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-scale land use changes considering profits

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Challenge & Research Questions

Small-scale, highly concentrated water erosion occurs within arable fields with specific soil, climate and relief characteristics and insufficient soil cover. Small-scale land use changes in these 'hotspots' may effectively reduce soil loss and off-site impacts. However, related profit losses for farmers should be considered.

- What is the current potential to reduce soil relocation from arable fields to aquatic ecosystems?
- Where are erosion hotspots suitable for small-scale land use changes?
- Are there related profit losses due to protective land use changes of hotspot areas?

Material & Methods

- Soil relocation to aquatic ecosystems calculated using the software InVEST SDR (The Natural Capital Project, version 3.9, Fig. 1)

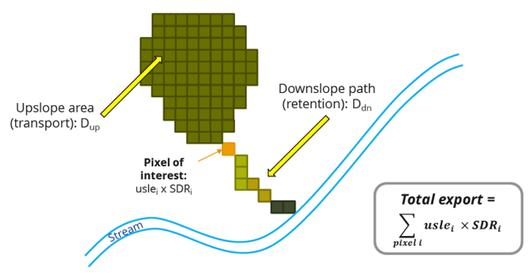

Fig. 1: Concept of the model InVEST SDR to calculate soil relocation into streams (The Natural Capital Project).

- Rain erosivity (Fig. 2a), relief (Fig. 2b), soil erodibility (Fig. 2c), land cover based on the crop rotations between 2015 and 2019 (Fig. 2d) and a map of waterbodies (Fig. 2e) processed into a raster (Fig. 2f) for threshold analysis and buffering to identify erosion hotspots (Fig. 3)

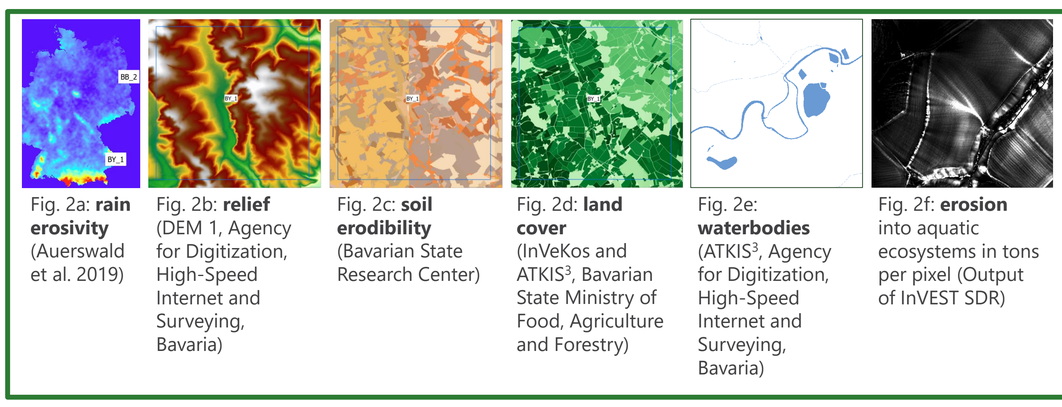

Fig. 2a: **rain erosivity** (Auerswald et al. 2019)

Fig. 2b: **relief** (DEM 1, Agency for Digitization, High-Speed Internet and Surveying, Bavaria)

Fig. 2c: **soil erodibility** (Bavarian State Research Center)

Fig. 2d: **land cover** (InVeKos and ATKIS[3], Bavarian State Ministry of Food, Agriculture and Forestry)

Fig. 2e: **waterbodies** (ATKIS[3], Agency for Digitization, High-Speed Internet and Surveying, Bavaria)

Fig. 2f: **erosion** into aquatic ecosystems in tons per pixel (Output of InVEST SDR)

- Annual economic profit per field calculated based on crop rotations using the profit calculator of KTBL[4]
- Costs to transfer arable land to extensive grassland equalized with the reduced acreage per field and proportionate profit losses
- Erosion prevention costs per hotspot or field (€/t) calculated, assuming that land use change reduces erosion by 100 %

