The Certainty of Landscape Degradation?

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Abstract. Users have the tendency to consider computer-generated maps as correct and uniquely identifying a given phenomenon. This study has an ambition to promote the natural critical thinking and to refine the decision making supported by GIS applications. The critical and spatial thinking is indispensable especially in natural risk management. The basic facts are linked to the project GeoRISK: Geo-analysis of landscape level degradation and natural risks formation. Project is trying to confirm the dependence of high level landscape degradation and propensity to natural risks emergence. This multidisciplinary approach is applied to model catchments with different natural conditions in the Czech Republic. Furthermore there were designed possible multidimensional (multiple kinds of uncertainty) representation of uncertainty.

Keywords: Cartographic visualization, Uncertainty, Data quality, Landscape degradation, River landscape, Natural risk

1. Introduction

Long-term increase trend of human activities has negative impact on the function and landscape stability. Anthropogenic pressure influences directly or indirectly approximately 30 % of the Earth surface. Environmental problems, which are caused by inappropriate land use changes, have adverse effect on human society. Such landscape degradation is demonstrated by local predisposition to occurrence of natural risks (flood events, slope instabilities).

The basic requirement for each map is its legibility and the ability to communicate timely and accurate information to potential readers. This information communication process, however, offers a number of variables that causes different final vision of reality of map users and its creator, a cartographer. The general public, with mostly lower cartographic knowledge, consider GIS produced information more reliable, than it was at the time of processing maps without software tools. In any reality display in the map there must inevitably lead to its simplification, because cartographers do not have a method that would allow for efficient real view of the observed phenomena. Therefore this model can be considered incomplete and uncertain, since there is an obvious discrepancy between geographic data and real world (Koláčný, 1969). Lack of transfer of geographic information is encoded in its very form of maps, but also the lack of critical usage and users' ability to identify the cartographic product information uncertainty.

The intention of this paper is promoting the concept of uncertainty and supporting the quality of decisions and interpretations models of the real landscape degradation using maps of man-made landforms in river landscape.

2. Assumption and Methodology

The transdisciplinary approach is applied to selected catchments in the Czech Republic. This approach includes basic geographical methods for quantification of the anthropogenic pressure and ecological stability relationship. Model areas were chosen on the basin of comparable natural conditions where the different human activities were taken place. The major geographical methods include hydromorphological field research, land use changes, and anthropogenic forms inventory. The equivalent analysis tool is cartographical visualization and application of uncertainty concept in spatio-temporal data, which complete the obtained results with reliability pattern.

2.1. Landscape Degradation

The landscape degradation research represents worthwhile source of information, which identifies global environmental changes in local and regional consequences. Process of degradation is perceived like significant modification of natural landscape features. Degradation is demonstrated local increased predisposition to occurrence of natural risks (floods, slope instabilities...). These phenomena have negative impact on human society.

Various human activities in different regions, river catchments, determine the degree of ecosystem´s interference. The hydro-morphological forms, land-use changes of risky territories have been mapped during the detailed field survey, and the Channel Capacity Coefficient (CCC), Channel Morphology index (CMI) (Jakubínský (2011), Jakubínský and Báčová (in print)) was determinate, Figure 1. Specifically the inventory of anthropogenic landforms and ecosystem services evaluation were investigated there (Demek, Embleton, 1978), with an expert estimate of weight characterized their effect on the process of floods (Goudie, 2010), and location in the catchment.

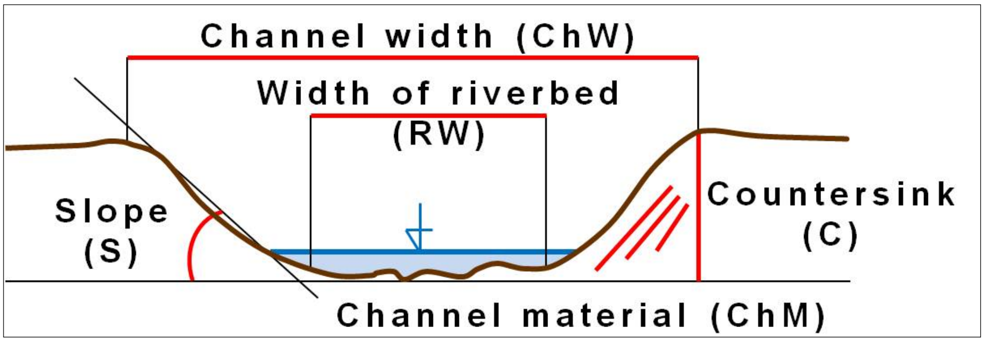

Figure 1. Elements to calculation Channel Morphology Index (CMI).

