Enhancement of the role of spatial planning in climate change adaptation by long term modelling of land use change in Hungary

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Introduction

The purposeful formation of land use significantly contributes to the moderation of the adverse impact of climate change. Since spatial planning plays a fundamental role in the formation of land use, therefore it is essential to integrate climate adaptation goals into the planning process (Biesbroek, G.R. et al., 2009). Spatial plans primarily assist the achievement of adaptation purposes by the delimitation and protection (primarily against urban sprawl) of areas (as zones, such as ecological corridors) which are important in adaptation and risk prevention. In Hungary at present the spatial planning system already contribute to the above mentioned objectives, but there are lots of unexploited capacities (e.g. new zones should be introduced such as areas of non-structural flood measures or elements of green infrastructure).

Background/Literature Review

The regional level spatial plans are fundamentally ecological and technical documents prepared in harmony with the environmental, social and economic priorities of territorial development, and are vertically coordinated to form a hierarchical structure. Their primary function is to determine the spatial physical structure and regulate the land use at national and at county levels. It is also their function to identify the potentials and limits of territorial development and ensure the protection of the assets of natural and built environment (CEMAT, 2011). There are three main components of the Hungarian regional spatial plans: plan of spatial structure (land use map), the zoning map and the related regulations (Act XXVI of 2003).

Goals and objectives

In this study we assessed and evaluated the current role of spatial planning in safeguarding those areas which may be important in adaptation to climate change in case of a medium-size city (Győr) and its urban region (Agglomeration of Győr). We also modelled the impact of the introduction of new zones. Győr Agglomeration is in the north-western part of Hungary, covering an area 1607 km.^{2} The city and the surrounding have a total of 257 thousand inhabitants. In Hungarian relation Győr is a dynamically developing industrial centre with fast growing residential and industrial areas. Between 2000 and 2012 – according to the Corine Land Cover database – industrial

areas increased by 30%, urban area expanded by 4%. According to the estimation and the results of our modelling of the future land development this growth will continue in the coming decades. However, Győr situated at the confluence of rivers and surrounded by a flood prone area. Furthermore the river banks are important habitats, which are the part of the National Ecological Network as ecological corridors. Furthermore a substantial part of the arable land has very high quality in terms of plant production and has excellent water management properties. The above mentioned areas play a very important role in climate change adaptation; therefore it is essential to protect them from urban sprawl. In this area the impact assessment of spatial plans on land use are particularly important. It is fundamental that spatial plans should have an influence on the control of area growth. We formulated some recommendation regarding the possible land management roles of spatial plans as well.

Method

In the assessment we used the method named Spatial Decision Support System (SDSS). It helped to model the changing process of land use according to different scenarios (Hedwig van Delden et al., 2012). By means of the SDSS we examined the growth rates of urban areas and impact on areas facilitating adaptation with and without spatial planning regulation, and thereby underlined the role of planning in area protection. Based on the results we formulated recommendations for strengthening the adaptation role of spatial planning. (Hedwig van Delden et al. 2011)

SDSS is a forecasting tool for planners and policy analysts working in urban and regional development (figure 1). It encompasses a spatially explicit integrated simulation model that allows exploring future developments of the planning area. The SDSS includes the following two model components from Metronamica 4.2.2 (RIKS, 2011). The first is a spatial interaction model component for calculating the regional population and jobs in main economic sectors. This component simulates the interaction between centres of gravity (the cities and regions) in their competition for people and jobs. The distribution of the national growth of these activities over the various regions as well as the migration between regions is based on the relative attractiveness of regions and their distance to each other. The main drivers are overall national socio-economic development, as well as the local and regional characteristics contributing to the attractiveness (RIKS, 2011). A cellular automata model component simulates land use developments at the local level (land use maps and related indicators). This component demonstrates the competition between the various actors to occupy locations of interest. The

main drivers are physical suitability, spatial planning, accessibility and human behaviour (the latter is represented by the inertia of land use functions), the attraction or repulsion of neighbouring land uses and the power to actually occupy locations of interest. Based on the combination of drivers a transition potential is calculated at cellular level which forms the basis for land allocation (White, R. et al 1993).

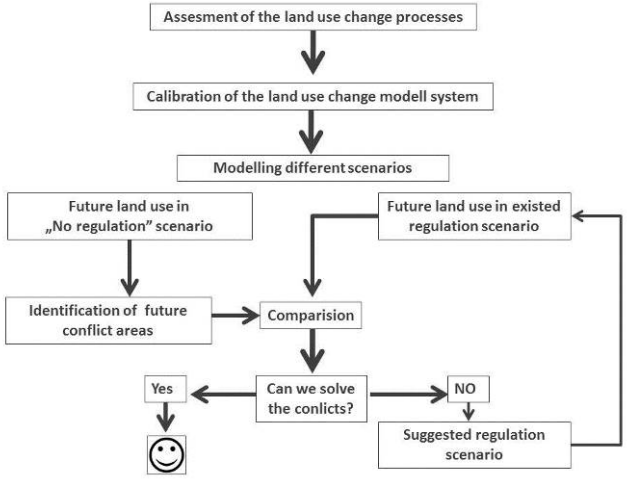

Figure 1. Process of modelling

For the decision making process we have created 3 different scenarios. We have modelled the future land use with and without the current regulations and the third scenario is based on the proposed regulation of the risk management. The three scenarios show three different future land use patterns in the agglomeration of Győr. Comparison of the three different scenarios helped to identify the conflict areas and showed the advantage of the proposed measures.

