Integrated projections of land cover and land-use parameters in IWRM – Concept, methods and testing in the Western Bug River Catchment (UKraine)

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Objectives
The future water cycle analogue to climate change will be influenced by the regional change of land use. The latter refers to the way of how humans employ the earth surface and may dynamic over time due to societal drivers such as land demand, urbanisation, and land management practices. In terms of integrated water resources management (IWRM), land use can be understood as all major pressures, dependencies and sensitivities of human activities with respect to the water cycle. To deal with the future land-use change a particular foresight approach is being developed that allows long-term projections of both land cover as the direct observable land surface and water-related land use parameters which represent the interactions between human activities and the processes of the water cycle. Results are expected to support an integrated assessment of climate change and land use scenarios.

Methodology
Conceptual frame
The following steps are seen as key for the projection of land use with its water-related parameters: First, a retrospective analysis of land-cover change serves as a basis for a spatially distributed change detection. Second, current land cover together with field and geo data are used to describe the interrelations between land use and the water cycle. Third, results of change detection and its correlation with socio-economic developments lead to scenario-based projections of the future land cover. Fourth, water-related parameter of land use are projected in the future in line with land cover and the underlying scenarios. Empirical applicability is ensured through testing the concept in the catchment of the upper part of the Western Bug River (UKraine).

Retrospective analysis of land-cover change
The investigation of land-cover change starts with an automatic classification of data for selected reference years. In the case of the Western Bug river catchment, empirical work addresses the years 1989, 2000, and 2010 due to reasons of societal transformation.

Analysis of current water-related interrelations of land use
Based on the land cover, parameters are identified to describe the interrelations between human activities and the water cycle. To ensure a comprehensive view, all major processes of the water cycle are screened in order to detect relevant land-use parameters. A literature review focusing on land use in the case study areas led to 20 processes which are crucial for land use in general, 19 parameters with a particular meaning for urban land use and 23 parameters for rural areas excluding settlements.

Initial results
Land-cover change
The expanded statistical analysis points out systematic processes of land-cover change with e.g. urban area systematically extending on grass land and in the vicinity of existing settlements and infrastructure. Another systematic finding is that grass land gains from arable land but also losses to arable land. The other way round of gains and losses for arable land shows the concentration on nutrient rich sites for agriculture. According findings are translated in GIS-algorithms using the gained land cover, soil maps, infrastructure and settlement layers for areas that are prone to change in future to artificial surface.

Land-use parameters
Statistical analyses are carried out for each land use parameter involving parameter values from in-depth investigations at test sites. Urban structures including bloc and building information have been detected from land cover adopting settlement classifications to IWRM requirements and running the model SEMENTAOI with local topographic data. Parameter values and urban structures are assigned to urban structure types (UST). Urban structure types are used to upscale water-related parameters for instance percentage of sealing. Since projections of parameter values require the inclusion of information in a consistent way, the GIS-based model PWF-LU (Parameter model for Water Related Features of Land Use) is being designed.

Conclusions and outlook
The focus on systematic transition rules delivers a consistent basis for future land-cover projection. Each land-cover class is linked with future potential areas for change which will be combined in a multi-criteria approach. A further step is to estimate the demands for land for each land-cover class using socio-economic data which correlate with the land-cover change. Water-related land use parameter are not always correlated with land cover and therefore need to be assessed in more detail. This is especially true for parameter values related to IWRM. Furthermore, the PWF-LU model facilitates the uptake by various tools for coupled modelling of the water cycle and the impact assessment of future change.

References

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Figure 1: Derivation of land-cover from remote sensing data ends up in change detection.

Figure 2: Scheme of water-related processes for urban structure types and vegetation structure types.

Figure 3: Statistic analysis yields in systematic processes of change and in GIS-based transition rules for potential future land-cover change.

Figure 4: UST (containing bloc and building information in Livr (a). Statistical analysis of parameter values used for UST (b). Linked water-related land use and urban structure. Example: percentage of sealing (c).