The development of a conceptual framework to assess multifunctional landscapes and the impact of land use changes on land use functions with “Pimp Your Landscape”

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Abstract: The assessment of land use functions (LUF) has become very important most notably in questions of sustainability and multifunctionality of landscapes. Models often are overparameterised and therefore regularly focusing on small study areas where input data are available. Systems for integrated environmental management often draw emphasize on certain land use types (LUT) (e.g. forestry, agriculture) or special issues (e.g. erosion risk, flood management). The aim of this work is to further enhance the evaluation basis for Pimp your landscape. This is an interactive tool for the visualization and evaluation of land use changes. The plan is to develop a holistic indicator-based evaluation approach on landscape level where all LUTs are considered and various LUFs can be regarded depending on the planning targets. According to a conceptual aggregation scheme the choice of suitable indicators is in progress. As expected, major constraints and problems are caused by the lack of comparability between e.g. economic parameters of different LUTs as it is depicted in this progress report. Participatory processes and expert knowledge will still be indispensable to adjust results. The beneficial aspect of the presented approach is the comprehensive manner with which we envisage to regard landscapes and their functions. Different LUTs are not considered uncoupled from other land uses but assessed in an integrative way where also structural properties of the study area will be accounted for.

Keywords: land use management planning; land use type; land use function; Pimp Your Landscape; landscape evaluation; land use evaluation

Introduction

Pimp Your Landscape (PYL) is a tool that has been developed to simulate to what extent climatic- or planning-induced changes of land use patterns might have an impact on the capability of a landscape to provide different land use functions (LUF) (cf. Fürst et al. 2010, this volume). It is a decision support tool with the purpose of visualizing management or planning targets on a landscape level. Thus the end-user has the possibility to get an immediate feedback of simulated land use changes according to a set of LUFs (Fürst et al., 2009). In order to simulate climate change scenarios with PYL a consistent approach for the evaluation of land use types (LUT) is needed.

The evaluation of LUTs and LUFs within PYL works in two steps: Firstly, the assessment of each LUT at a relative scale from 0 to 100 submits a basic identification of ecological, economical, aesthetic and water quality values. Besides this basic valuation of LUTs other drivers will have an impact on the final evaluation. Spatial characteristics, neighbourhood relations, the respective environmental conditions, regional planning objectives and general restrictions will be accounted for (figure 1). In a second step, landscape metrics (LM) will up- or devalue the ranking points on the relative scale of the four mentioned criteria (cf. Frank et al., this volume). LMs are based on structural components of a landscape. They provide an additional landscape related evaluation element to assess the impact of land use changes on land use functions & services such as biodiversity / ecological value and landscape aesthetics.

1. Objective

The aim of this work is to build up a more sensitive evaluation basis for PYL. By doing this it is necessary to evaluate each LUT according to its impact on the chosen landscape functions. That is, the different goods and services provided by the individual LUT have to be considered. For the current project region in Saxony, Germany, we have chosen four target dimensions to be assessed: Economy, Ecology, Water Quality and Aesthetics.
In order "to achieve comparability between the different indicator systems and formats" underlying the evaluation, a relative scale from 0 (worst) to 100 (best) is used (Fürst et al., 2009). The rating matrix (table 1) allows an evaluation of each LUT in relation to every other regional LUT on the above mentioned scale. This value should as good as possible reflect the contribution of the individual land use type to the respective LUF. From the value assigned to each LUT and the corresponding surface area, the impact on the LUFs and its final performance in the considered region can be estimated.

