Marvin Melzer, marvin.melzer@zalf.de

# Project presentation of:

# *Relevant ecosystem services in landscape windows – A GIS-based approach*

## Introduction

The worlds current land use and food production is not in line with human's needs (Willett et al. 2019). Agriculture is criticized for destroying forests and biodiversity, wasting water and releasing one-quarter of global greenhouse-gas emissions (Schmidt-Traub et al. 2019). Unfortunately, decision makers of the world's food system are strongly influenced by representatives of the agricultural supply chain, unable to evaluate the sustainability of food production in the overall context of an agroecosystem (Schnyder et al. 2019). Agricultural measures to solve the above mentioned problems are known but poorly implemented to a lack of economic valuations and incentives, practical concepts and expertise. Therefore, farmers need independent and holistic advice (Schnyder et al. 2019), that i) meets the present and future challenges of sustainable agriculture and that ii) assigns an economic value to previously unremunerated services.

The joint research project DAKIS (Digital Agriculture Knowledge Information System) aims to facilitate this holistic advice by processing all relevant parameters of sustainable agricultural production and making them available as a decision making tool for agriculture and politics. A fundamental objective of DAKIS is the analysis, optimization and economic evaluation of ecosystem services (ESS), which are provided by agriculture. The analysis will take place in delimited areas with specific landscape characteristics, denoted as landscape windows (Sousa et al. 2004; Shanley et al. 2013), in the federal states Bavaria and Brandenburg. In this subproject i) the appropriate landscape windows and ii) the most relevant ESS will be determined and quantified regarding Status Quo and optimization Potential, based on available GIS data, to answer the following question: Do the relevant ESS in landscape windows differ between Bavaria and Brandenburg or even within the federal states?

## Approach

### 1. Determination of required GIS data:

The landscape windows should be defined, characterized and differentiated on the basis of selected natural and anthropogenic landscape characteristics, which are also suitable for an analysis of ESS (Table 1, Table 2).

### 2. Data acquisition and management:

GIS data (vector data, raster data) which can quantify landscape characteristics will then be collected. A database of required and already existing GIS data will be created and regularly updated to enable the participating DAKIS project groups and collaborative partners to specifically search, provide and collect GIS data. The database contains (at least) the following information:

*ID, official name of the file, availability, category, origin/source, license, costs, short description, resolution, covered area (e.g. county, state, country), creation date or age of the data, data size*

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## 3. Selection of the landscape windows:

Manifestations of the landscape characteristics in parts of the trial regions can be represented in a GIS as polygons and intersected with each other (Osterburg et al. 2009). This results in roughly delimitable areas, which in turn are represented as polygons in a GIS (Figure 1) similar to Meynen and Schmithüsen (1953-1962). The selection of some of these polygons or partial sections as landscape windows (e.g. 5x5 km or 10x10 km) is based on the following prerequisites:

1) The landscape windows should differ from each other with regard to one or more landscape characteristics.
2) Landscape windows should not be located in border areas to other polygons to avoid problems in the later statistical analysis.
3) Experimental areas which are already established, should be part of the landscape windows, to test agricultural measures developed by DAKIS.
4) Farmers with arable land that would like to participate in the implementation of the project (cooperation design) must be within the landscape windows to test agricultural measures developed by DAKIS under real conditions.

