Respecting the Role of Agriculture for an Untegrated Landscape Development at the Urban-rural Fringe Using Geodesign Tools

Hans-Georg Schwarz-v.Raumer[1], Johannes Jörg[2], Mohammed Alfiky[3]

[1]University of Stuttgart, Stuttgart/Germany · svr@ilpoe.uni-stuttgart.de
[2]University of Stuttgart, Stuttgart/Germany · jj@ilpoe.uni-stuttgart.de
[3]Ain Shams University, Kairo/Egypt · mohammed_alfiky@eng.asu.edu.eg

Abstract: This paper documents a Geodesign teaching experiment held at Stuttgart University. In a densely urbanised area of traditionally intensive agricultural use the students have to develop a spatial vision which encourages green infrastructure and keeps a balance between food production, construction of built infrastructure and multifunctional land services. Different tools support their effort to iteratively find and optimize a solution in a Geodesign workflow. We describe the task, the workflow, the overcome of restrictions by Geoinformation Technology (GeoIT) and the results of the experiment and we discuss our experiences.

Keywords: Geodesign teaching experiment, agriculture and urbanization, change impact tools

1 Introduction

We report on a Geodesign experiment during summer term 2015, which applies GIS-modelling in landscape design. In the workshop 12 master course students of "Integrated Urbanism and Sustainable Design", three teachers and a GIS toolset worked together to iteratively find an optimal solution for the rearrangement of a case study region at the urban-rural fringe. Here rural and urban landscapes collide (DANIELS 1999), are mixed up and thus rural land use here is intensively affected by urban activities and urbanization processes and vice versa. Here complex interrelationships lead to specific conflicts and synergies between land traditionally called "rural" and "urban", but which is now to be addressed by terms like "Zwischenstadt" (SIEVERTS, 1997).

The case study region we selected is called the "Filder", which means "fields" and which is located on a fertile plateau of a slightly undulated topography. In this region highly fertile soils can be found – some of the best soils for agricultural production in the southwest of Germany – and accordingly the region ever was and still is a hot spot in intensive agriculture.

Located in 15 km distance to city center of Stuttgart, Filder is an important suburban residential area hosting more than to 300.000 dwellers. Furthermore, the flat, open plain was in its history designated to land consuming infrastructure projects like highway A8, Stuttgart Airport or the Stuttgart Trade Fair. In the context of the railway project "Stuttgart 21", a high-speed rail line is being built. This project will link the Filder region to Stuttgart City center with an 8 minute travel distance train connection. This will be the driver for further housing and industrial development. So the already existing lack of green infrastructure will be aggravated as well as the conflict between food production and the need for additional land for construction.

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a) Bird's eye view and famous Kraut production

b) Urban sprawl and pressure on agricultural land

c) Multifunctional open landscape

d) Citizens as farmers: New formats for agriculture

Fig. 1: Study region "Filder"

Two main transformation processes are related to the Filder region and are considered in the experiment:

(1) The urban sprawl of Stuttgart and its suburbia has led to a faceless hotspot of settlements, landscape fragments, industries, transportation systems and energy infrastructures. The ongoing urban sprawl leads to a merging of urban structures that threatens the ecological value, environmental functionality and quality of people's life. Open space and landscape have to provide not only food but moreover space and scenery for recreation and leisure use, aesthetic and identification values as homeland for residents, supply of fresh and cool air, habitat for plants and animals, retention of storm water, buffer capacity for groundwater protection, and so forth.

(2) At the same time there is a tendency that the future of agriculture in urban environments will strike out in new directions. Many farms sell their products locally, e. g. in an own farm shop, on street markets or they offer for people to harvest fields. In addition many farmers in metropolitan regions are service providers for the urban population e. g. they search for other sources of income and offer courtyard cafés, educational farm tours, barn and celebration events (e. g. children's birthday), corn mazes, horse and carriage rides, or they host horses. And at the same time, new forms of agriculture emerge within the urban realm itself: urban farming, urban and rooftop gardening, community gardens, vertical farming and so on. These urban forms of agriculture are increasingly becoming popular and offer a huge potential for ecologically and socially sustainable development in urbanized areas.

2 The Task

Considering this complex situation several Geodesign teams developed a spatial vision for a set of case study areas. They have been supported by suitability maps and by an ArcGIS toolset which evaluates drafts in regard to farmers' income and a set of control indicators for soil erosion, eutrophication, nitrate leaching, cold air production and bio-connectivity.

