Leibniz Centre for **Agricultural Landscape Research** (ZALF)

DAKIS
Digital Agricultural Knowledge and Information System

Off-site impacts of water erosion - Identification of hotspots on arable land for small scaled land use conversions

Marvin Melzer[a,b,c], Sonoko Bellingrath-Kimura[a,c]

[a] Leibniz Centre for Agricultural Landscape Research e.V., Eberswalder Straße 84, D-15374 Müncheberg
[b] Bavarian State Research Centre for Agriculture, Kleeberg 14, D-94099 Ruhstorf a. d. Rott
[c] Humboldt-University of Berlin, Unter den Linden 6, D-10099 Berlin

Introduction

The future common agricultural policy of Europe aims for a performance-based remuneration of agricultural measures and there impacts on ecosystem services (ESS) (Europäische Kommission 2011). The assessment of ESS is one major goal of the project DAKIS[1]. Erosion control was identified as one pivotal ESS strongly impacted by agricultural land use changes (Smith et al. 2017). Previously, on-site erosion was calculated based on the universal soil loss equation which quantifies soil relocation within areas. However, less information is available on both the amount of soil removed from a field and the final destination of eroded soil and relating impacts on surrounding ecosystems. Small-scaled, highly concentrated erosion such as rill and gully erosion can occur within arable fields. These hotspots are caused by specific relief characteristics, especially in the connecting lines between the lowest points of all cross profiles in the longitudinal direction of a terrain. Using precision agriculture (PA), a targeted conversion of land use in these hotspots can effectively reduce soil loss and related negative on-site and off-site effects while economic losses are minimized.

Research Questions

- How much soil is exported from delimited arable fields due to water erosion?
- How much soil enters attached waterbodies?
- Where are the biggest sources (hotspots) of water pollutions due to erosion?

Material and Methods

- 25 km² landscape section in the tertiary hill country, Bavaria
- data: rain erosivity (Fig. 1a), relief raster DEM[2] 1 (Fig. 1b), soil erodibility (Fig. 1c), land cover through current crop rotations based on administrative data (Fig. 1d).
- a map of waterbodies (Fig. 1e) was included to the model to calculate the soil export into aquatic ecosystems.
- input data was processed using InVEST SDR (The Natural Capital Project, version 3.9, Fig. 2) with an adapted Python script
- resulting raster data set was further processed by GIS tools (threshold analysis, buffer) to identify small scaled erosion hotspots (Fig. 1f)

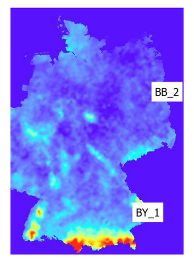

Fig. 1a: **rain erosivity** (Auerswald et al. 2019)

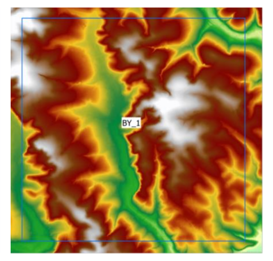
Fig. 1b: **relief** (DEM 1, Agency for Digitization, High-Speed Internet and Surveying, Bavaria)

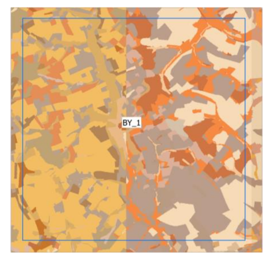
Fig. 1c: **soil erodibility** (Bavarian State Research Center)

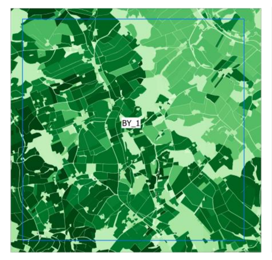
Fig. 1d: **land cover** (InVeKos, Bavarian State Ministry of Food, Agriculture and Forestry)


Fig. 1e: **waterbodies** (ATKIS[3], Agency for Digitization, High-Speed Internet and Surveying, Bavaria)


