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Spatial Analysis of Ecotones Variability

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Abstract: The term of ecotone is read very widely. It comprises transitional zone between two biomas, meadow-forest border and differentiation of forest edge, but ecotones are also generally border zone among adjoining diverse society. From spatial point of view, ecotone is characterized by space and time, which reflects powers of interaction between boundary elements (ecosystems). Ecotones like spatial elements have diverse inner structure and construction, spatial attributes and other properties conditioned abiotically and biotically (contrast, inner differentiation, width, shape). Simultaneously, they have properties conditioned by time, development and function—these are permeability, stability and elasticity. To analyze spatial relations of landscape parts means to identify its building items and also system and relationship quality among these parts. In content with understanding the landscape and landscape parts and present state of problem solving of ecotones will be analyzed and typologically distinguished from the view of spatial bonds, heterogeneity, elasticity (influence), physical-geographic conditions, spatio-temporal stability etc..

Key words: Ecotones, spatial analysis, changes of land use, indices of landscape metrics.

1. Introduction

During the last 250 years, the changes of the landscape were very intensive. The landscape has changed continuously from the natural landscape, determined only by the physico-geographical conditions of the territory, to the agricultural landscape. This process happened in almost the whole area of our republic with exception of the elevated locations and those territories where climatic, terrain and soil conditions do not allow greater expansion of agricultural production. Nowadays, the authentic structure of the landscape is evident only in the territories with less favorable physico-geographical conditions for the expansion of agriculture.

The transformation of the landscape structure continuously proceeded during the past centuries. However, faster and more significant landscape changes happened in the 20th century. These changes have led to a remarkable simplification of the landscape structure as a result of compounding and reallotment of land, destroying of balks, field paths and land covers. During the fifties of the last century, blocks of arable land were established, whose sizes increased several times during the further development of the socialistic's agriculture. This happened with increasing concentration of agricultural large-scale production in the seventies of the last century. The formation of larger blocks of arable land totally destroyed the native landscape structure as the landscape was fanatically adapted for only one purpose—agricultural large-scale production supported by heavy mechanization.

The increase of the areas of landscape components resulted in a decrement of the mosaic of the landscape and its generic diversity. This has also affected the ecotones and transition zones between the two different gilds which have decreased together with the simplification of the landscape structure.

The landscape structure, its components and their developments are possible to monitor from several mutually complementary aspects: arrangement of gradients (abiotic and biotic) across the territory without significant and sharp boundaries, arrangement

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of areas in the mosaic of the landscape, network of areas and corridors, system of boundaries and rims in the landscape mosaic [1].

The aim of the paper is analysis of spatial dependences of ecotones. The study is carried out in a scope of cabinet research in a map scale of 1:25,000 in the Trkmanka River basin. The study is a part of the project of GA ČR 205/07/0821 "Analysis and modelling of spatial relationship dynamics of ecotones in GIS".

2. Ecotones

Natural boundaries are often characterised by transient or fuzzy zones. They are sparsely sharp or liner. Sharp lines can be found at terrain edges, beside rivers and reservoirs or at anthropogenic objects. They are formed as a result of differential effective usage of the landscape. An ecotone is generally defined as a boundary or transition zone, or edge gild between two or more ecosystems. As a consequence of a crossover, the ecotone often has higher biodiversity and more favorable conditions for organisms than every boundary biocoenosis, thus exhibiting a greater variety of plant and animal species present within it [1-3]. In other words, the ecotone is an element of the spatial structure of the landscape component (i.e. ecosystem), which represents a differently wide transition zone or line of interface between neighboring landscape components (i.e. ecosystems), which is characterized by a higher diversity of organisms and density of population in comparison with those in both neighboring biocoenosis (the so-called edge-effect) [4, 5]. In the ecotone, one can thus find both species from the neighboring biocoenesis and specific species, typical for this transition zone. However, Hansen and Di Castri [6] also consider sharp boundaries (i.e. narrow transition zones) to be the ecotone. In today's cultural landscape, the ecotones are the places of the contact of a natural territory with a territory influenced or controlled by humans (i.e. agroecosystems).

From the spatial point of view, the ecotones are characterized by a space and time which reflect the forces of interactions among boundary units (i.e. ecosystems). Hansen and Di Castri [6] have reported that changes of the space-time structure or functions taking place in the ecotone are faster than changes in the landscape as a whole. The ecotones, as a spatial units, have different internal structure and construction, spatial attributes and other properties, conditioned abiotically and biotically (i.e. contrast, internal product differentiation, width, shape). Simultaneously, they exhibit properties determined by time, development and function—transmittance, stability, elasticity. From the spatial point of view, they can be characterized by following typical properties [6-8]:

- Plasticity of transition. The transition zone can have different appearance, from gradual to sharp and discontinuous gradients. Sometimes, the ecotones can display the appearance of wedged ledges or tongues, salient from neighboring gilds;
- Time stability. Their existence and/or persistence are determined by the mechanism or factor of their formation. It is affected by a variant degree of dependence on external or internal natural processes and their manifestations. Human activities can also have the influence (planted hedgerows vs. non-grubbing forest belt);
- Ledges from landscape structure. They occur in a different degree of the contrast with each other and neighboring surface objects (in geology, geomorphology—rock and terrain shifts, in succession age of neighboring vegetation, in salinity in aquatic environment—for example at the entry of the river to the sea);
- Biological and spatial stability. The stabilization functions in the landscape result from their graded ability to react on a disturbance in terms of both resistance and/or resilience of the system and in dependence on a degree or intensity of the action of the respective factor;
- Source, support (standby) function. The ecotones influence neighboring, especially adjoining ecosystems. They act as a source of germs or nutrients.