According to concepts which are typically used in a Geodesign process (STEINITZ 2012, SCHWARZ-V.RAUMER & STOKMAN 2013, 2014) and organized in several Geodesign teams the target is to develop a spatial vision for one of a set of case study areas. Following a spatial typology the spatial vison should – based on comprehensive considerations and document research – seriously reflect agriculture as a driving force and in parallel as a weak actor in the field of urban development and protection of open landscape. To develop their spatial vision the teams must

- organize the collaboration between science, GeoIT and creative thinking,
- use the diagram of Fig. 2 for workflow structuring,
- use GIS for mapping and visualization and
- use GIS and models for iteration in the design process.

The design task was to elaborate integrated visions for urban-landscape development scenarios on the Filder. The vision should reflect the relationship between urban development and agricultural land management and experimentally redesign this relationship. In that respect we encouraged the students not to hesitate to suggest massive change in the geography of the case study region. Guided by key questions they should enhance the relationship and the spatial contribution of housing and farming: how should the border between and the mixed

pattern of urban areas and open landscapes look like, can agricultural lands designed here e. g. as hybrid park structures? Should there be a border at all or can agricultural landscape structures be merged with open space structures of the built-up area? What patterns of urban growth enhance the mutual benefits? How can urban green spaces be managed and designed in an agro-economic way?

The new landscape design should rearrange the patterns and distribution of settlement areas and agricultural lands, take under control urban climate, biodiversity, water protection and recreation and should follow the following objectives:

- Improvement of the quality of life inside the settlements and the quality of ecological conditions and landscape qualities outside.
- No decrease of the total urban area. The redistribution of urbanized areas has to be done in a way which compensates for loss in other places. An increase of urban settlements can be proposed, depending on the design concept.
- No decrease of the total agricultural profits. However a decrease of areas of exclusive agricultural production is well possible. If your design suggests a reduction of agricultural areas, the yield of the remaining areas has to be increased, for example with proposals for new forms of income or more profitable forms of agriculture. Multifunctional use of space is another way to deal with this.
- Identify conflicting space requirements, discuss possible development scenarios critically and develop an attitude for the future of agriculture in the Filder area.
- Use Geoinformation on suitability and risk zones (agricultural suitability, water protection, ventilation, nature conservation, visual and recreational landscape quality etc.)
- Use the indicators for the quality control of your changes as reported by the impact tool.

3 The Impact Tool

According to each of the factors mentioned simple impact indicator calculations were implemented. The models do not estimate impacts on a high level of evidence! We must clearly have in mind this restriction of indicator model use and respect this when doing design decisions. Beside this and other specific requirements for the use of numeric models for the design process the outcome of the impact indicator calculations can't be considered as the truth, rather as a hint, a direction. Therefore, the report of the tool delivers aggregated summary statistics.

Using ArcGIS we built up impact evaluation models which could be run without any other software. The following control factor calculations and models have been implemented in ArcGIS model builder:

(1) **Estimate of farmers' income.** From statistical data we got variable gross margins per ha for specific agricultural activities. As a control for the design impact the sum of farmers' variable gross margins is calculated and reported.

(2) Three **agro-ecological impacts** are reported by the tool: **Nitrate leaching** based on an overlay of a map indicating permeability of groundwater coverage and a map which assigns to each land-use/cover type a leaching risk class. The tool calculates **soil erosion** according to the Universal Soil Loss Equation (WISCHMEIER & SMITH 1978) and reports the sum area

assigned to a specific soil erosion risk class. The sum of cells which have direct input of eroded sediments into biotopes or creeks we assume as an indicator for **eutrophication**.

(3) Tabular **cold air production** rates are or have to be assigned to land-use/cover types. The tool sums up cold air production by air-sheds which are classified as no, weak, medium and high concerning the importance for ventilation. The importance is assigned according to the size of the air-sheds (ability to cool) and the contribution of the air-sheds to settlement (actual cooling effect).

(4) Two indicators concerning impacts on species and biotopes have been implemented: the balance of **habitat quality** per se and the improvement of existing **biotope networks** in habitat quality. It was planned to run an invertebrate movement simulation software to prove the effect of connectivity.

4 The Workflow

As a first step – which sticks to standard design methodology – the students had to fix their spatial vision in a paper draft proposal. Starting from their initial conceptual ideas, they then include provided geographical data to analyse and review their initial ideas with regard to control factors and parameters. The design–review–redesign iteration then starts and refines the initial design in loops. The concept is being enriched based on geographical information and optimized with regard to the control parameters and factors.