Fig. 1f: **erosion hotspots** as raster data filtered by threshold analysis

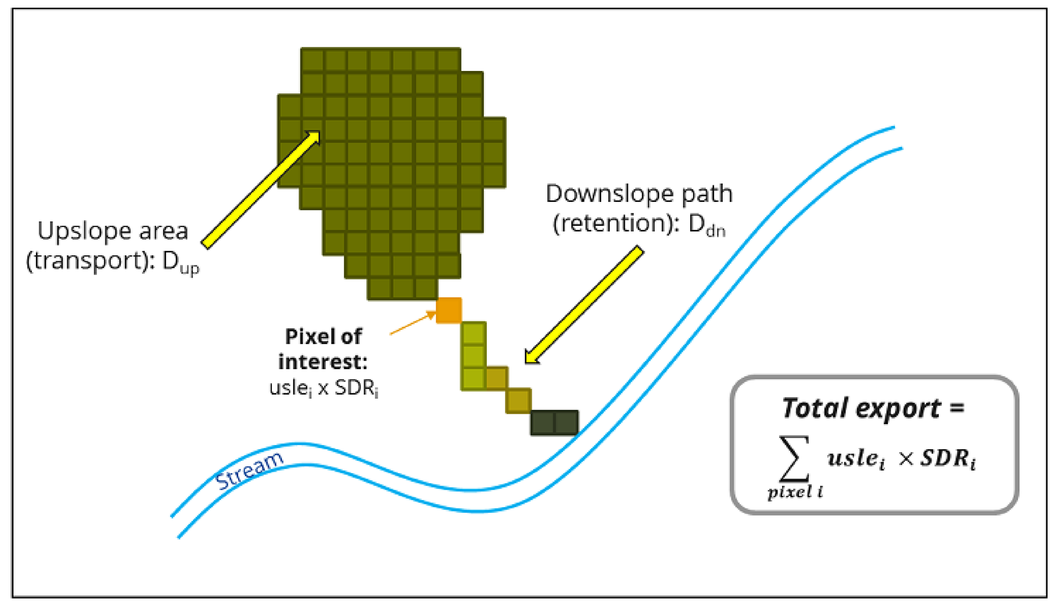

Fig. 2: Concept of the model InVEST SDR (The Natural Capital Project).

Results

- 312 identified erosion hotspots within fields visualized in a map
- mean soil import to aquatic ecosystems per hotspot: 4.5 t ha^{-1} a^{-1}
- mean area per hotspot: 710 m²

Fig. 3: Final map showing the calculated soil import to aquatic ecosystems per field or erosion hotspot in t ha^{-1} a^{-1} based on threshold analysis and buffering of calculated model output.

Discussion

- high resolution data about relief (1 meter) and ATKIS waterbodies allows consideration of finely branched stream systems next to arable fields as primary sink of water pollutions due to eroded soil
- detailed map can be used by PA technologies to realize highly effective, small scaled conversion measures e.g. grassland buffer stripes
- reduction of erosion quantified in t ha^{-1} a^{-1} is a suitable reference value for performance-based remunerations in accordance with current political objectives

References & Annotations

1. Auerswald, K.; Fischer, F. K.; Winterrath, T.; Brandhuber, R. (2019): Rain erosivity map for Germany derived from contiguous radar rain data. In Hydrology and Earth System Sciences 23 (4)
2. Europäische Kommission (2011): Die Biodiversitätsstrategie der EU bis 2020. Luxemburg: Amt für Veröff. der Europ. Union.
3. Smith, A. C.; Harrison, P. A.; Pérez Soba, M.; Archaux, F.; Blicharska, M.; Egoh, B. N. et al. (2017): How natural capital delivers ecosystem services: A typology derived from a systematic review. In Ecosystem Services 26.
4. The Natural Capital Project: InVEST. Sediment Delivery Ratio. http://releases.naturalcapitalproject.org/invest-userguide/latest/sdr.html#the-model. (last accessed 17/02/21)

[1] DAKIS, Digital Agricultural Knowledge and Information System: https://adz-dakis.com/
[2] DEM, Digital Elevation Model
[3] ATKIS, Administrative Topographical-Cartographic Information System

Leibniz Centre for Agricultural Landscape Research (ZALF) | Eberswalder Straße 84 | 15374 Müncheberg | Germany
Contact: marvin.melzer@zalf.de

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