They pollute or entrap (dust, pollen, seed, etc.) or "eject" predators or pests to the surrounding;

- Increased density of biomass. The edge-effect represents a tendency of gilds for densification and diversification of the biota in the transition zone. There exist either species from both neighboring formations or specific species, absent in neighboring territories.

In the landscape, the ecotones thus create a network which presents a stabilization and source element of the landscape and landscape components. The above mentioned properties of the ecotones are influenced by physico-geographical and socioeconomic conditions of the territory.

3. Area of Interest

The area of Trkmanka River basin, restricted by the boundary of the drainage basin, is situated in the Southern Moravia, easterly of Brno. Trkmanka River springs in Ždánický les Mts., which is located northwest from Ždanice town, in an altitude of 300 m above the sea level. The river then flows to the south and after 42.5 km it influences into the Dyje River from the left in a place, northeast from Lednice Town, with an altitude of 158 m above sea level.

The interested territory has elongated shape. In the north, the territory comprises of a system of Ždanické vrchy hills with the highest point called U Slepice (437 m above sea level). In the south, the territory reaches to the floodplain of the Dyje River. The north part of the area is forested, and the middle part of the interested territory represents a typical agricultural landscape with a small portion of woods and the south part of the territory is intensively agriculturally exploited.

The Trkmanka River basin belongs to the territories with a long history of the settlement and to the regions with a landscape highly influenced by humans. Suitable conditions of this landscape favor highly developed agricultural production that is concentrated mainly on a growing of the grapevine, which represents long-time tradition in this territory [9].

4. Methods and Procedure of Solution

The ecotones have a spatial pattern therefore they appear to be suitable for the research of their usage in geoinformation technologies. In GIS environment, the individual components of the real world, which are thematically divided, can be saved in separate digital spatial layers. These layers can be combined together in any way. One can derive new information. In addition, these layers and their combinations can be subjected to spatial analyses that provide further valuable spatial information which is unreachable from other methods [10].

The material for the research of the ecotone properties of the basin of Trkmanka river originated from a transfer of the spatial phenomena of the real landscape to the digital vector thematic layers. We have analyzed digital layers of the usage of the landscape of the study area from the years 1764, 1836, 1877 and 2007 at the map scale of 1:25,000.

The 1st Millitary Survey maps from 1764-1768 were not made on the basis of astronomical-geodetic measurements. The absence of matematical bases causes very low map's accuracy [9]. The 2nd Millitary Survey from 1836-1840 required preparation of a koherent astronomical-geodetic network. The 3rd Millitary Survey from 1876-1878 was carried out mainly due to the improvement in the measurement precision. The present land use/land cover (further only LU/LC) was created from a coloured orthophotos that was made on the basis of measuring air shots from 2004-2006.

The layers of the land use were modified with respect to the aim and purpose of the study. Therefore, any administrative and possessive features within one facet have not been considered with the aim of construction of the model corresponding to the real landscape as much as possible. Vector layers of the land use have been used as a competent theme, whose categories have been treated as landscape components. Every facet (i.e. polygon) represents a space of the landscape component [11].

5. Results

Edges or lines between each facet are considered as ecotones. The net of polygons could be named as the net of ecotones in the real landscape. The development of the identified landscape elements in the watched time horizons is shown by means of NP (number of patches) and MPS (mean patch size) indexes in Table 1.

Table 1 clearly shows the trend in the change of elements number during the years 1764-2007. Two increases are visible, namely during the 2nd Millitary Survey (1836) and at the present time (2007).

This trend can be identified in all categories with the exception of built-up areas, orchards and gardens, where the number of patches constantly grows. Also water areas category, where the situation is in opposite to the most LU/LC categories, are the exception from the trend, because there is a visible decrease in the number of patches during the 2nd Millitary Survey and then its moderate growth.

It is impossible to find a uniform trend for most categories within the index of mean patch size. MPS of arable land and wood during the 2nd Millitary Survey (1836) and at the present time (2007) is decreasing, meaning that sizes of individual elements decrease. In opposite, mean patch size of water areas increases exactly between 1764 and 1836, then to 1876 rapidly decreases and finally between 1876 and 2007 only slight MPS decline is noticed. The development of mean permanent grassland elements sizes and vineyards is almost identical, in particular between 1764 and 1836 MPS decrease is noticed, then stagnation and between 1876 and 2007 the mean patch size is again lower. Built-up areas, orchards and gardens are distinguished by moderate MPS growth.

