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COMPARATIVE CASES OF URBAN PATTERNS AS A RESPONSE TO THE SOCIO-ENVIRONMENTAL CHANGES: A METHODOLOGICAL SKETCH

Using multi-source data analysis a complex comparative geospatial analysis has been performed: the development, current & past environmental and social problems of three cities are studied. The main particularity of this project is its integrity and complexity: multi-source data used (geospatial, narrative, statistical, visual, visualized graphs and tables, pictures and archive information), multi-disciplinary approach (geography, history, statistics, sociology, economics, demography, and environmental studies).

Cities... Capitals and small towns, regional centers and megapolises, dynamically developing and historically conserved. Or may be combining both modern and ancient attractions. Business centers of religious treasures. Student villages and “IT-silicon valleys”. Cities are absolutely different and yet similar to each other in processes that they go through. Alike to people who pass different stages during life (childhood, youth, adolescence, maturity, elderliness), cities overpass similar processes like birth (starting from the small unknown population settlement until the world-wide known famous centers attracting people and thus growing more and more like snowball). Cities are not only our places to live & work. They are our heritage. Knots of global social network. Hubs of economic activities. What are current tendencies in the development of the cities? What is the different in their changed faces? Why one city was developed in this way, while another – in that one (even by similar socio-environmental conditions)? Do environmental and geographic factors direct the history of the city? If yes, how can we visualize and map it? Demonstrate, how city “breath” during decades (i.e. changes in its shape, form, intensity of internal processes, density of inhabitants)? Cities are miraculous complex constructions created as entangled combination of both human thought and will (projected, planned, modified), natural determination (relief, water streams, climatic factors) and global external factors: standing on the crossroad of the modern “Silk Road”, or almost forgotten by everyone...

Characterization of past and current urban development activities in various cities of Russia and comparison of cities through spatial analysis is the aim of the study. The objective is to summarize existing knowledge on the changes in urban development observed on the study area (Russia), in terms of the detected urban sprawl and description of the land use changes,

spatial location of new districts and city development in time, conditioning factors and triggering factors (socio-economic growth, people work and study migration), compilation of the consequences caused by the movement of people and economic development. All information is stored in a GIS database (including metadata to assess uncertainty), and relevant maps (inventories, controlling factors) will be produced. Reconstructing the historical space of the cities (major ones: Moscow and St.-Petersburg, as well as minor cities: Voronezh, Kazan, Yekaterinburg, Novosibirsk) and comparisons to other changes of socio-environmental factors are essential to identify causal relationships able to control changes in the frequency and intensity of land use changes within the city.

The first part of the research concerns the documentation of past and actual development of the cities. Several techniques are used to compile this information, from archive investigation to spatial remote sensing data collection (Landsat TM), air-borne or space-borne images. Controlling factors of socio-economic processes are analyzed in terms of conditioning and triggering factors («what triggers people to move to other cities?»). Possible causal relationships with the occurrence of the new districts and constructed buildings are determined through the statistical analyses, as input to the city sprawl assessment of the research.

The performed tasks are: 1) documenting city sprawl in Russia over the period of 1900-2010 in the 2 study areas (Moscow and St.-Petersburg); 2) characteristics of the way of city development and mechanisms; 3) identification of environmental factors (relief, water availability, geology, land cover, etc) and triggering factors (climatic factors, earthquakes risks) for each city, and identification relationship with their spatial and temporal development of the cities nowadays.

The documentation and characterization of the city sprawl has been performed at the comparative regional scales (Moscow and St.-Petersburg). Although long time series related to socio-economic factors are often available, historical records of city sprawl are rare. The main challenge of this task was to collect and critically analyze all information on the historical city development and human masses flows (migration, relocations) observed in the past (since XVII century), including available online documentation.

The proposed methodology combines archive investigation (available online reports, old maps, old photographs, and cadastre maps), multi-source air-borne and space-borne images and narrative description from literature sources for the reconstruction and recognition of urban sprawl processes. Because of the synoptic view it offers, air-borne and space-borne techniques are used to characterize land use changes with both capitals (Moscow and St.-Petersburg). A global multi-temporal aerial archive (last 80 years) and satellite archive (last 20 years, space borne optical images) is helpful and

useful for this purpose. Historical activity is documented in the study area at national (Russia) and local levels (cities) for two „hotspot“ sites within the study areas (Moscow and St.-Petersburg). The result of this work includes inventory maps on the landuse changes for several periods of the history of cities, relevant for the definition of scenarios.

Conditioning and triggering factors controlling urban development processes, timing and intensity are crucial factors for the urban analysis. Comparison of the cities Moscow and St.-Petersburg includes mapping ecological factors that control urban development, locations of the most notable districts of the city sprawl, and intensity (e.g. local relief and its derivatives, hydrology, land cover, etc) for both regional and local levels, with different resolution, accuracy and classes. For some socio-environmental parameters with a high rate of change in the study area (such as existing and changed landuse pattern, population dynamics, etc), a series of maps has to be created for various periods [3]. Local factors might change the characteristics of the urban development process even without any other triggers. Hence, at the local level (comparison of selected districts for Moscow and St.-Petersburg), socio-induced changes are taken into account: e.g. creating new fabrics and work places as crucial factors of migration.

Deliverables includes following results: 1) Inventory GIS-based maps of the urban city sprawl processes for the study area of the major cities: Moscow and St.-Petersburg, with relevant spatial and temporal attributes (process type, date, intensity, description, people at risk, districts lost and changed, etc); 2) Maps of control factors for various process, at different spatial and temporal scales; 3) Critical thresholds in the triggering factors controlling the occurrence and intensity of the urban development processes.

