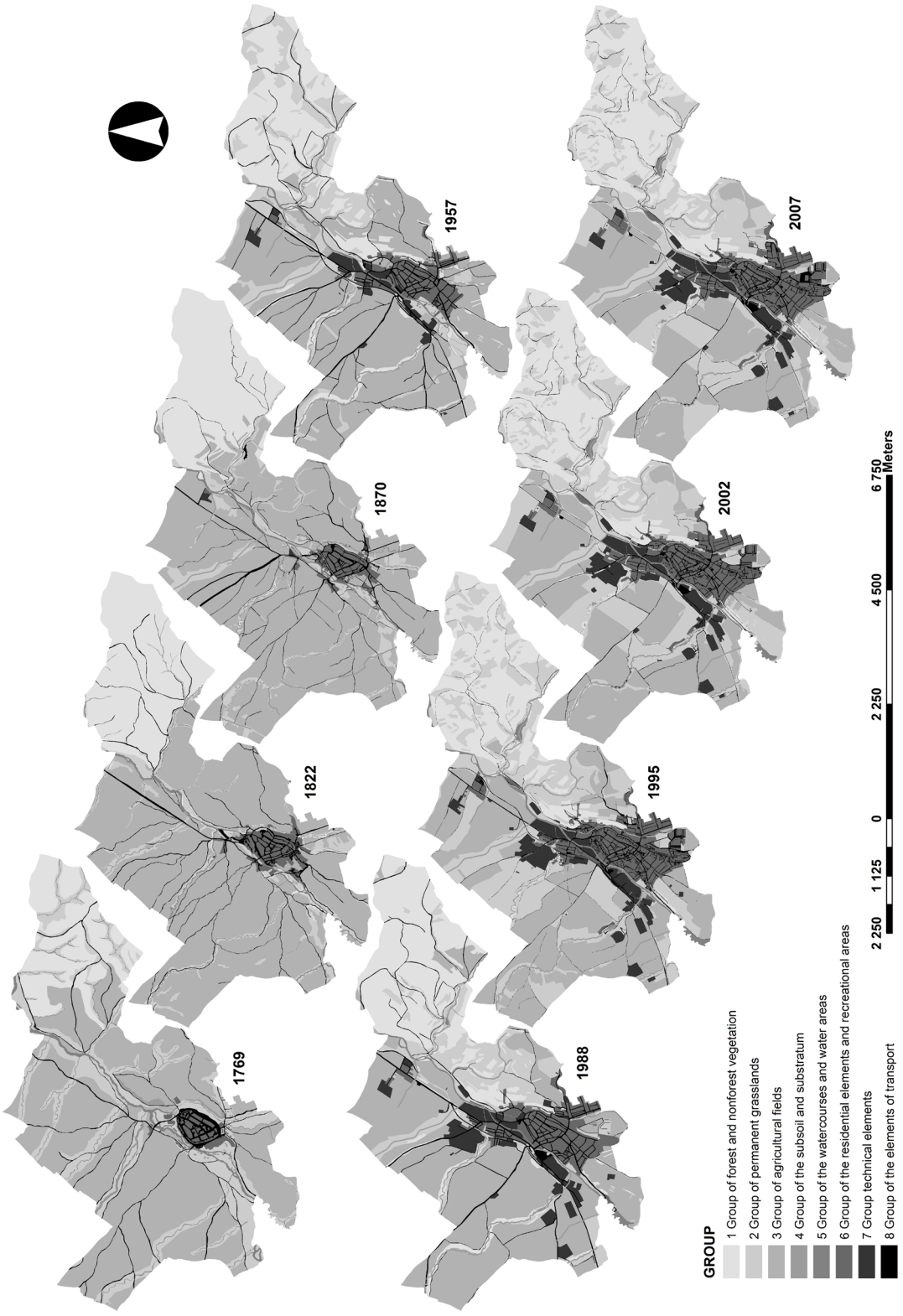
Appendix 1. Comparison of the land use changes in cadastral territory of Kežmarok



Appendix 2.. Comparison of the relative intensity of land use changes between different time horizons.