Each ecotone is the element of the net, whose qualitative and quantitative properties are influenced by the type of the landscape. The spatial character of the ecotones could be considered as the quantitative indicator. This work is based on the study of these indicators.

The length of the ecotone is the attribute, which is composed of two different characteristics. The first one is the absolute length of the ecotone—the length of the centre line in the landscape segment. The analysis of these characteristics in three different time horizons is shown in Table 2. The second one is the relative length of the ecotone. It shows the length of the active border of the ecotone. The proportion of the above mentioned characteristics influences the area of the ecotone. In Table 2, TE index is given in absolute values (km) and in relative (%) between two given categories (e.g. wood—arable land, permanent grassland—water areas, etc.). A patch edge is understood as the boundary between two patches of different types.

Table 1 NP and MPS indexes development from 1764 to 2007 in Trkmanka River basin.

	NP (number of patches)				MPS (mean patch size) (ha)			
	1764	1836	1876	2007	1764	1836	1876	2007
Built-up areas	197	245	234	302	5.09	3.77	3.80	7.89
Unmetalled road	13	50	134	317	35.81	14.90	3.83	2.10
Metalled road	1	9	11	24	10.88	4.35	10.05	10.23
Railway	0	1	1	2	0.00	7.11	7.15	36.99
Arable land	730	1055	828	1043	30.34	15.78	27.73	20.92
Permanent grassland	323	825	499	528	25.22	8.51	9.20	2.53
Orchards and gardens	0	11	2	343	0.00	2.15	3.05	3.52
Vineyards	127	412	225	601	27.34	11.72	11.40	5.17
Woods	198	477	205	1207	46.08	15.01	29.97	5.74
Water areas	56	17	39	67	19.30	29.36	2.88	1.89
Total	1645	3102	2178	4434				

Table 2 TE index during 1764-2007 in Trkmanka River basin.

	TE (total edge)						
	1764	1836		1876		2007	
	%	km	%	km	%	km	%
Built-up areas	3.25	236.62	2.95	224.20	3.41	448.41	5.23
Unmetalled road	30.30	2968.72	37.04	2050.02	31.19	2649.48	30.89
Metalled road	0.36	78.50	0.98	221.35	3.37	440.76	5.14
Railway	0.00	9.52	0.12	9.56	0.15	98.60	1.15
Arable land	32.74	1879.16	23.45	2385.69	36.30	2093.02	24.40
Permanent grassland	16.88	1356.69	16.93	799.79	12.17	469.65	5.48
Orchards and gardens	0.00	8.09	0.10	1.50	0.02	294.08	3.43
Vineyards	4.77	608.59	7.59	326.43	4.97	608.03	7.09
Woods	9.58	821.79	10.25	522.28	7.95	1431.97	16.69
Water areas	2.12	46.55	0.58	33.93	0.52	43.64	0.51
Total	100.00	8014.23	100.00	6572.53	100.00	8577.68	100.00

From the percentage substitution of the individual categories edge lengths, it is easy to determine the development of TE index that has a different course for each LU/LC category. The most substituted (about 30%) are categories arable land and unmetalled roads that include wood and field roads. The TE value of unmetalled roads increased during the 2nd Millitary Survey (1836) from 30% to 37%, and then decreased again to the starting value. The category arable land has a very dynamically changing course of TE index with the decline during the 2nd Millitary Survey and at the present time to about 24% and in opposite with high values during the 1st and 3rd Millitary Survey (1764-1876), when the TE value fluctuated over 30%. Very rapid decrease was noticed for LU/LC class of permanent grassland, when between 1st and 3rd Millitary Survey the value stagnates, then rapidly decreases from 16.88% to today's value of 5.48%. For wood category TE index increased from 9.58% (1764) to almost 16.69% at the present time. For the other categories no significant changes were observed, with the exception of metalled roads (today's highways and motorways), where the number grew.

Table 3 shows the boundary lengths between chosen

Table 3 The boundarys' lengths between chosen LU/LC categories during 1764-2007.

	TE (total edge)						
	1764	1836		1876		2007	
	%	km	%	km	%	km	%
Wood-unmetalled road	9.81	608.30	15.44	267.61	8.31	107.60	25.50
Arable land-unmetalled road	37.00	1131.35	28.71	1337.77	41.54	921.32	21.82
Vineyards-unmetalled road	2.35	406.66	10.32	111.51	3.46	313.95	7.44
Arable land-metalled road	0.47	44.74	1.14	174.39	5.42	237.52	5.63
Arable land-wood	3.91	53.31	1.35	129.35	4.02	198.99	7.71
Arable land-permanent grassland	14.71	445.83	11.31	413.76	12.85	178.32	4.22
Arable land-vineyards	5.51	78.50	1.99	159.64	4.96	145.18	3.44
Arable land-bulit-up areas	3.47	45.22	1.15	76.97	2.39	139.89	3.31
Permanent grassland-wood	3.43	75.98	1.93	62.61	1.94	47.22	1.12
Permanent grassland-vineyards	0.64	57.88	1.47	28.43	0.88	39.65	0.94
Wood-vineyards	0.81	40.90	1.04	13.08	0.41	26.02	0.62
Water areas-arable land	0.13	8.95	0.23	11.36	0.35	21.67	0.51
Permanent grassland-bulit-up areas	0.48	28.44	0.72	19.27	0.60	16.87	0.40
Water areas-permanent grassland	3.92	37.78	0.81	17.02	0.53	12.58	0.30
Total	100.00	4969.60	100.00	4777.81	100.00	5382.78	100.00