The students had an excursion and a lecture on the regional geography of the Filder and were requested to enhance their knowledge about the region and local spots by own field visits and remote sensing images available in the web. We suggested to start with optimizing the most relevant factor.

We strictly structured the workflow as shared by (a) the students – who are not skilled in GeoIT but who have a background in design, (b) two teachers skilled in GIS and modelling, the one educated in urban design, the second in geography and (c) a teacher who "traditionally" supervised the students design. All the main steps in the Geodesign workflow are represented in Figure 2 and follows considerations made by SCHWARZ-V.RAUMER & STOKMAN (2013, 2014).

To implement this workflow the following main challenges had to be tackled, at the one hand side concerning the transfer of inputs into the system

- How can the students with no GIS-experience conveniently edit the geometry ofspatial representations of ideas?
- How to give freedom in the choice to define what should be the new type of land utilization?

and in return when getting results from the system:

- What are the requirements and limitations of change reporting?
- How to interpret an iteration impact report?
- What is an appropriate decision for next design change?

The first two bullets refer to the next chapter, the second group of three bullets is discussed in the conclusion.

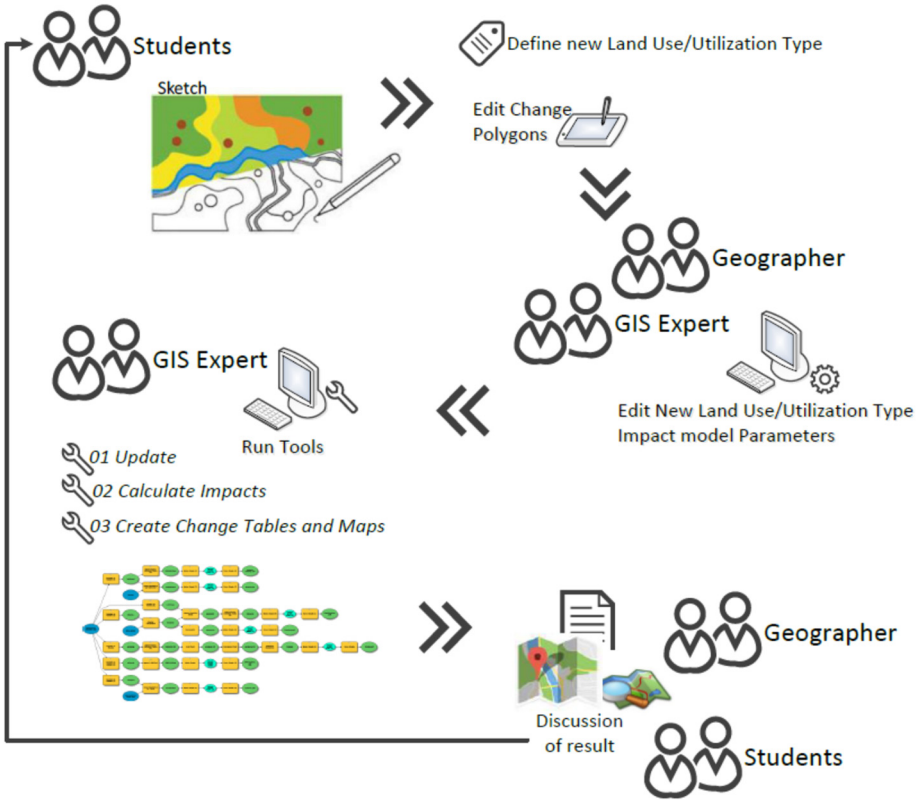


Fig. 2: Workflow implemented in the experiment

5 A Data Structure and a Tool for Change Editing

The first challenge concerning the "change of geography" (STEINITZ 2012) is, that students are supposed to and in deed do invent new land-use and thus new land-cover types. For example they want to convert an agricultural field into something they call "agropark", an recreational landscape which is open for citizens gardening. The easy step is to fix that in a id-code value and in a map legend. But what about the impact models? Our solution was to link each impact model to a specific land-use/cover type by specific parameter values, e. g. the C-factor for plant coverage in the soil erosion risk calculation. So the core of linking the creativity of the designer with the GIS-data structure consists of a so called "Land parameter table" (LPTab). This lookup-table organizes the classification and the specific parameter values as an input into the impact indicator models. This table has to be edited as a first step, when having finalized a new design.