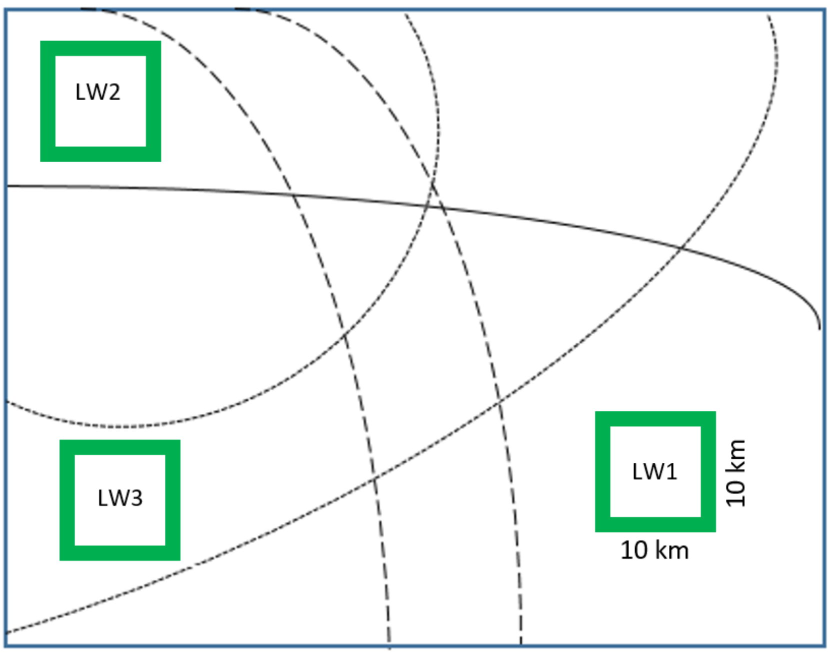


**Figure 1** Landscape section divided by three landscape characteristics (solid, coarsely dashed and finely dashed line type). A line of a line type results in two, two lines of a line type result in three manifestations of a landscape characteristic. The intersections result in polygons of which partial sections (10x10 km) are used as landscape windows (LW). LW1 and LW2 have the most possible differences to each other, no manifestation of a landscape characteristic is the same. For LW3, one manifestation is identical to LW1 and LW2.

### Natural and anthropogenic landscape characteristics

In contrast to anthropogenic landscape characteristics, natural landscape characteristics cannot directly be influenced by humans and are relatively stable. They are the basis for the characterization of landscape windows. The anthropogenic landscape characteristics partly result from the natural (e.g. soil type and climate determine land use), specify the characterization of the landscape windows and are essential for the analysis of the relevant ESS (Figure 5) planned later in the project.

**Table 1** Natural landscape characteristics and associated GIS data for determining landscape windows and for analyzing Status Quo of ESS.

| Natural landscape characteristics | Required data | Specific GIS Data/sources |
|---|---|---|
| soil | soil type; soil texture | Rbs (Reichsbodenschätzung); buek200 (Bodenübersichtskarte) |
| precipitation | annual mean, monthly mean, extreme events | DWD RADKLIM (radar climatology) |
| temperature | annual mean, annual course, daily min/max | DWD |
| wind | annual mean wind speed | DWD |
| relief | slope $m^{-2}$ | dgm10, dgm1 |

Example of a clearly distinguishable manifestation of a natural landscape characteristic is the relief in the federal state of Passau shown by the slope, derived by the digital elevation model (Figure 2).

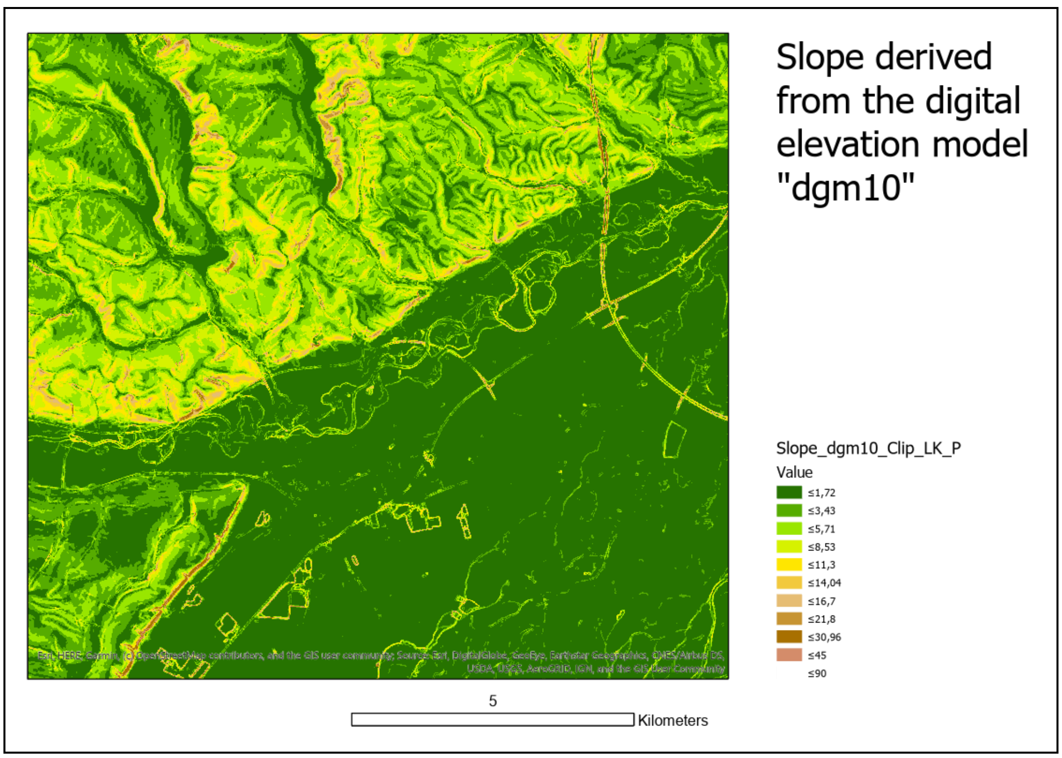


**Figure 2** Relief of the federal state of Passau shown by the slope, derived by the digital elevation model (dgm10). © GeoBasis-DE / BKG 2017.