LU/LC categories in all monitored time horizons. The values are given as absolute and relative for the comparison with the 1st Millitary Survey.

It is obvious that the longest boundaries are created by unmetalled roads, i.e. field and wood roads and the most area substituted categories. In the past, the dominant type of boundary was the arable land-unmetalled road, but at the present time the first position has the boundary wood-unmetalled road, due to the large number of wood roads in the present LU/LC. Also a huge decrease in boundary length between arable land and permanent grassland was recorded, that was varying between 10% and 15% in the past, but according to the present LU/LC, it captures only about 4%. Sharp decline nowadays is explained by a drastic reduction of permanent grassland area. Such categories of boundaries like between arable land and wood or arable land and vineyard have the social character of development. The progress of both of them imitates the arable land development in the monitored time horizons. Their area was decreasing during the 2nd Military Survey (1836), then it was increasing in 1876, and finally moderate decrease of area is observed in present LU/LC.

Table 3 shows also percentually insignificant boundaries lengths between chosen categories. There is a noticeable change of the boundary length between water area and permanent grassland, which during 1764-1836 decreased about 3/4, and now is proceeding, but not so sharply. In the monitored time horizons the percent of substitution of the length between water area and arable land is increasing. There is also a very big decrease of the boundary length between wood and permanent grassland, which dropped about 2/5 during 1764-1836, then stagnation and now again decrease is recorded about 2/5 when compared to 1876. The great dynamic development appears also between built-up area and arable land, where the decrease of area is evident during 1764-1830. The reason of such situation lies in the increase of vineyard areas that were very often occurring close to farms and permanent grassland at this time. Between 1836 and 2007, the boundary length of arable land-built-up area increased due to the decrease of permanent grassland area and moreover due to the increase of built-up area. Very similar course of development have boundaries like vineyard-wood and vineyard-permanent grassland. In both cases, it expresses as a change of the vineyard area, which according to the 2nd Military Survey was increasing, meaning that also boundaries wood—vineyard and permanent grassland—vineyard increased. After this time the decrease of the vineyard area follows (1876) together with the decrease of boundary with wood and permanent grassland. Nowadays, according to the present LC/LU, the moderate increase of vineyard area and its boundary length with wood and permanent grassland is observed once again. The boundary length between permanent grassland and built-up area imitates changes of permanent grassland in the monitored time horizons with the maximum length in 1836 and minimum at the present time.

The last monitored parameters were diversity landscape indexes. On the basis of these indexes, it is possible to measure spatial landscape pattern. Shannon diversity index (SDI), Shannon equilibrium index (SEI), and Domination index (D) were calculated for the whole area, not for individual LU/LC categories, with following results:

(1) Shannon diversity index (SDI) quantifies landscape diversity based on two elements: the number of different area types (richness) and their evenness. SDI is increasing when the number of different area is increasing, or when the evenness for the individual type of area is uniform. The maximum value is reached when the maximum number of area class is substituted in landscape equally [12];

(2) Shannon’s Evenness Index (SEI) is based on the distribution and substitution of the individual types of area. It originates from Shannon diversity index, which is calculated for the maximum SDI for the monitored area types [12];

Table 4 The SDI, SEI and D indexes development during 1764-2007 in Trkmanka River basin.

	1st Millitary Survey	2nd Millitary Survey	3rd Millitary Survey	2007
SDI (Shannon diversity index)	1.40	1.49	1.22	1.37
SEI (Shannon's Evenness Index)	0.67	0.65	0.53	0.60
D (Domination index)	0.68	0.81	1.08	0.93

(3) Domination index is a supplement of SEI. The higher the value, the lower landscape diversity and only one type of area dominates.

Calculated values for SDI, SEI and D indexes are shown in Table 4.

Table 4 demonstrates that the highest landscape diversity was in the time of the 1st Millitary Survey (1764), even though the SDI calculated for 1836 was higher than for 1764, but there was lower number of categories presented in the Military Survey. The smallest diversity is noted during the 3rd Military Survey (1876).

6. Conclusion

The current development of the landscape is in conflict with the sustainability of ecotones according to the results. The authors have observed strong changes of the landscape structure in the time horizon 1877-1955 in the given area of the Trkmanka River. The area of each facet has grown. The length of the borders has increased. The proportion of each landscape elements has changed, too.

