# Google Earth as a visualisation tool for stakeholder engagement in natural flood management

Smith K[*1], Berry R[†1] and Clarke L[‡2]

[1]Countryside and Community Research Institute, University of Gloucestershire, UK
[2]Department of Geography, School of Natural and Social Sciences, University of Gloucestershire, UK

January 9, 2018

**Summary**

One approach to reducing flood risk that has received considerable interest is natural flood management (NFM), which aims to work with nature alongside other measures. Incorporating multiple NFM interventions over a wide area this is also thought to offer additional benefits for water quality and biodiversity. Using the River Isbourne catchment in Gloucestershire as a case study, this paper examines the potential of 3D landscape visualisation (Google Earth) for enhancing the communication of complex spatial information to educate people about, and generate interest in, a proposed NFM project that is being implemented in the area.

**KEYWORDS:** Flooding, natural flood management (NFM), Google Earth, 3D landscape visualisation, GIS

## 1. Introduction

Fluvial (river) flooding in the UK is a serious problem that is predicted to worsen. Recent estimates suggest that economic losses from flooding could rise from a level of £1.2 billion (2012), to between £1.6 and £6.8 billion by 2050, with other significant negative impacts on the environment and health and well-being of people also likely to increase (Ramsbottom et al., 2012). In 2007, a major flood event affected several areas of the UK including Gloucestershire, North Yorkshire, Hull and the Thames region. Across the UK thirteen people died and 55,000 properties were flooded. A key component of the subsequently published 'Pitt Review' (Pitt, 2008) was to reduce the risk of future flooding.

Policy developments in the fields of water resource and flood risk management have led to a shift from a technical, structural approach using traditional engineering solutions to control rivers towards a sustainable management approach to reducing flood risk (Cook et al., 2016; Rouillard et al., 2015). Natural Flood Management (NFM), defined by Wentworth (2011) as the "alteration, restoration or use of landscape features to reduce flood risk", is a sustainable approach to catchment management. It seeks to reduce flood risk alongside conventional flood risk measures, using a suite of nature based techniques designed to attenuate or slow the flow of water (Wilkinson et al., 2014). Unlike engineered solutions, which tend to focus on the use of single sites to protect large areas, it utilises multiple interventions over a wider landscape or catchment scale to achieve a targeted threshold of change (SEPA, 2015).

Achieving early engagement with stakeholders, and maintaining their support, is a critical component of NFM planning, as the implementation of a range of measures across a wide area at a catchment level requires a collaborative partnership approach to be successful (Wentworth, 2011). This could involve

[*] KatherineSmith2@connect.glos.ac.uk
[†] rberry@glos.ac.uk
[‡] lclarke@glos.ac.uk

a range of stakeholders including wildlife and landscape organisations, local authorities, landowners, farmers and the wider community. One of the research gaps identified by the Environment Agency in their review (Environment Agency, 2014), was how to effectively engage stakeholders and communities at an early stage to help identify options and make decisions. This included the identification of key messages and methods of communication to demonstrate the multiple benefits of NFM, noting the potential for employing IT approaches and visual aids.

Previous research has investigated the use of virtual globe tours to communicate local impacts of climate change (Schroth et al., 2011) and ecosystem services (Harwood et al., 2015). Using a virtual globe tour approach on the Google Earth platform, this research considers how practical and accessible the method is for developing a landscape visualisation for a catchment wide NFM project, and how effective it is for communicating information to enhance understanding for a variety of users.

## 2. Methods

The River Isbourne catchment is located within the counties of Gloucestershire and Worcestershire. The river rises to the North East of Cheltenham and flows in a northerly direction for 30km, before converging with the River Avon at Evesham (Figure 1). The catchment covers an area of 88km2. A scoping study conducted by the University of Gloucestershire and the Environment Agency (EA) as part of a wider research initiative, recommended a collaborative NFM-based approach to tackling flood management in the catchment (Clarke et al., 2016).