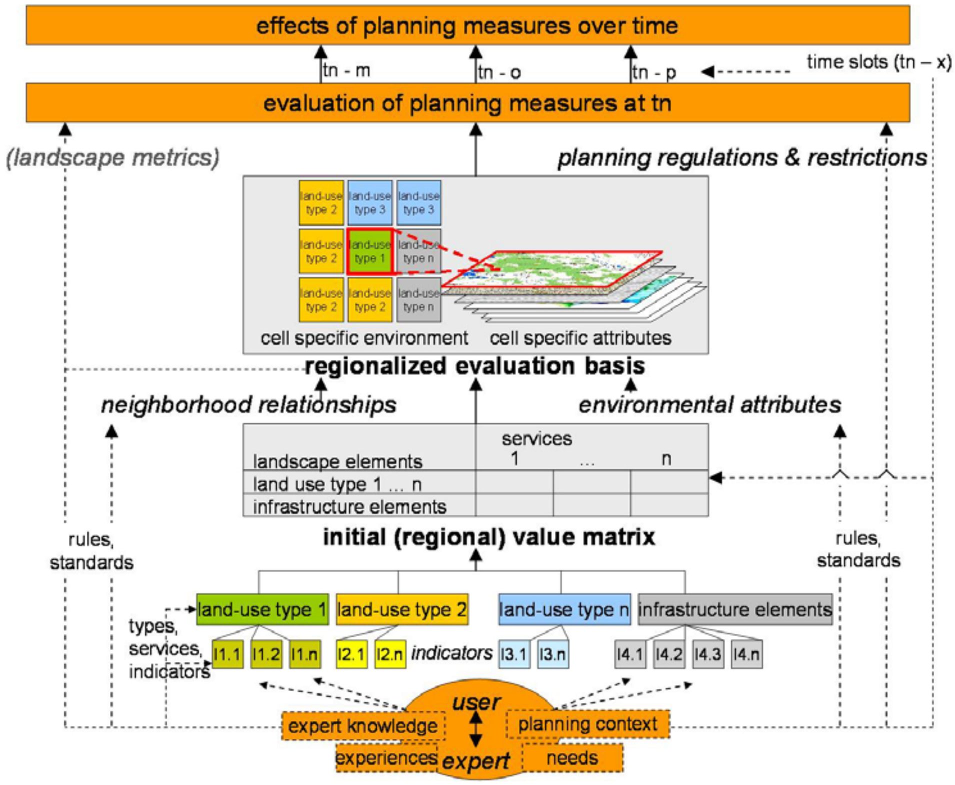


Figure 1. General evaluation approach of Pimp Your Landscape (PYL) (Fürst 2010, this volume).

To attain an integrated assessment of the divers LUTs (with their multifunctional character) a holistic evaluation approach is required. In Literature there are a multitude of approaches related to sustainability and multi-functionality assessment (e.g. de Groot, 2006; Therond et al., 2008; Verburg et al., 2008; Wiggering et al., 2006). They focus mostly on (semi-) natural landscapes or work out impacts on a sectoral level. Here, we do not want to draw emphasize on a specific land use type (e.g. forest, agriculture) or land use question (e.g. erosion risk, flood management) (Fürst et al., 2009). Instead the whole focus area should be accounted for not justone component of it. Therefore, it is essential to incorporate also urban agglomerations, settlements and residential areas into the evaluation approach. The methodology is probably more fittingly described as "landscape diagnosis" as it is a more comprehensive approach (Bastian et al., 2006). Furthermore, interactions between land use types are taken into account.

Summarizing, the task is to develop an interdisciplinary "valuation methodology" for landscapes. Although urban areas are included the development of rural areas will be the main focus. The valuation system of PYL should be simple and less time-consuming to ensure a transferability of the approach to other regions.

Table 1. Example of an evaluation table as result of expert knowledge, stakeholder consultation and referencing on regional research data derived from literature. Adjustment also was conducted via experiences knowledge (Fürst et al., 2009).

Corine Landcover 2000 (CLC 2000) land use classes	value for land use function			
	water quality	biological diversity	Regional economy	aesthetics
urban areas	0	0	100	0
industry	0	0	100	0
agriculture	20	30	80	20
fruit trees and vegetbles	30	35	75	40
pastures	60	35	60	50
deciduous forest	80	100	30	80
coniferous forest	50	60	40	60
mixed forest	80	90	35	90
natural grassland	70	100	5	90
wetlands & waterbodies	100	100	5	100

2. Methodological Approach

In the current version of PYL the evaluation is based principally on expert knowledge and estimations. A subsequent adjustment with publications, modelling results and environmental evaluation serves as correction factor. In a further development step it is now planned to develop a sounder basis in order to enhance traceability and transparency of the valuation process.

The challenge of assessing LUFs has been addressed in many studies (e.g. Paracchini et al., 2009; Pérez-Soba et al., 2009; Verburg et al., 2008). To get hold of LUFs the various goods and services provided by a landscape regularly are classified into groups of benefits as the following: (i) material and immaterial goods and services, (ii) commodity outputs (COs) and non-commodity outputs (NCOs), (iii) land-based and non-land-based production, (iv) use and non-use values, (v) market and non-market goods and so forth. This is done mainly in order to describe the multi-functionality or sustainability of a landscape.

The complexity of landscapes and the requirements of PYL make it necessary to work with condensed information. Aggregated indicators giving information about the performance of LUTs in different categories might serve to develop a practicable evaluation approach. As no single indicator is suitable a variety of indices are going to be valuated on a multi-indicator basis.