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Adaptation and New Water Policy—Answer for Climate Change

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Abstract: Adaptation in water policy is an integral and preferable method of adaptive integrated water resource management (AIWRM). Very important claim of water policy using adaptive integrated water resource management is: "Plan and design robust systems". The starting point in water policy should be the accomplishment of the "win-win" and "no regret" actions, i.e. actions that need to be realized in all cases regardless of climate change. The problem of inadequate adaptation capacity can be solved by the modern technology like geoengineering.

Key words: Adaptation, water management, climate change.

1. Introduction

The growing worldwide exposure to natural catastrophes has become very evident in recent years, as a result of the major floods, heat waves and forest fires in Europe, as well as the disastrous hurricanes in the USA. Over the last two decades, the world has experienced a clear increase in the number, scale and economic impact of such events. The scale and frequency of natural catastrophic events are likely to increase. In fact, the increase has started.

Despite the evident climate change impact, some deniers of climate change do not like to see:

- Increasing global air and sea surface temperatures;
- Rising global average sea level;
- Widespread melting of snow and ice;
- Greater temperature increase at higher northern latitudes;
- Faster warming of land regions than the oceans;
- Faster winter months temperature increase than summer months;
- Rapid warming trend over the past 30 years;
- Extreme weather events likelihood;
- Increase of losses due to extreme weather events precipitation and temperature patterns;
- Increase of losses due to severe floods and sea surge;
- Increased costs of coastal protection and land-use relocation;
- Damage to coast and coral riffs;
- Land degradation;
- Wildfires;
- Losses in agriculture (area affected by droughts);
- Soil erosion, flash floods, land- and mud-slides;
- Heavy precipitation events;
- Increased frequency of heat waves.

According to the reports of IPCC (UN Intergovernmental Panel on Climate Change) namely the Fourth Report AR4 published during the year 2008 the influence of mankind activities namely burning of fossil fuel are the main reason of climate change [1]. The reaction of politicians was straightforward—it is necessary to mitigate the climate change by reducing

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emissions of greenhouse gases (GHG) emissions, namely the CO_2.

The requirement for reduction of emissions of GHG seems as a quite reasonable solution of the situation climate change and global warming problems. However, now some scientists deny such straightforward relation between concentrations of GHG and climate change.

They argue that the proxy data from the past 650,000 years show that the first temperature begins to increase and CO_2 concentration follows (different time lag 200-800 years) [2].

Leroux [3] even did a question mark to his investigation of temperature increase as a result of CO_2 increase and concluded: greenhouse effect does not control the evolution of temperature. Such statement if proven would have very important impact on our reaction.

Other scientists like Lomborg [4] claimed that reduction of fossil fuel emissions will cost much more than direct adaptation actions like adaptation in water resources management and other sectors. He is a perfect statistician and every sentence written in his book is based on a statistical analysis.

The "Open Letter" [5] of one hundred of scientists to the general secretary of UN (Ban Ki-moon) on the climatic conference in Bali criticize the way of interpretation of the results of many scientists by IPCC with preference of one hypothesis of the role of GHG in the atmosphere and global warming.

Other warning reports in UK (The Report of the House of Lords Select Committee on Economic Affairs [6]) criticize the work of IPCC. In results of AR4 the positive effects of climate change were underestimated. The report states that global warming will continue even under the worldwide actions (like promised by EU of G8).

This introduction has the main idea: the problem of climate change and its causes has not been definitely solved by the reports of IPCC. It is still a scientific problem and the political reaction to it should consider this fact.

2. Climate Change Scenarios

In literature namely popular literature there are many attempts to forecast our future on the basis of changing climate. These predictions vary from relatively slow step-by-step changes to revolutionary possibilities with instability and wars [2]. IPCC investigated this problem and offered six main scenarios of the human society development (IPCC SRES-[1]) namely A1Fl, A1B, A1T, A2, B1, and B2. The scenarios are the basis for prediction of the GHG concentration (so-called post-SRES), derived by different climatic models. Using these scenarios and climatic models, the prediction of temperature till 2100 increases from 1.1 °C to 6.4 °C (with a majority between 1.8 and 4.0 °C). Further analysis is necessary to achieve more precise estimation.

Despite this situation, some scientists (like Stern [7]) force the politicians to immediately start actions as he and others recommend applying the so-called precautionary principle. He claims that postponing might be very expensive. Other scientists, like B. Lomborg and president of the Czech Republic V. Klaus, recommend postponing adaptation and mitigation actions like expensive reduction of GHG emissions as future generations will be far richer and their technology will be more developed to deal with the problems of climate change.

Can a recommendation for water policy be derived under such different attitudes to the problem of climate change? Yes, it can, and it will be summarized in the conclusion part!

3. Policy Response to Mitigation and Adaptation to the Climate Change

In their proclamations the majority of politicians agree on the necessity to reduce the emissions of GHG. The slogan of EU in 2020—20% reduction and in 2050—50% is a clear example. However, in the negotiations of COPs (Conferences of UNFCCC) it comes out that the transition of these proclamations into concrete commitments is a very difficult process!