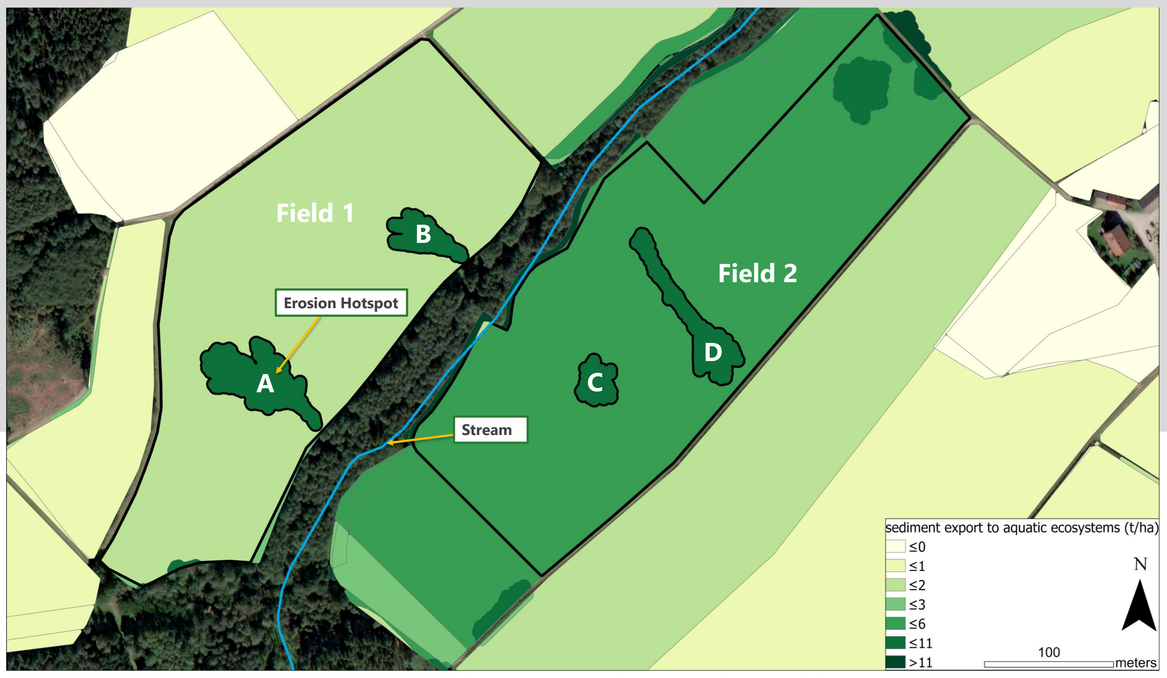

Fig. 3: Section of final map shows erosion hotspots in agricultural fields with high soil imports to aquatic ecosystems (e.g., a stream, blue line). Darker greens indicate higher values of erosion. Four hotspots were selected and further described (Tab. 1). Hotspots A and B refer to field 1, hotspots C and D refer to field 2.

Results & Discussion

- Streams as sinks of water erosion used to identify erosion hotspots (Fig. 3)
  → Hotspots should be transferred to simple geometries adapted to agricultural machinery and aligned with driving lanes across the slope

- Costs to prevent erosion (€/t) in hotspots lower than in surrounding fields (Tab. 1)
- Costs borne by farmer have to be balanced with costs of off-site damages to infrastructure, society and environment

Tab. 1: Exemplary calculation of erosion prevention costs (€/t) of four hotspots (Fig. 3) based on calculated erosion to aquatic ecosystems and economic profits of previous crop rotations.

fieldname	area (ha)	profit (€)	erosion (t)	costs (€/t)
Field 1	6.62	586	18.03	33
Field 2	7.18	368	30.11	12
Hotspot A	0.34	33	2.38	14
Hotspot B	0.15	14	1.13	13
Hotspot C	0.10	6	0.86	6
Hotspot D	0.26	15	2.64	6

Conclusions

- Novel approach considers water bodies as sinks for erosion in a high-resolution elevation model to identify hotspots for small-scale land use changes
- Land use changes in hotspots as a compromise, effective in reducing erosion while maintaining normal crop production in the remaining field
- Positive effects on other ecosystem services and biodiversity
- Calculated costs facilitate performance-based remunerations in accordance with current political objectives

References & Annotations

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2. Europäische Kommission (2011): Die Biodiversitätsstrategie der EU bis 2020. Luxemburg: Amt für Veröff. der Europ. Union.
3. Kuratorium für Technik und Bauwesen in der Landwirtschaft e. V. (Ed.): Leistungs-Kostenrechnung Pflanzenbau. Available online at https://daten.ktbl.de/dslkrpflanze/.
4. 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.
5. 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
[4] KTBL, Kuratorium für Technik und Bauwesen in der Landwirtschaft e. V. („Curatorium for Technology and Construction in Agriculture")

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