**Table 2** Anthropogenic landscape characteristics and associated GIS data for analyzing the Status Quo of ESS.

| **Anthropogenic landscape characteristics** | **Required data** | **Specific GIS Data/sources** |
|---|---|---|
| land-use | Proportions and/or areas of arable land / grassland / forest / settlement / industry; forage / food / animal production; organic / conventional | InVeKoS = IACS (Integrated Administration and Control System |
| field size / farm size | fields $A^{-1}$; farms $A^{-1}$ | InVeKoS = IACS (Integrated Administration and Control System |
| settlement structure | inhabitants $A^{-1}$ or municipal | GV-ISys |
| structural elements | biotopes / hedges / trees / forests / water bodies $A^{-1}$ | bio_fbk (FFH biotopes); CIR biotopes; |

Example for the different manifestations of an anthropogenic landscape characteristic is the field size in Bavaria, county Passau (Figure 3) compared to Brandenburg, county Märkisch-Oderland (Figure 4).


**Figure 3** .Typical field size in Bavaria, county Passau in a 5x5 km section. Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


**Figure 4** Typical field size in Brandenburg, county Märkisch-Oderland in a 5x5 km section. Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

The landscape analysis comprises the evaluation of the available (primary) GIS data as well as the modelling and processing of secondary data. (e.g. erosion maps can be derived by soil type, precipitation topography and land-use). Already available secondary data can considerably accelerate the progress of the project and will therefore also be collected and included in the database (Table 3).

**Table 3** Additional primary and secondary GIS data for the DAKIS project

| Name | Unit |
|---|---|
| erosion (water) | t $A^{-1}$ |
| erosion (wind) | t $A^{-1}$ |
| Cross Compliance erosion level | CC level 0-2 |
| nutrient balance | N, P kg $A^{-1}$ |
| Nitrate in groundwater | Mg $l^{-1}$ |
| water quality of water bodies | german water quality classes (I-IV); P $l^{-1}$ |
| biodiversity | specific animals $A^{-1}$ |

## Field based radar-analysis of ESS

Once the landscape windows have been determined and characterized, the relevant ESS within the windows are quantified by means of a landscape analysis. The amount of work should primarily be limited to three ESS: Biodiversity, yield potential, erosion.

The analysis of an ESS (e.g. biodiversity on the basis of structural elements) can be carried out starting from the center of a field inside a landscape window. The range of analysis can be defined by a certain radius, similar to a radar, which is necessary for the recording of the ESS. Different data from different GIS layers within the analysis radius are collected and calculated. The result is used to classify the state of an ESS into a scale (e.g. 0-1). The mean of all examined fields within a landscape window is then compared with other landscape windows. All manifestations of landscape characteristics previously selected for polygon delimitation are the same within the analysis area if the analysis area is within the polygon boundaries and does not intersect them. Thus disturbing factors can be excluded.

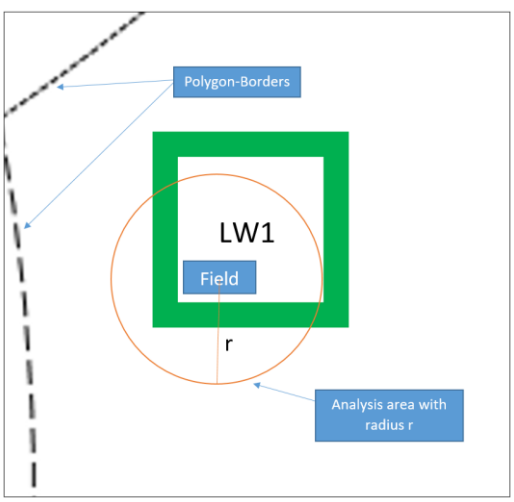


**Figure 5** Detail from Figure 1, bottom right. A field within the landscape window LW1 is analyzed regarding an ESS. The analysis includes the surrounding landscape within the circle with radius r.

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