Every man-made landform was weighted with two indicators – Effect on the process of floods and the distance the landform from the channel. The most degraded regions identified by aforementioned indicators were compared with areas at risk of floods and landslides. We try to obtain the reliability pattern by the supplementation of observed characteristics to temporal and thematic uncertainty characteristics.

2.2. Uncertainty in Geographic Data

Uncertainty is generally considered as a quantitative or a qualitative variable characteristic of the spatial, typological or temporal value of reference attribute. Its origin is evident in all stages of modeling reality. It arises in the collection, transformation, and visualization of a geo-data. These causes of its formation are influenced by the using technology, the human factor, and by a visualization and communication of geographic information.

So far, there are many approaches to the conceptualization of uncertainty and its use in visualizing spatial data Goodchild (1994), Pang (1997), and Shi (2010). But for the purposes of this article the geographic information uncertainty has the following meaning, which is based on a study Zhang and Goodchild (2002), MacEachren (2005): Where the imprecision in geographic data is characterized by gross errors, and uncertainty (Fig. 2.). Gross errors, we can identified unforeseen mistakes that are mostly caused by human factor, and often by using the wrong research methods.

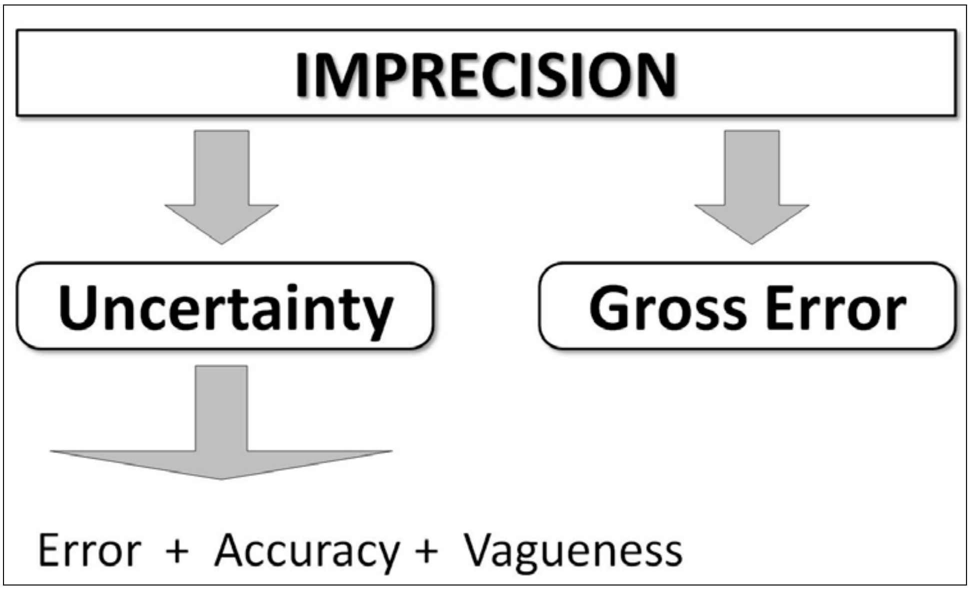

Figure 2. Concept of the uncertainty in geographic information (Based on: Zhang and Goodchild (2002), MacEachren (2005)).

The Uncertainty is an indicator of systematic and random errors, together with accuracy, and vagueness. Uncertainty is evident in all phase data processing. In the data collection, data transformation, and cartographic visualization (Pang, 1997), there we expect the potential sources of imprecision of geo-data. Al these hypotheses describe the inherent uncertainty, but we should think an epistemic uncertainty too, which has a dissociated effect on the way and quality of information transfer by maps.