Study past and present conditioning factors of urban sprawl risks is inevitable work step for assessing dynamics of the city growth. Urban sprawl is controlled by predisposing factors (e.g. development of the city, creation of new working places) as well as triggering factors (e.g. human activities, dynamics of population) [1]. As it is supposed that baby-booms are not usually influenced by the global changes, only the triggers of social factors, (family, women health, etc.), land use and economic patterns should be considered.

Landuse changes within the city over time (living districts expansion, abandonment of traditional agricultural practices, abandonment of irrigation/drainage works, creation of new work places, new housing, intense construction of cottages, hotel boom on the seaside, etc) can make city more susceptible to overpopulation. As well, land use and other socio-economic changes (development of recreation activities, tourist pressure on coastal cities, such as Gelendzhik and its surroundings in the Black Sea, and urban expansion in the adjacent areas can modify the exposure of people and

properties to uncontrolled city sprawl, risks and hazards, and thus increase people vulnerability and uncontrolled consequences.

Environmental variables for urban development include local changes in climate factors over 100-years: rain intensity and amount, air temperature, snow cover, etc. They may also be factors that affect city development in century-scale. The relationship between the environmental and socio-economic parameters in the cities is not obvious. Therefore, only satellite images analysis and modelling allows suggesting some causal probable links. The simulated environmental values should be carefully validated both in terms of geographic fields and through their effects on the impact models which will use these data as inputs. The main limitation is spatial scale of the environmental data for the city development. However, they are governed both by the general environmental patterns at large and medium scales (for the country and city level, respectively) but also by small scale (selected city districts). Therefore, the objective of this research step includes detecting land use patterns, socio-economic and environmental changes for several periods in the past through the analysis of historical archives for both cities: Moscow and St.-Petersburg. The objectives of this task are reached through comparing past and present environmental patterns and socio-economic trends in Moscow and St.-Petersburg.

Studying dynamics in the environmental patterns of Moscow and St.-Petersburg can be performed through statistical analysis of the average and extreme conditions observed in the study areas (land cover, rain, temperature, snow amount), the construction of regionalized environmental parameters (e.g. thematic maps) and simulation of the time series of changing environmental parameters. The also includes upscaling local observations and simulations of the environmental parameters at the scale of the study area.

In a first stage, the main features of the observed (e.g. past) and recorded (e.g. now) environmental parameters are analyzed in terms of land use changes analysis for all cities. The statistical distribution is computed at the each grid point of the map in order to estimate a relationship between the present and past environmental situation and conditions based on the map overlays. The results consists in both time series and maps of environmental parameters for the past and the present for the study cities.

Compare the past and present socio-economic trends considers demographic, social and economic situation of the research areas by using several indicators (number of inhabitants, number of tourists, type of socio-professional categories, local economy, soil types and soil functionalities, etc). This information can be collected from any open data and local database available from the local stakeholders. On a second stage, the main assets will be defined and the elements at risk will be inventoried. Several attributes

characterizing their vulnerability (construction type, number of floors, functions of the elements, etc) will be collected and stored in a GIS database.

At the second stage, data on population dynamics are analyzed through several spatially-distributed dynamic models using examples of existing methods and research [2], [4]. The objective is to analyze the observed (historical) landuse changes and to explore the possible landuse changes in the near future for different development scenarios. Possibilities of the landuse change models via the GIS approach are tested. Scenarios can be calculated to evaluate different situations caused by differences in urban landuse requirements and spatial policies. The models may be modified in order to take into account demographic and socio-economic changes for different areas in Moscow and St.-Petersburg. The performance of the models can be quantified on the observed changes in 1970-2010, and main drivers of changes in the study areas can be identified through a geospatial analysis. These drivers show prospective landuse scenario modelling.

Conclusion. Deliverables include following results: 1) Environmental parameters database for the study areas (Moscow and St.-Petersburg) for the past and present; 2) Thematic maps of environmental parameters at the regional scale for the past and changed climate for the cities; 3) Past and present landuse maps at different dates for Moscow and St.-Petersburg; 4) Database: elements at risk, attributes, observed damages and changes; 5) Detailed socioeconomic maps produced at several dates based on the analysis of multi-source data (aerial photographs, old terrestrial landscape photographs, old maps and cartographic documents).

From a scientific viewpoint the main expected outcome is the development of an integrated methodology for quantitative socio-environmental dynamics assessment taking into account changing patterns in the predisposing and triggering factors: environmental, social, economic and anthropogenic changes. Consequently, the proposed project will improve our ability to forecast development of the cities in Russia and detect future risk zones for uncontrolled urban sprawl, pave the way to new adaptation strategies in response of changes in the city expansion, or in the exposure of the social system.

The patterns of urban risks in three representative regions of Russia (Moscow and St.-Petersburg) are assessed for different climate change scenarios. Expected future human activity is represented by the trajectory of quantitative indicators from the past (1970) up to date (2012/2015). Updated inventories, as well as human susceptibility towards urban development, possible consequences of uncontrolled city sprawl, and risk maps will be produced for each city (Moscow and St.-Petersburg) for several time periods.

The improvement in the geospatial assessment methods (spatial directions of the city sprawl, temporal probability of occurrence, intensity of

population dynamics) owing to climate change is the second scientific outcome of the project. A coupling between the assessment of social systems and environmental changes and the use of statistical and process-based prediction methods of natural parameters will provide a framework concerning the trends of social, economic and environmental impact in different regions of Russia. Consequently, it is expected to identify what are the types of the city development, which districts of the cities are the most exposed to the changing patterns (economics, sociology, environment) and what are the predisposing parameters and triggering environmental and anthropogenic parameters controlling city dynamics, hazard and risk for different environmental and socio-economic settings.

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