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Work Package 6 – Trade-off Analysis for catchment-based decision making

This report outlines the development of a desk-based Geographic Information Systems – Multi Criteria Evaluation (GIS-MCE) demonstration tool, designed to assist in catchment planning and management. The tool enables users to identify spatial conflicts and prioritise areas for woodland planting within the Aire and Calder catchment area using a weighted overlay analysis. The tool, developed in the Shinyapps.io framework for R, allows users to customise spatial factor weights to reflect different land use priorities. Key constraints, based on established criteria, include agricultural suitability, peatland exclusion, transport proximity, and flood risk assessment.. A weighted overlay analysis integrates these factors to create a user priority composite suitability map, enabling informed decision-making. Recent enhancements include improved metadata, reclassification functionality and a save feature for user preferences. Future improvements may expand its functionality by incorporating additional environmental and socioeconomic variables and enhancing integration with other GIS platforms. This GIS-MCE tool demonstrates the value of interactive, user-driven spatial analysis in land-use planning and provides a replicable model for catchment-based decision support systems, promoting sustainable land management and conservation efforts.

Background

Catchments and their river systems are, by definition, spatial. Within a catchment, the interaction between geographical patterns of topography, climate, land use, settlement, infrastructure, etc., will dictate what is and isn't possible with regards to flood and water quality policy and management. Often, policy and management actions require trade-offs to satisfy the multiple demands placed upon both land and water throughout a catchment. These trade-offs occur at multiple spatial scales, across multiple stakeholders. often involving conflicting interests. GIS- MCE tools can be used to map and better understand where such trade-offs are required. The aim of this Work Package is to develop a desk-based GIS-MCE demonstration tool for the identification of spatial conflicts in catchment planning and management.

Research methodology

A trade-off analysis tool, using relevant spatial datasets, was developed for the River Aire and Calder catchment to answer the following questions:

1. Where could more trees be planted in the uplands to reduce runoff entering stream channels?
2. Where could floodplain areas be "roughed up" or naturalised to slow runoff into the main river channel?

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This study completed the following activities:

- Undertook a catchment-wide inventory of relevant spatial datasets including topography, land use, human settlement and infrastructure.
- Used these datasets to derive spatial models of relevant factors and constraints.
- Used example weights and priorities to identify spatial patterns in trade-offs between stakeholder groups and communities in the River Aire catchment.
- Explored the need and demand for web-based decision support tools using Web2.0 interfaces and existing research tools. Early tools such as WEIGHTER (Carver et al., 2007) have been evaluated and decisions made to continue development using more modern applications. The ShinyApps https://www.shinyapps.io/ interface was used in this study.
- Undertake extensive sensitivity testing using both bootstrapping and jack-knifing techniques.

Recommendations

- To enhance the GIS-MCE tool, further refinements could be made to improve usability and the accuracy of the spatial analysis.
- Additional environmental and socio-economic datasets should be integrated to expand the tool's functionality.
- Stakeholder workshops could be conducted to validate the tool's outputs, incorporating feedback to align the tool with real-world applications.
- Publication of this web-based tool could facilitate broader accessibility and enable collaboration among users in different regions.
- Future research could investigate the use of machine learning techniques to optimise weight selection, making the decision-support process more efficient.
- Evaluating the tool's effectiveness through pilot studies in additional catchment areas will provide valuable insights into its applicability and scalability.
- Developing comprehensive training materials and user guides will support widespread adoption among planners, policymakers, and conservationists.
- Local and regional government agencies responsible for land-use planning and environmental management should be consulted to ensure the tool aligns with policy requirements.
- Environmental non governmental organisations and conservation groups involved in catchment management and woodland planting could contribute practical insights, while funding bodies and policymakers at national and international levels could help secure necessary financial and legislative backing.

Read the final report by Prof Stephen Carver and Dr Sani Garber, School of Geography, University of Leeds

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