

Modelling erosion and sediment transport to inform Payment for Ecosystem Services schemes

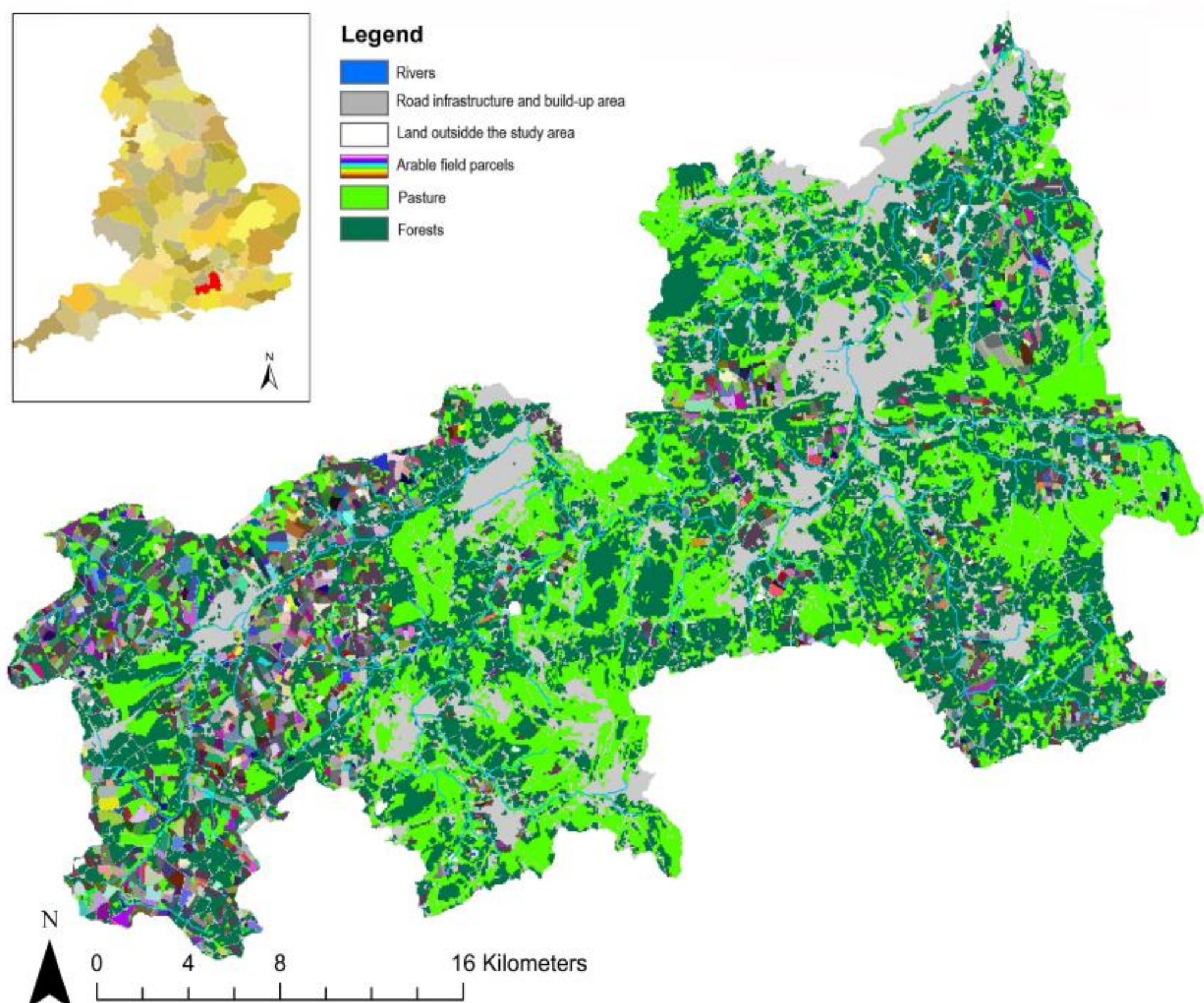
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Introduction

Erosion and the associated redistribution of sediment increases water treatment requirements and, thereby, associated costs [1]. Erosion may also have an impact on productivity of agricultural soils [2]. Catchment management solutions can reduce multiple impacts simultaneously but may involve significant costs [3]. Payment for Ecosystem Services (PES) schemes helps determining the range of benefits provided by nature-based solutions and identifying service buyers and sellers [4]. Modelling tools are useful to design catchment management measures and assess their efficacy [5], and have potential to inform PES.