Many approaches define their own system of uncertainty propagation. We have seen many improvements of metadata (ISO 19157:2012, ISO 19158:2012), statistical methods for its propagation (statistic probability, fuzzy statistic)... But the uncertainty has an obvious spatial pattern, and therefore we need to visualize it.

3. Cartographic Visualization of Uncertainty

The most of visualization techniques, we can use, are strictly focus on the single, resp. only a few selected parameters of uncertainty. For each parameter there are a number of recommendations on the most appropriate method of communication of the phenomenon, but only some of them are empirically based. Examples of these can be found e.g. Leitner, Buttenfield (2000); Edwards, Nelson (2001); Kubíček, Šašinka (2011).

Cartographic visualization of uncertainty is a big challenge for cartographers, and in our case study we try to show possibilities of its multidimensional form. We used two visualization methods – comparative, and combined maps (MacEachren, 1992).

Both of our examples handle the thematic ant temporal uncertainty in the system of landscape degradation, which is sourced from experts' estimate, and some features variability in time. For example – the hydromorphologist are sure with the effect of some landforms on the flow and process of floods near the stream. But what is its impact in the rest of catchment, they only speculate. The temporal uncertainty is caused by temporal instability of some man-made landforms and by the time of measure in the field, e.g. the agricultural heap is in the different state of succession.

Comparative maps are made by two map layouts. One represents a level of landscape degradation, and the other qualified level of thematic and temporal uncertainty together. Level of degradation is presented by the changing color saturation of hexagonal mosaic map, and the uncertainty is presented by the scale symbol and their color saturation (Fig. 3.). Hexagonal mosaic map objectify the distribution of examined phenomenon. All these methods based on recommendations of world studies (Buttenfield, 1993; MacEachren et al., 1992; Pang et al., 1997; Drecki, 2002; Thomson et al., 2005; and Kubíček, 2010).

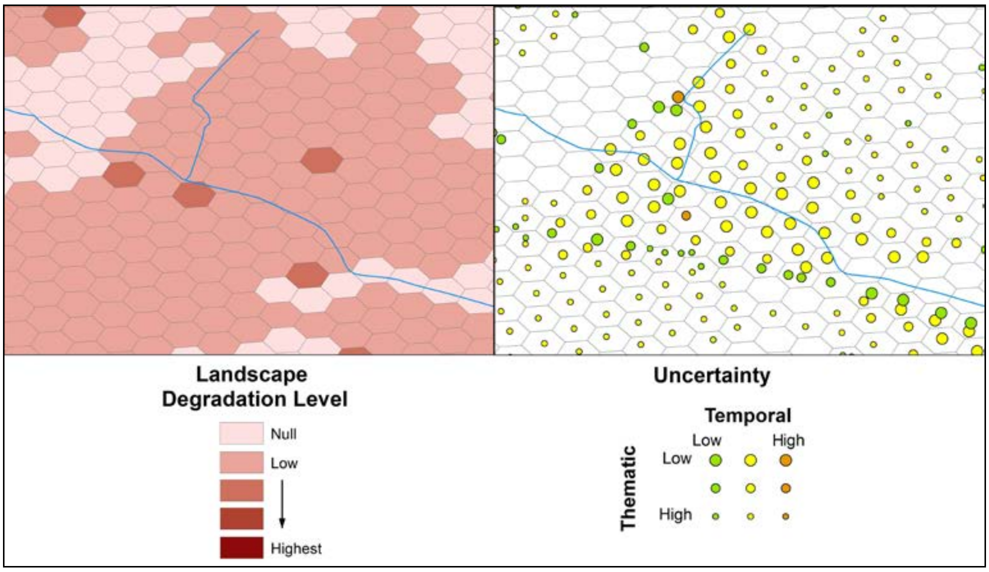

Figure 3. Comparative uncertainty maps.

Combined maps (Fig. 4.) are represented by composition of all three variables together. In order to maintain the map legibility there has to be modified the means of expression. We need to visualize three characteristics in one map. Many authors deal with multidimensional uncertainty visualization – Davis, Keller (1996), Shmidt et al. (2004), Miller (2008). We use the color saturation hexagonal mosaic map for visualization of landscape degradation and two other representation methods for uncertainties. The thematic uncertainty, like a more dominant characteristic, is expressed by landscape metaphore. It is only the repressed expression using shadows to display the illusion of space. Closer objects are more certain, and the object in the base of map is more thematically uncertain. The temporal uncertainty is presented by the changing density hatches. The more stable objects are represent with the sparse hatches, and more temporal uncertain with the dense hatches. All these proposals are prototype and their fitness for use and legibility must by empirically tested by users.