Further, the financial crisis threatens climate-change momentum. Experts fear the credit crunch will discourage governments worldwide from turning to taxpayers for assistance in climate-change efforts. Some politicians threaten to veto the world-leading European Union climate agreement on the grounds that businesses hit by the crisis should not be asked to carry extra costs on climate mitigation actions. On the other hand the ecologists claim that the "unprecedented" financial crisis, no matter how severe, will be short-lived and should not stand in the way of global action on climate change.

Many economists warn that each percent of reduction may result in a very expensive reduction of GDP with transfer of production to the third world like China and India. Reaction of politicians for water policy should stay on the ground and do the "win-win" actions that will assist to water management in each situation—small changes of climate or big ones.

4. Risk Management and Geoengineering

Planning of economic development under the risk of climate change and its impacts is a typical risky situation. Why not apply the methods of risk management to find the most critical parts and situations of the economic and environmental systems and concentrate on solving of these situations? Of course, the solutions require adequate technical measures to be at hand in the time of the necessity of their application. The proposal for such measures exists, and it is not new. Even in 1965 on president of the USA Johnson's desk there was a report: "Restoring the Quality of Our Environment" that recommended raising the albedo (reflectivity) of the Earth to counterbalance the effect of CO_2 increase. Such a change in albedo could be reached by splitting of some material (aluminum powder or sulfates) in the upper part of atmosphere–stratosphere. This method was lately called geoengineering, i.e. the worldwide engineering action to govern the climate system.

The up to date debate on geoengineering was started by Crutzen [8], winner of the 1995 Nobel Prize in chemistry for his ozone hole work. The prestigious journal Climate Change devoted an entire issue to the subject. This journal published many articles on this topic. The original Crutzen's proposal is to pump sunlight reflecting sulphur particles into the atmosphere. We have had several experiences with the cooling effect of atmospheric sulphur. The eruption of Mount Tambora 1815 caused the "year without summer". In 1991, Mount Pinatubo spewed forth enough sulphur to cool the Earth about 1°F for several years. That's about equal to the planetary warming we've experienced over the past 100 years.

Other ideas [9, 10] include placing aluminum-powder into stratosphere. Detuning airplane engines, jets "fly dirtier" and emit more carbon soot (therefore it is called "sunscreen" proposal), and spraying seawater into clouds to increase the albedo effect. All of these proposals would cool the planet without any reduction in CO_2 emissions.

Even proponents don't believe that geoengineering would solve all the problems. Rather, it is a valuable method of risk management when all other methods fail to stop immediately the climate change impacts, e.g. the rapid increase of the sea level. It buys time while we develop and deploy alternative fuels and figure out acceptable policies to reduce or stabilize atmospheric CO_2. On the other hand the effects of geoengineering are counted in months (rather in decades) [11].

Geoengineering will receive ever more attention from scientists and policy makers, as the hidden costs of schemes like the Kyoto Protocol become obvious. These costs are probably too high for politicians to bear, namely facing the economical crisis. Of course, we can control ("geoengineer") the climate, but it raises important questions. Who sets the thermostat? Do residents of small islands turn the dial, since a future rise in sea level could submerge their homes? Or do the Russians? They might prefer some moderate warming to increase agriculture in Siberia and provide ice-free ports etc..

Dealing responsibly with our changing climate requires a portfolio of strategies, probably including geoengineering. However, it will be a long way from the recommendation of scientists like Crutzen to the portfolio of politicians.

5. Impact of Climate Change on Water Policy in EU and the Czech Republic

The two basic methods to deal with the impacts of climate change are mitigation and adaptation. While mitigation is in general out of scope of water policy (with the exception of preference water power plant with no emissions of GHG to thermal power plants), the main method in water policy is adaptation. However, the question might be adaptation to which station of the climate system moderate or severe change of climate. The answer is relatively easy—adaptation to unexpected situations (IIASA, 1979). In water resources systems it means to be prepared for a possible operation outside of the range of design parameters.

In water policy, there is a very rare the case of a project with over-designed parameters. Water policy projects are typically multi-objective and if one objective is not fully justified at this moment the other can stand in his place. The resulting requirement is: plan and construct robust systems that are able to adapt to climate change impacts.

Various adaptive arrangements are taken for minimizing the negative consequences of climate change. For water management in the Czech Republic the basic adaptive measures were summarized in EEA Technical Report No. 2/2007 as cited in Table 1.

Table 1 Main adaptive measures in the Czech Republic [12].