Materials & methods

Case study: River Wey catchment [6]



Tool: WaTEM-SEDEM [7]

- Water erosion (RUSLE)
- Transport capacity
- Tillage erosion

$$TSE = TSP - TSD - TPD$$

TSE: total sediment export, TSP: total sediment production, TSD: total sediment deposition, TPD: total pond deposition

Catchment measures for sediment reduction

- 24 retention ponds of 2 ha on arable fields with average size of 86 ha and 10 ha in urban areas; assumed depth of 1m.
- Cover crops in all arable land: Reduction of RUSLE C factor and transport capacity
- Buffer strips around all arable field parcels bordering the river and its tributaries

Ecosystem Services buyers and sellers

Measure	ES seller	Ecosystem service benefit [8]	ES buyer
1 - Ponds	Farmers & local authorities	Wild animals and their outputs	Recreationists (fishermen)
		Buffering and attenuation of mass flow	Water companies
		Flood protection	Local councils
2 - Cover crops	Farmers	Fibres and other materials from plants	Businesses
		Mass stabilisation and control of erosion rates	Farmers
		Buffering and attenuation of mass flow	Water companies
		Pest control	Farmers
3 - Buffer strips	Farmers	Mass stabilisation and control of erosion rates	Farmers
		Buffering and attenuation of mass flow	Water companies
		Pest control	Farmers

Cost-Benefit analysis

- Cost = Investment + Annual maintenance + Annual opportunity cost
- Benefit = Annual benefit
- A scenario is considered to provide higher future returns than costs when it results in higher values of the Net Present Value (NPV)

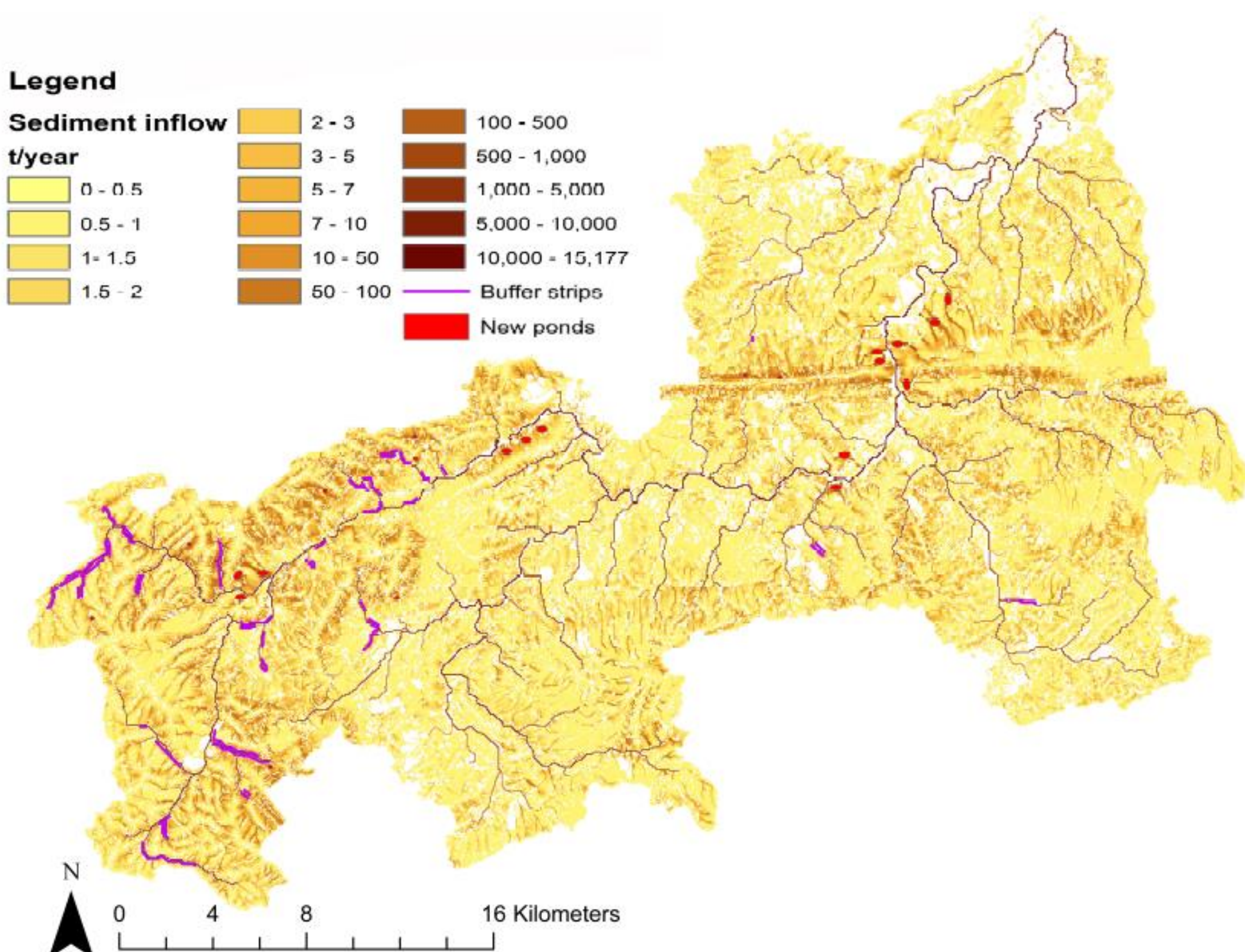
$$NPV = \sum_{t=0}^n \frac{R_t}{(1+i)^t}$$