First of all applicable indicators are needed. For the environmental function “ecology“ e.g. biodiversity variables and landscape metrics (LM) might be very useful. LM will play an important role also with regard to “Aesthetics”. As depicted in figure 1 structural components will be accounted for following the basic evaluation (cf. Frank et al., this volume). The LUF “Water quality” might be sufficiently described by using nitrogen and phosphorus contents measured in seepage water from different land covers. In the following paragraph we want to illustrate the assessment of the dimension “economy” as an example of the procedure, pitfalls and restrictions.

Economy

The available economic indicators (some of which are displayed in figure 3) perform at different scales and have different dimensions! In general one can distinguish between values on macroeconomic and business level. Further a differentiation in sectoral parameters is possible.

After quantitative indicators will have been chosen we intend to condense them following the aggregation scheme of figure 3. By consulting the parameter value (e.g. contribution margin for land based production) of different land uses the value is normalized to a value between 0 and 1. The same applies for all other indices which are utilized for the economic valuation (of a LUT). The number of indicators contributing to the score of each LUT might vary. So we have for every LUT a different set of parameters. The individual indicators participate with different weight to the final LUT-score. The linkage between the indicators is problematic. The indicator values of that first evaluation level (cf. figure 3) have to be ranked according to their importance and added up to produce a value, a kind of composite indicator (*I*), for example for the land-based production (equation 1, Mando and Munda and Nardo, 2005).