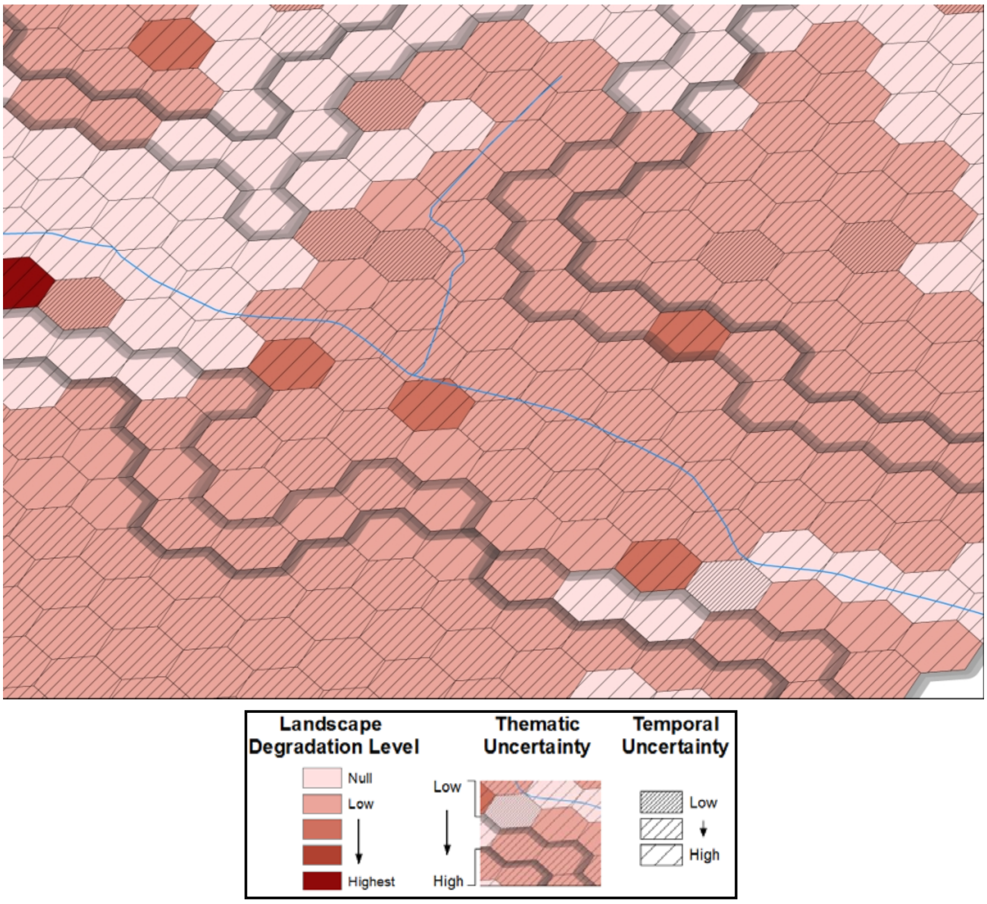

Figure 4. Combined uncertainty map.

4. Conclusion and Future Plans

There were identified the most degraded areas on the basis of environmental values' research. These areas were compared with values of susceptibility to the natural risk creation. Observed characteristics were subjected to cartographic visualization and were enriched with thematic and temporal uncertainty values. We used two possible cartographic methods – comparative and combined maps with a few graphic variables - color saturation, hatches, and 3D space. All these designs tolerate current and past cartographic studies, but their usability is still to be confirmed.

For the future it is necessary to make a set of case studies taking into account the specificity of disciplinary conventions and role of users. But there will be more studies objectify their hypotheses and solution design. The weakness of uncertainty research is the instability of uncertainty concept, which makes it impossible to compare the results with others. It is recommendable to start transdisciplinary dialogue and support the critical thinking and working with maps presenting uncertainty.

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