Results

By means of land use change modelling we analysed the probable directions of the growth of built up areas in the Győr urban region. The comparison of the outcomes of three scenarios highlighted the future conflicts and the impact of the proposed regulations.

First we analysed the impacts of current regulation. In the case of the "no regulation" scenario the simulation of future land-uses pointed out conflicts in several parts of the urban area. The high quality arable land suffered the most extensive damage due to the growth of built up areas. (figures 2., 3.)

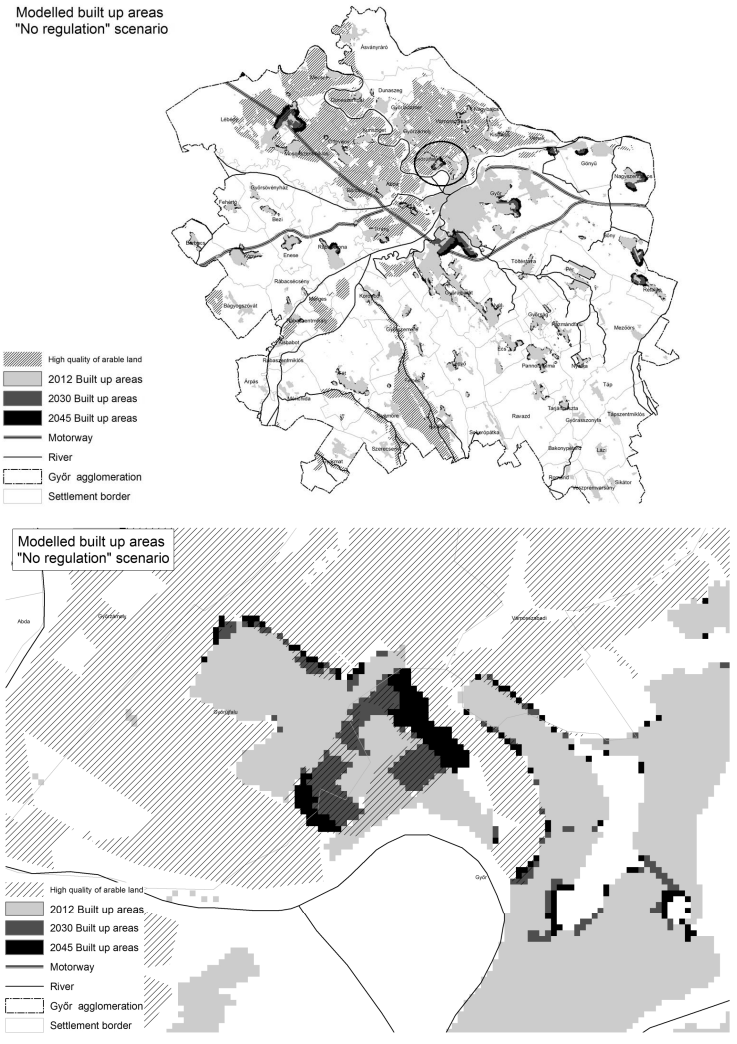

Figure 2.and 3. Conflict areas in the high quality arable land

The growth of built up areas would also affect some minor parts of the ecological network in the case of no regulation.

We wanted to find out whether these areas, which are essential for adaptation to climate change, are protected enough with regulations, to attain that the growth of built up areas can be limited or avoided. Another question is about the alternative locations for building development. Therefore a scenario was worked out assuming regulations for the limitation of built up area growth.

In a conflict area next to the city the modelling of building development indicated the growth of built up area in spite of the current regulation, though at a lesser rate than in the case of no regulation.

At another place a little further away from the central city building development was averted by the force of regulation, and therefore the ecological network avoided the risk. (figure 4)

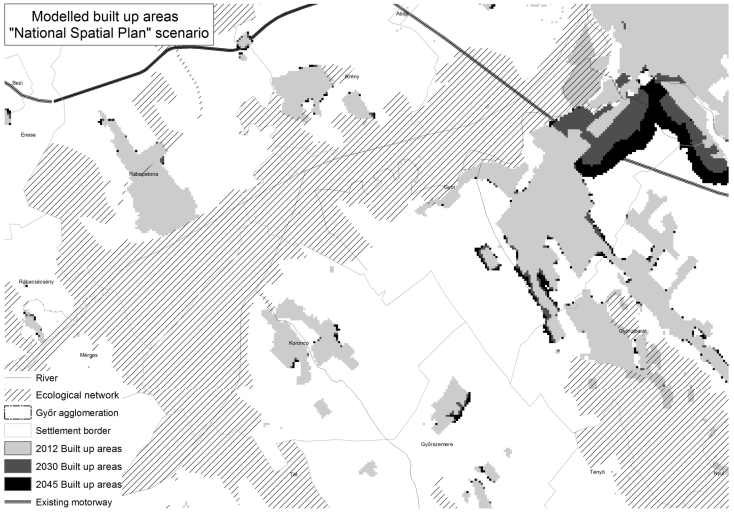

Figure 4. Long term land use pattern under the current regulation in the ecological network