Flood protection
Technical + natural (retention support) flood protection
Standards for building development
Improving forecasting and information
Improving insurance schemes against flood damage
Improving dams operation plans
Drought/low flow protection
Technical measures to increase supply
Increasing efficiency of water use
Economic instruments + legislative restrictions of water uses
Landscape planning measures to improve water balance
Improving forecasting, monitoring, information
Improving insurance schemes against drought damage
Coastal zones
Reinforce or heighten existing coastal protection infrastructure
Retreat strategies, e.g. managed realignment of dams
General adaptation measures
Awareness raising or information campaigns
Educational training, legislation support

6. Water Policy and Adaptive Integrated Water Resources Management

Integrated water resources management (IWRM) was defined as "a process, which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". This resulted in the human dimension and stakeholder involvement being identified as an integral part of water management. The adaptive approach is based on the hypothesis that IWRM cannot be realized unless current water management regimes undergo a transition towards more adaptive integrated water management (AIWRM). AIWRM can more generally be defined as a systematic process for continually improving management policies and practices by learning from the outcomes of implemented management strategies. New water policy focuses on the transition of current water management regimes to adaptive water management where adaptive management is aimed at integrated system design. These general ideas should be applied for the Czech Republic water policy.

7. Conclusion

Adaptation in water policy is an integral and preferable method of adaptive integrated water resource management (AIWRM). Very important claim of water policy using adaptive integrated water resource management is: “Plan and design robust systems”. The starting point in water policy should be the accomplishment of the “win-win“ and “no regret” actions, i.e. actions that need to be realized in al cases regardless of climate change. The problem of inadequate adaptation capacity can be solved by the modern technology like geoengineering. Geoengineering should be considered mainly as a short term method of risk management that can solve risky climate problems.

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Photogrammetry and Remote Sensing on the Study of Disasters

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Abstract: Internal and external factors have formed the earth. Man-made factors influence environment (the surface of the earth, the sea and the atmosphere). Various scientific and technologic disciplines, as geosciences, plant sciences and engineering, study the earth and the relevant phenomena, including catastrophic phenomena for man and environment, that is, disasters. Photogrammetry and remote sensing (defined by Statute II of ISPRS) is the art, science, and technology of obtaining reliable information from non-contact imaging and other sensor systems about the Earth and its environment, and other physical objects and of processes through recording, measuring, analyzing and representation. Photogrammetry and remote sensing present rapid advances, as for example in data acquisition systems (detectors, sensors, platforms). They are basic components of geoinformation. This paper includes analytical and critical consideration of examples of disasters as well the contribution of photogrammetry and remote sensing on their study and management.

Key words: Photogrammetry, remote sensing, geoinformation, disasters, landslides.

1. Introduction

Endogenous and exogenous factors have formed the earth. These factors in combination with man-made ones continue to act. The environment, in which man lives, refers to the surface of the earth, the sea and the atmosphere.

This paper concerns general principles of photogrammetry and remote sensing, in a way to approach their methods and resulted products. Next, we refer to the term "disaster" and considerations of their classification and study, with particular reference to landslides.

2. Photogrammetry and Remote Sensing

Photogrammetry and remote sensing use information from non-contact imaging. Radiation, coming from the physical objects themselves or from the reflection of the solar radiation on them, is the primary source.

The radiation concerns, according to the case, different parts of electromagnetic spectrum (visible, thermal, microwave, etc.).

Scientific and technologic advances have resulted in various devices to capture this radiation (sensors, detectors, scanners). Radiation is recorded, measured, analyzed and represented.

Methods of photogrammetry and remote sensing concern the above process and the acquisition of relevant products. Different instruments-systems and suitable terrestrial, aerial and satellite platforms are used.

Photographic sensor and the corresponding picture (photography) were the first that were used and that still continue to be efficient.

In some cases, the sensor itself emits and receives the returned radiation (active sensors-radar systems).

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In other cases, photogrammetry and remote sensing may be combined with different technologies as for example the combination of laser technology with inertial measurement unit and GPS results to Lidar.

Sensors, detectors and scanners on various platforms finally result in images of different kind as thermal, radar, multispectral, panchromatic, etc.. The images may be in analogical or digital form. Image interpretation requires analysis and understanding of it. Metric exploitation, nowadays, can be done with analytic and digital methods. The resulted products can be graphical (alignment, contours, sections etc.), digital (coordinates of points x, y, z), pictorial (rectification, orthophotograph), digital terrain models, etc..

3. Disasters

Physical phenomena of various kinds occur on the surface of the earth (lithosphere, hydrosphere) and in the atmosphere. Among them, catastrophic phenomena are of particular importance because of their impacts.

Disasters can be considered as extreme events that induce broad scale losses in lives and properties, as well social and economic disruption in different levels (local, regional, national, global).

Disasters may be subdivided in two broad categories:

- Natural disasters (earthquakes, volcanic eruptions, floods, landslides, etc.);
- Anthropogenic-technologic disasters (forest fires, accidents in nuclear plants, oil spills, etc.).

In a consideration that takes in mind the study objects of civil engineering, we include groups of disasters in the following thematic areas:

- Constructions: technical works, urban structures, etc.;
- Hydraulics-hydrology: drainage network, streams with heavy flow, dams, floods, etc.;
- Geotechnical subjects: foundations, erosion, slope instability, landslides, earthquakes, volcano, etc.;
- Transportation: road networks and potential damages, etc.;
- Environment: pollution, wastes, desertification, etc.;
- Cultural heritage: monuments and historic centers.