The second step of vision transfer into the GIS is to create an "update layer". In this layer new polygons – and latest here we have to mention the convention we set, that only polygons are used for change editing – are edited by defining the geometric shape and by assigning a new land-use/cover type. To ease the editing procedure we did not use the default editing

tools offered by ArcGIS due to being a bit complicated for unskilled students. We created a special editing tool which is only capable to click a new polygon and to assign an item from the prepared LPTab.

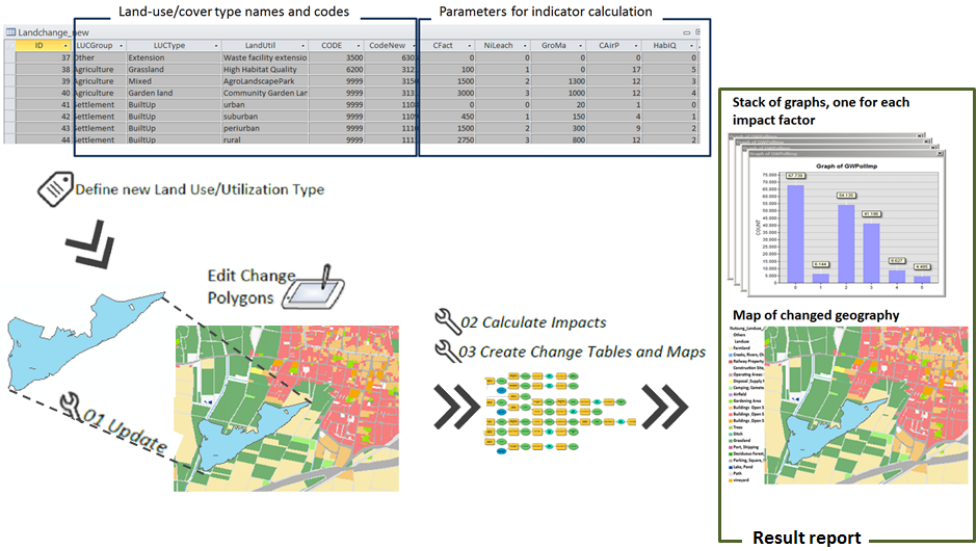


Fig. 3: Land parameter table (LPTab), update layer and result presentation

6 Example Excerpts

It is not possible to report and discuss the student's results in detail here, we just want to illustrate a bit their work on the task by some excerpts (Figure 4). The students had different conceptual ideas. One group worked on the development of green networks, other groups focused on moderating the transition between settlements and agricultural fields, whereas one group tried to establish a "green coherence" between existing green infrastructure inside the settlements and a changed land dedication outside. Ideas to upgrade existing creeks by locating nature based residential areas were generated as well as to completely relocate industrial areas.

In the c) part of Figure 4 you find the most distinctive representation of the iteration results concerning the indicators. The students of this group separated quality from risk indicators and were successful in the improvement of landscape qualities and in the reduction of risks.

7 Experiences, Conclusions and Outlook

How to optimize landscape? From the exercise and especially from working in the Geodesign loop it could be experienced, that in urban and regional planning trade-offs occur. At the

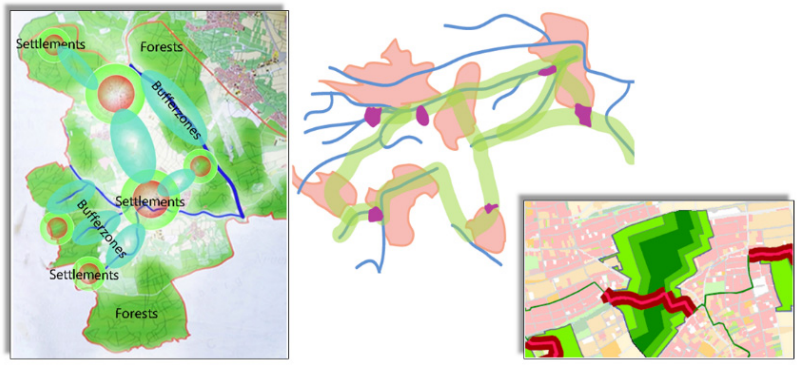
same time an increase of negative impacts due to additional urban development and a decrease of negative impacts from agriculture can be observed. It could be learnt that to balance the effects of reducing intensive agriculture when introducing new multifunctional landscape types (e. g. “agropark”) means to explicitly specify their ecological and economic parameters, and thus to not only invent but also to precisely and quantitatively describe them.

How to organize the group workflow? Each iteration loop took up to 3 days. The reason was that after the initial draft the students worked remote and submitted the change layers to the GIS operator who then sent back the results calculated by the impact tool. The consequence of this was, that not only personal schedules cause breaks, moreover the students lost the advantage of a creatively focused flow of try and retry in multiple fast repeating loops.