Rt: Net benefit = Benefit - Cost
 n: 10-year period
 i: 5% discount rate

Results

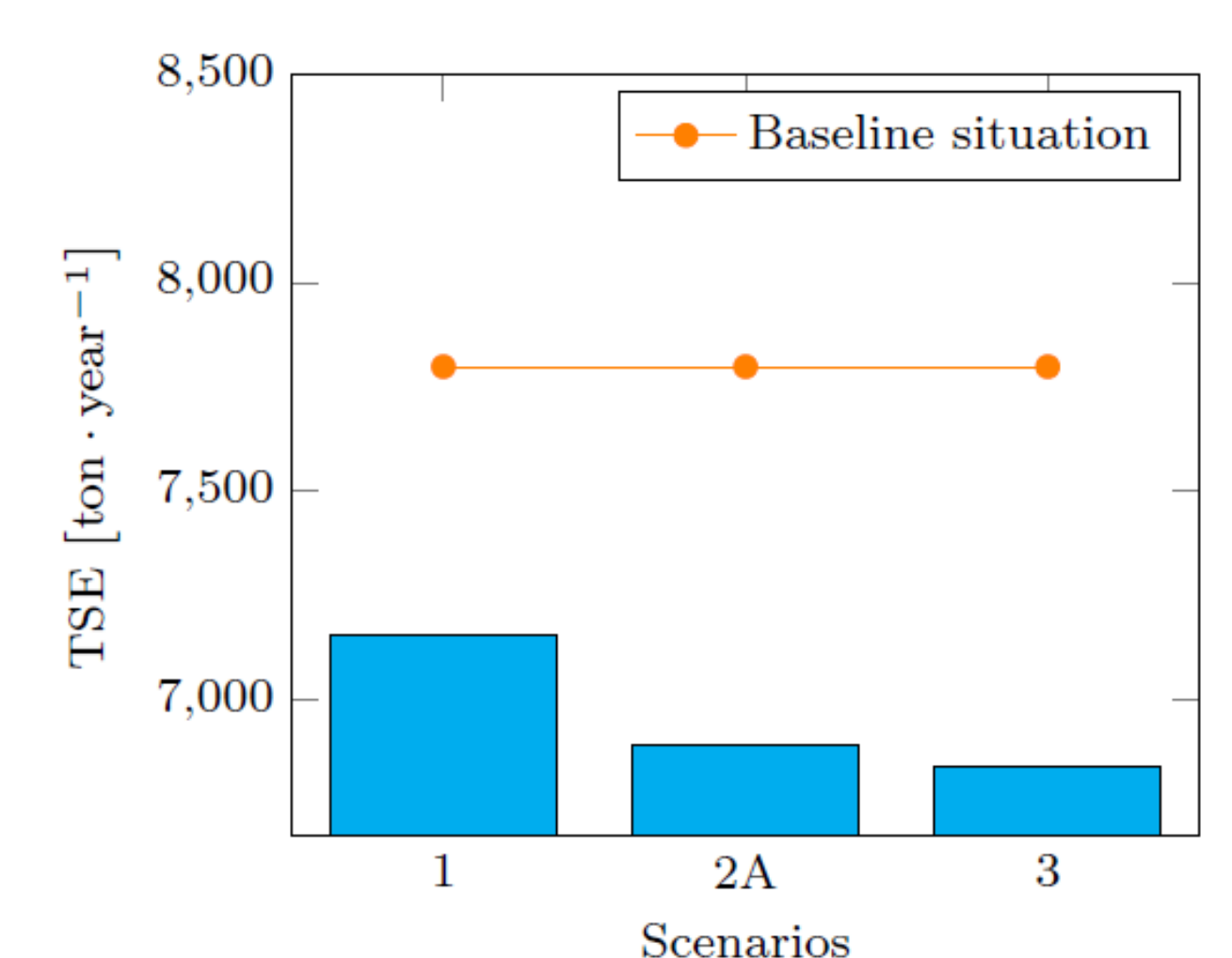
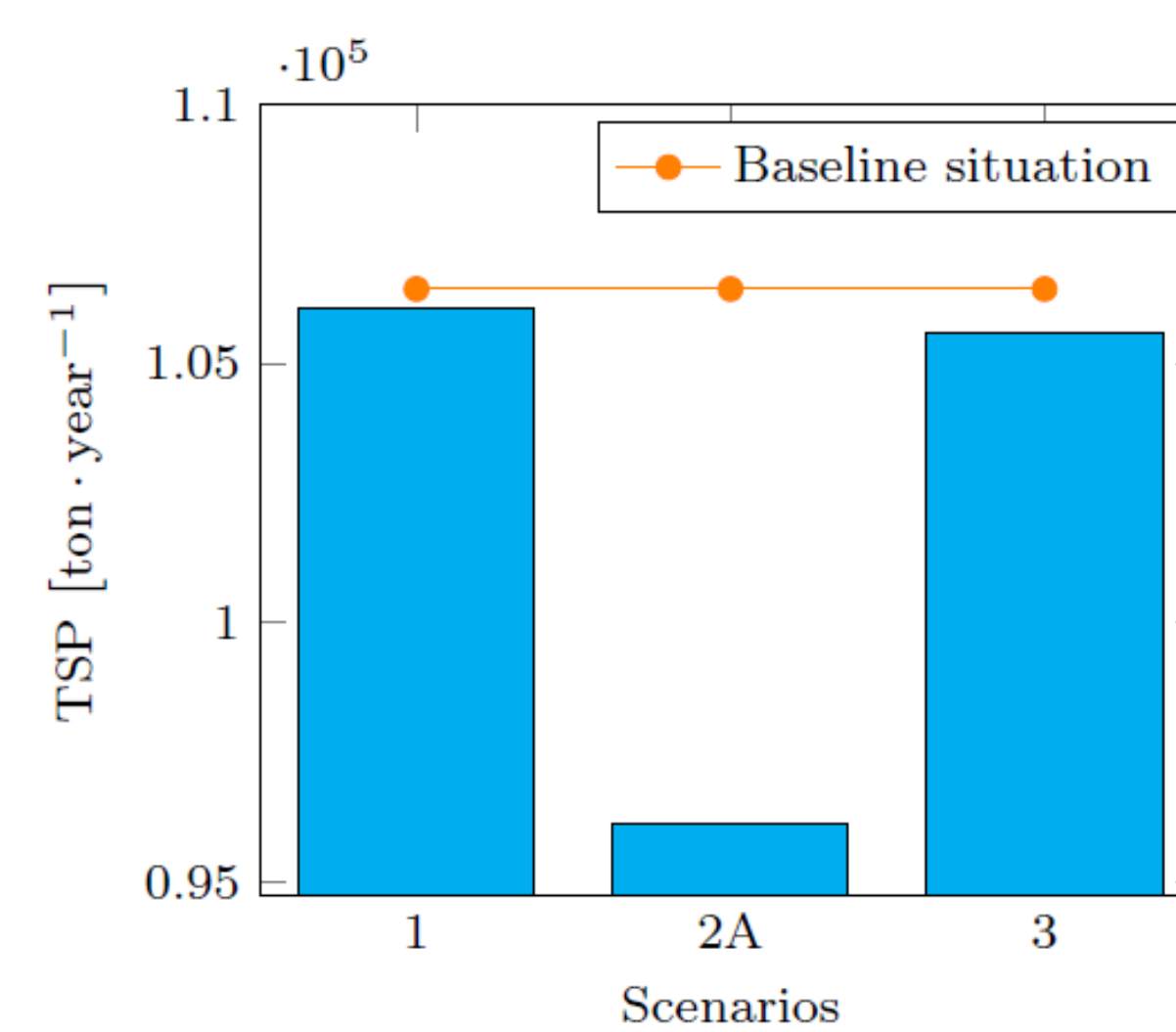
Baseline