The necessity of disasters study is obvious. Various scientific and technologic disciplines as geosciences, plant sciences, engineering etc. are engaged.

This study, in a pre-disaster phase, involves understanding of mechanisms and procedures that cause the disaster, as well the wide area in which it may occur (geomorphology, geology, soils, hydrology, land use, land cover, vegetation, etc.).

During the disaster, relevant information and data from any available source are evaluated. The speed of information collection in this phase is of “key” importance.

In the post-disaster phase that follows, assessment of the destruction is done, measures for relief and restoration are taken and the stroke area is monitored.

Photogrammetry and remote sensing play an important role in disaster study. These can also be used in link with geographic information systems (GIS) for management subjects, as monitoring [1].

Unmanned airborne platforms [2] and application of synthetic aperture technology are also used for disaster study and support.

4. Landslides

The term landslide concerns mass (soils, rocks, etc.) movement under the influence of gravity. Landslides happen worldwide, either isolated, or in combination with other natural disasters, as earthquakes, floods and volcanic eruptions. Their impacts may be destructive for properties, man lives, settlements, technical works, road and railway network, etc..

Important factors for the formation and the appearance of landslide phenomena in an area are the following: geomorphology, geology, soils, land use, land cover, climate and man.

Several kinds of landslides occur, depending on the type of the movement (slide, flow, fall, etc.), its speed, the material involved (soil, rock, debris, etc.) and the mechanism that caused them (earthquake, heavy storm, flood, man, etc.).

The detection and recognition of landslide areas in images depend on the size of the landslides, tonal and textural differentiations, but also the total appearance of the wide surroundings (changes of drainage patterns, vegetation, etc.).

Typical features of landslide indication may include crescent scarps, abrupt changes of vegetation with characteristic changes in micro-relief and drainage network disruptions (leakage, relation of landslide with drainage).

The above features may be possible to be detected in aerial photographs in scales 1:15,000-1:25,000 [3], and particularly during photointerpretation study of stereoscopic pairs of aerial photographs, that remains essential [4].

In many cases, some of them are detectable in optical satellite data (mainly SPOT data and Very High Resolution data), after digital processing. However, satellite imagery, particularly multispectral images, can be used for the acquisition of information about the relevant factors-parameters as geology, soils, land cover, etc.. Information about relief subjects and geomorphology in a wider sense are possible to be acquired from satellites that have the potential of stereopairs (SPOT satellite, Ikonos, etc.) and/or from the combination of satellite imagery with digital terrain model, that was produced by photogrammetric techniques. Aerial and terrestrial laser scanning is also used [5], as well SAR (synthetic aperture radar) methods and interferometry [6].

Old landslides are important because they indicate areas in which the combination of factors permitted landslides occurrence. However, we must have seriously in mind that the time that is passing may result in a homogenization of the appearance with the surrounding area.

In Fig. 1, an area of an old landslide is presented, from one of our relevant papers [7].

The area presented in Fig. 1 is located in north-western Greece. The used satellite data concern SPOT 5 imagery (SPOT Image, CNES), dated 2007-07-21, level processing 2A, multispectral mode: green (0.50-0.59 μm), red (0.61-0.68 μm), near infrared (0.78-0.89 μm) and SWIR (1.58-1.75 μm) with 10 m spatial resolution. ERDAS Imagine 10.0 software was used. Histogram equalization was considered useful for the detection of the drainage basin (yellow line) in which the old landslide has occurred as well the basic drainage axis (rounded line). Erosion areas and soil accumulations are presented with white and light pink color respectively in Fig. 1.

5. Discussion and Conclusions

The framework of photogrammetry and remote sensing (methods, products) and disasters were briefly searched through, under the interests-activities of Photogrammetry-Remote Sensing Laboratory in the Department of Civil Engineering, A.U.Th.

Deal of catastrophic phenomena requires the cooperation of many scientific and technologic disciplines. Photogrammetry, remote sensing and geoinformation systems (GIS) compose geoinformation and essentially contribute to disasters study and management, in all the phases (pre-disaster, during the disaster, post-disaster/monitoring).

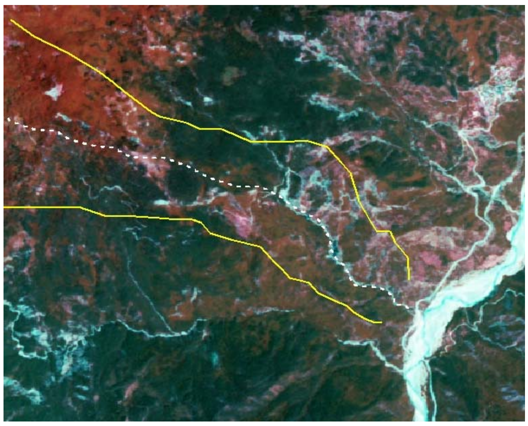

Fig. 1 Old landslide area image.

Because of the global importance of the subject, it has to be faced in all the levels (local, regional, national, global).

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