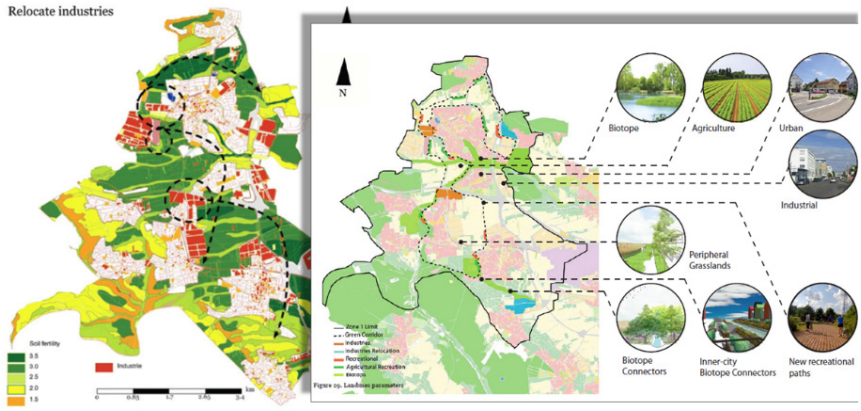
How to encourage rigorous solutions? The big advantage of the system we installed is to be able to simulate fundamental and massive rearrangements of the geography in the study area. This was not seen by the students. Probably due to not being familiar with the workflow most students started and perpetuated tiny and careful increments.

How to link idea and creativity with a GIS data structure and indicator calculations? We answered this question by the setup of a running system between a lookup-table, an editing tool, impact models and generating automatically result graphs and maps. This had different effects for the students: (1) Theirs creativity was interfered or blocked by having in mind that their result must be in accordance to technical requirements of the transmission processes into the system. (2) When getting the response from the system, which we provided in an aggregated information – as recommended when using indicators of weak evidence, the students immediately ask for a precise quantification and a precise location of change. It is difficult for them to fall back from quantitative control into a design world of unproved assumptions, non-quantified facts and qualitative reasoning. From both reasons the students trap into a sort of construction process instead to continue to be a designer. It could be seen, that ideas, concepts, objectives and principles formulated at the beginning were not considered and respected anymore.

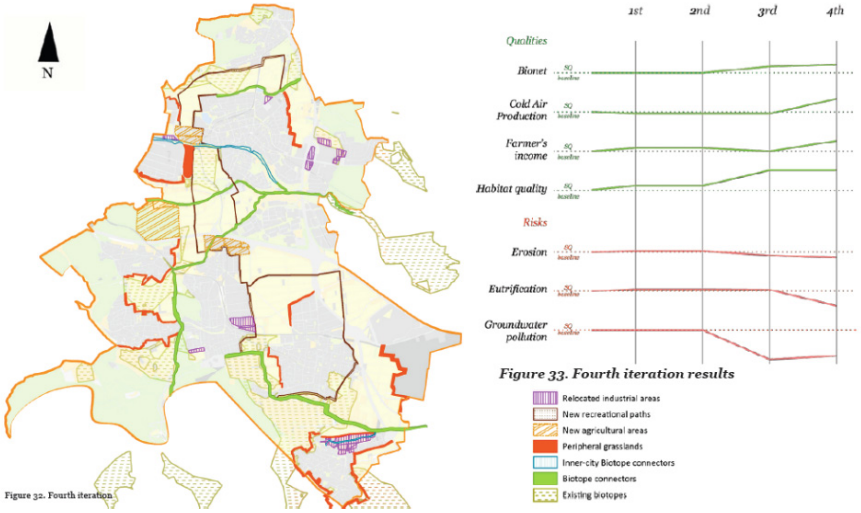
Each of the four questions we will take into account when planning a repetition of the experiment, having in mind that repetition is fundamental to gain knowledge in experiments.



a) Conceptual sketches



b) Locating, relocating and updating existing land-use/cover



c) Control of indicators in the course of iterations

Fig. 4: Some excerpts from the student's work

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Sources of Pictures in Fig. 1: Google maps, Stuttgarter Bildarchive (Frank Oschatz), Stuttgarter Zeitung, Mamas Rezepte, Stuttgart Tourist, Projektgesellschaft Neue Messe GmbH, Johanns Jörg, Rainless Einradtouren, Essbare Stadt Tübingen, Teckbote (Jürgen Holzwarth).