The comparison of building development in both scenarios indicates that in case of regulation in force the growth of built up areas will continue thought at a limited rate in the urban region of the city of Győr. (figure 5)

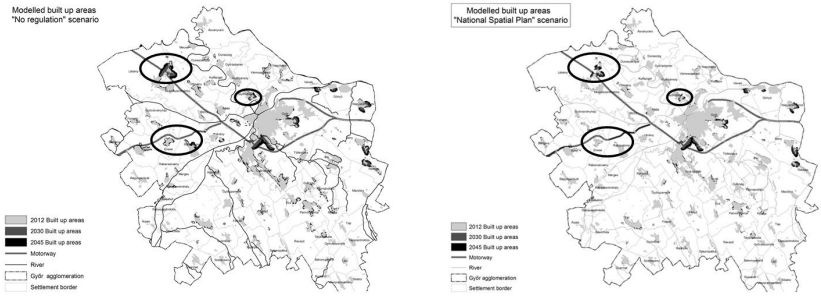

Figure 5. Comparison of the consequences of no regulation and current regulation

In the elaboration of the third scenario we assumed that climate change would involve more robust floods than so far, and then the currently flood-proof, deep lying areas will be more vulnerable, because the dams would not be able to channel the more abundant flow of water. We also relied on the domestic results of flood risk mapping. In this scenario we assume the launch in the endangered areas further regulative measures of flood risk management, which restrict the development of new built up areas. Under the impact of the proposed measures the location of new industrial areas forecast for 2045 significantly differs from the one evolving in case of the continuation of current regulations (figure 6).

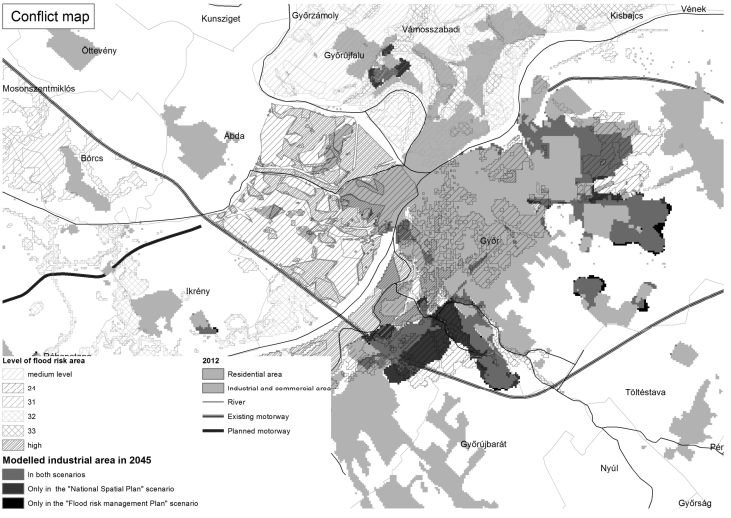

Figure 6. Impact of the new restricted regulation on long term land use structure

The comparison of the location of new industrial areas in both scenarios demonstrates that the further land use regulation measures of flood risk management restrict the development of new industrial areas in the direct vicinity of the city of Győr (purple colour), but there is ample potential for new investment somewhat farther from the river (turquoise colour)

Discussion

The adaptation to climate change would require an approach to land use regulation which is appropriate for the character and role of specific areas. These areas are basically of three kind:

— areas of green infrastructure which mitigate the adverse impacts and promote the migration of the species

— areas which gain the added value under the impact of climate change (e.g. high quality arable land)
— the areas suffering natural risks (e.g. areas with increasing frequency and magnitude of flood risk)

A more sophisticated land use regulation (which involves the restriction of building development and the enhancement of ecological land cover) might involve consequences in the economic and social urban structures, which need further consideration. For the appropriate functioning of the specific areas additional interventions are needed (e.g. afforestation, wet land rehabilitation).

Conclusion

The proposed land use regulation does not only restrict, but also promotes particular land uses of some crucial areas:

— the suitable land cover of areas of potential green infrastructure - serving for mitigating the adverse impacts of uncontrolled water flow, habitat fragmentation and soil degradation - can be grassland or woodland;
— the high quality arable land, should be under special protection with the help strips of woodland
— the areas exposed to highly frequent and robust floods need water resilient land cover such as swamp forest, wetlands, and even temporary water surfaces

The proposed regulation and recommendations would contribute to a more natural land use structure and enhance the connectivity of habitats, reduce the runoff and the potential damages of climate change. In consequence,, the overall land use, including the urban structure would change. The area allocated for industrial and urban investments will be scattered, but the advanced industrial technologies and transport links will easily adapt to such new conditions.

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