- Satisfactory model performance with percent bias of 6.26% with respect to the observed sediment loads.
- Annual average sediment transport with location of introduced retention ponds and grass buffer strips:

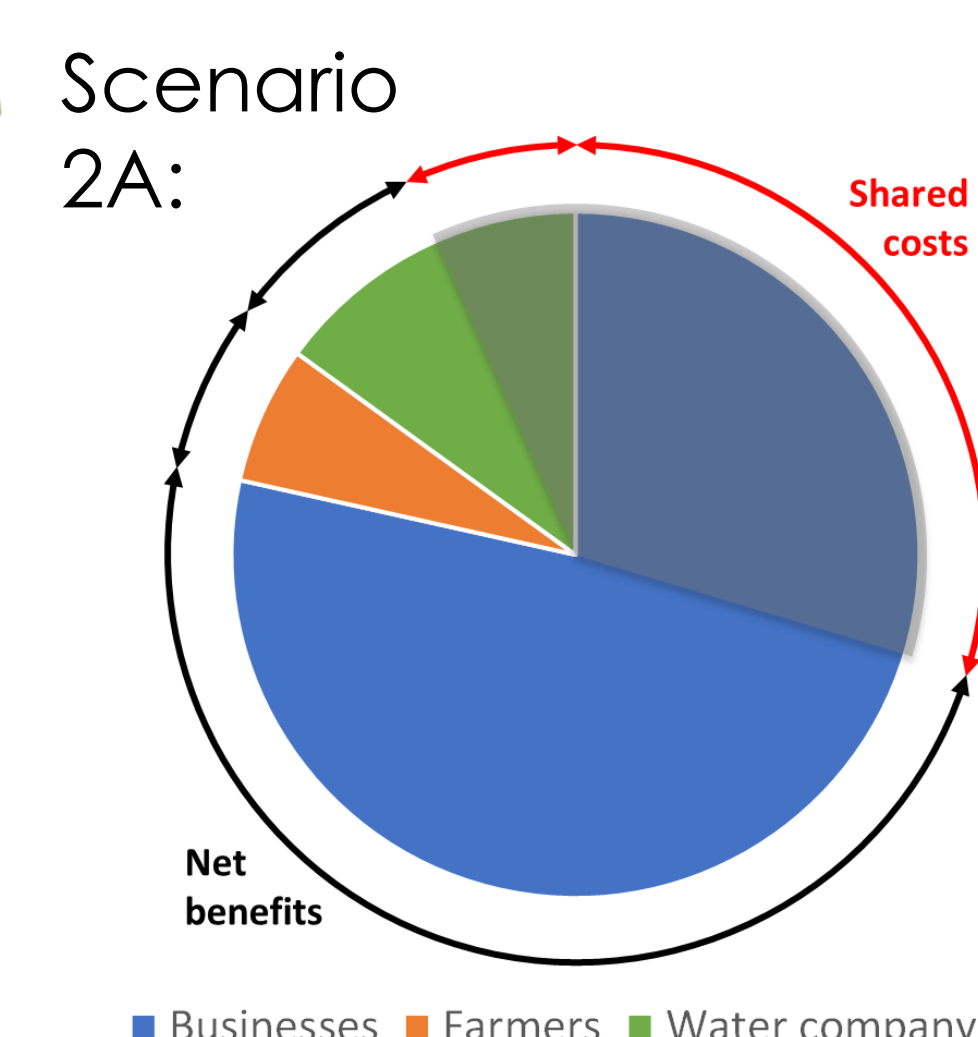
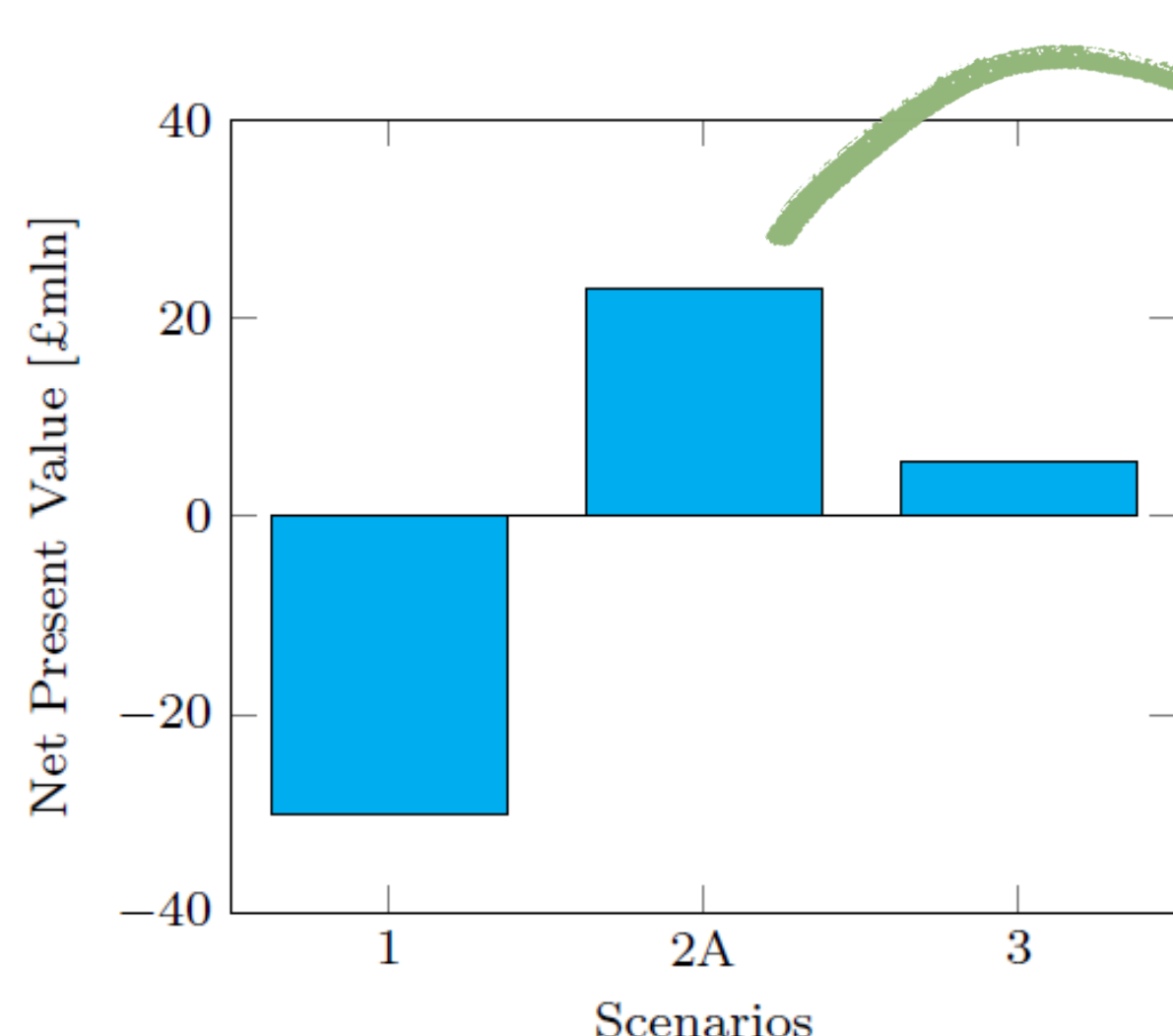


Catchment management scenarios

- Effectiveness of measures:



- Cost-Benefit, ES buyers and sellers:



- PES scheme:
- Businesses and the local water company cover 80% and 20% of the costs, respectively.
 - Farmers contribute with the additional labour of managing cover crops.

Conclusions

- WaTEM-SEDEM can be helpful for decision makers in planning the type and location of catchment management measures for sediment reduction.
- The combined use of models and cost-ES benefit analysis can support the development of Payment for Ecosystem Services schemes as basis for implementation of nature-based solutions.

References

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