$$I = \sum_{i=1}^{N} w_i x_i \quad (1)$$

x_i a scale adjusted variable (e.g. GDP) normalized between 0 and 1

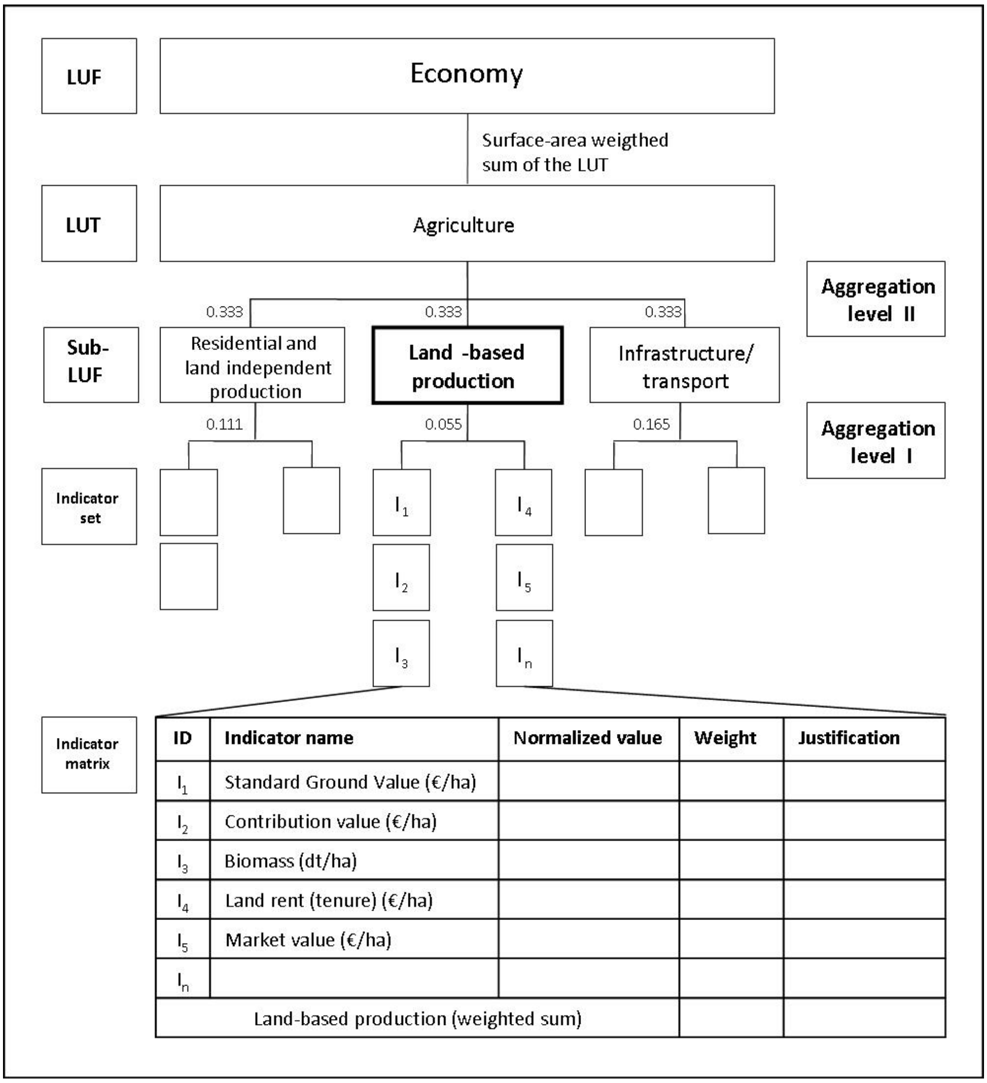
w_i a weight attached to x_i

i 1,2,...N

The distinction between residential and industrial use, land based production and infrastructural outputs seems necessary to accommodate the different factors required for the creation of value which depend on the LUT. According to their dominating attribute, more or less each LUT can be attached to one of the three sub-functions. Agricultural outputs for instance are for the most part connected to the revenue from harvest yields. That is why agricultural land use will be assigned to land-based production. In the third evaluation step (cf. figure 3) every LUT has to get weighted in relation to the other LUTs to deliver an “Economy” value between 0 and 100. From a sectoral point of view the weighting is very important because of the economic imbalances of rural and urban value creation (gross value). At last it is one of the most crucial points.

Weighting can be based on the standard ground value (SGV) which integrates land allocation rules, market forces, potential soil yields, subjective purchase decisions etc. An additional advantage is that it is updated regularly and determined according to a standardised procedure which enables a comparison of different LUT even of residential areas. Unfortunately the standard ground value is not yet available in a comprehensive manner and one is forced to collect the data from every administrative district. Thus, the SGV probably might play relevant role as key or interlinkage indicator modified with regard to the LUT.

The foremost problem of economic evaluation of land uses is the lack of comparability between the various indicators. Here especially the consideration of settlements/ urban areas turned out to be very difficult due to a considerable diversity of uses.



ID	Indicator name	Normalized value	Weight	Justification
I_1	Standard Ground Value (€/ha)			
I_2	Contribution value (€/ha)			
I_3	Biomass (dt/ha)			
I_4	Land rent (tenure) (€/ha)			
I_5	Market value (€/ha)			
I_n				
Land-based production (weighted sum)				

Figure 3. Provisional conception for an aggregation scheme exemplarily for the economic assessment of the land use type (LUT) "agriculture" (Paracchini et al. 2009, modified). The underlying indicator matrix shows economic indicators possibly appropriate for assessing this LUT.

Conclusion

Characteristic for land use evaluation are the manifold difficulties owing to the huge complexity of the task. Besides urban areas the integration of water bodies in an economic context is challenging. The consideration of NCOs might be essential. Nevertheless these rather qualitative functions will be addressed at a later stage. The search for objective valuation criteria and indicators that might be convenient is still in progress.

A good parameter basis is at hand for example for agricultural use but only one LUT is assigned to that kind of land utilization. Perhaps we should distinguish them more specifically given the main purpose of this interactive planning tool being the simulation of land use scenarios under changing climatic conditions. In this context a discrimination of cultivated crops and crop rotation practices is very important.

Indicators seldom refer to equal surface classes. The currently used Corine Land Cover classification (CLC, 2000) does not sufficiently reflect the land uses. Hence, a regional adapted PYL-classification system is going to be developed. This is fundamental and therefore needed for pushing forward the evaluation.

In principle, the procedural method, here exemplified for the function "economy" can be adjusted to any other LUFs such as "ecology" or "water quality" etc. It therefore is necessary to either alter the sub-functions in appropriate categories required to describe the respective function (cf. Paracchini et al., 2009) or to completely remove the second evaluation level. This is the case when regarding water quality. The evaluation of water quality is less complex and convenient indicators are usually obtainable (e.g. nitrogen discharge and phosphorus export per LUT).

The beneficial aspect of the presented approach is the comprehensive manner with which we envisage to regard landscapes and their functions. Different LUTs are not considered uncoupled from other land uses but assessed in an integrative way. Also structural properties of the study area will be assimilated (cf. Frank et al. 2010, this volume). Moreover the end-user will be able to select from various target functions and can introduce regional planning objectives and restrictions. Thus the adaption to different focus-areas is possible.

Because there is a substantial lack of information we envisage to use participatory techniques for data collection. Furthermore, are we exploring methods which allow the compensation of data gaps of one level with data of another aggregation level.

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