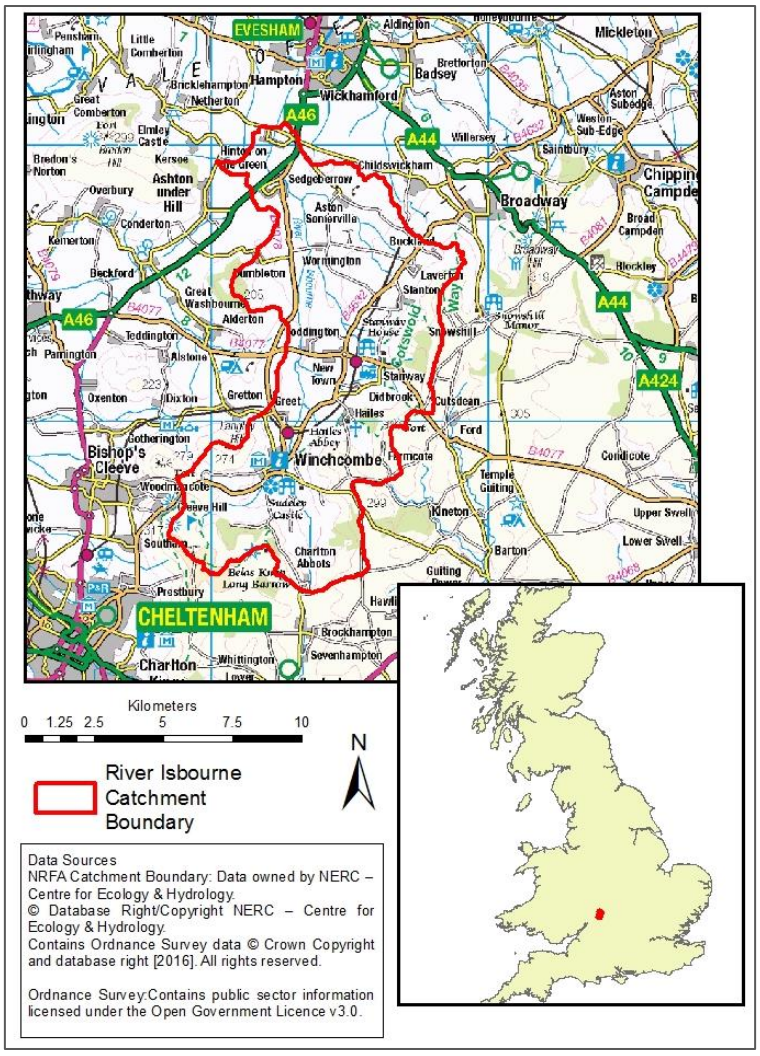


**Figure 1** The River Isbourne Catchment

Following a review of the literature, it was clear that a variety of landscape visualisation tools and techniques were available for research into the communication of spatial data to facilitate understanding and stakeholder engagement. These included 3D software packages such as Visual Nature Studio, and dynamic interactive virtual globe tours created with online platforms such as Google Earth and NASA World Wind (Lovett et al., 2015). The landscape visualisation technique selected for this research was a Google Earth virtual globe tour.

The design and development of the virtual globe tours took into consideration guidance on the use of 3D landscape visualisations from Lovett et al. (2015), and criteria suggested by (Sheppard and Cizek, 2009) in their paper on ethics and Google Earth. The animated tours and data layers were created using Google Earth Pro (v7.1.7.2606) on a Windows 10 PC. The text editor Notepad++(v7.3.2) was used for scripting with XML language and the output saved as KML files, which were used to customise the animation and behaviour of features in Google Earth. Esri ArcMap 10.4.1 was used for pre-processing and analysis of GIS datasets used in the tour, and for converting spatial data to KML format for use in Google Earth.

An initial prototype tour was evaluated in a workshop setting by members of the Isbourne Catchment Group and academic staff at the University of Gloucestershire. The findings and recommendations from this pilot study were used to formulate a 'final' tour (Figure 2) that was evaluated by users in a supervised laboratory setting and a remote web-based, unsupervised setting. The online, web-based approach aimed to reach a wider range of participants than the lab-based approach to maximise the potential number of survey respondents (Berry and Higgs, 2012) and cover a range of learning styles for generalisation (Wissen et al., 2008). Using both facilitated group and web based approaches enabled comparison of the results to identify any differences between the settings.

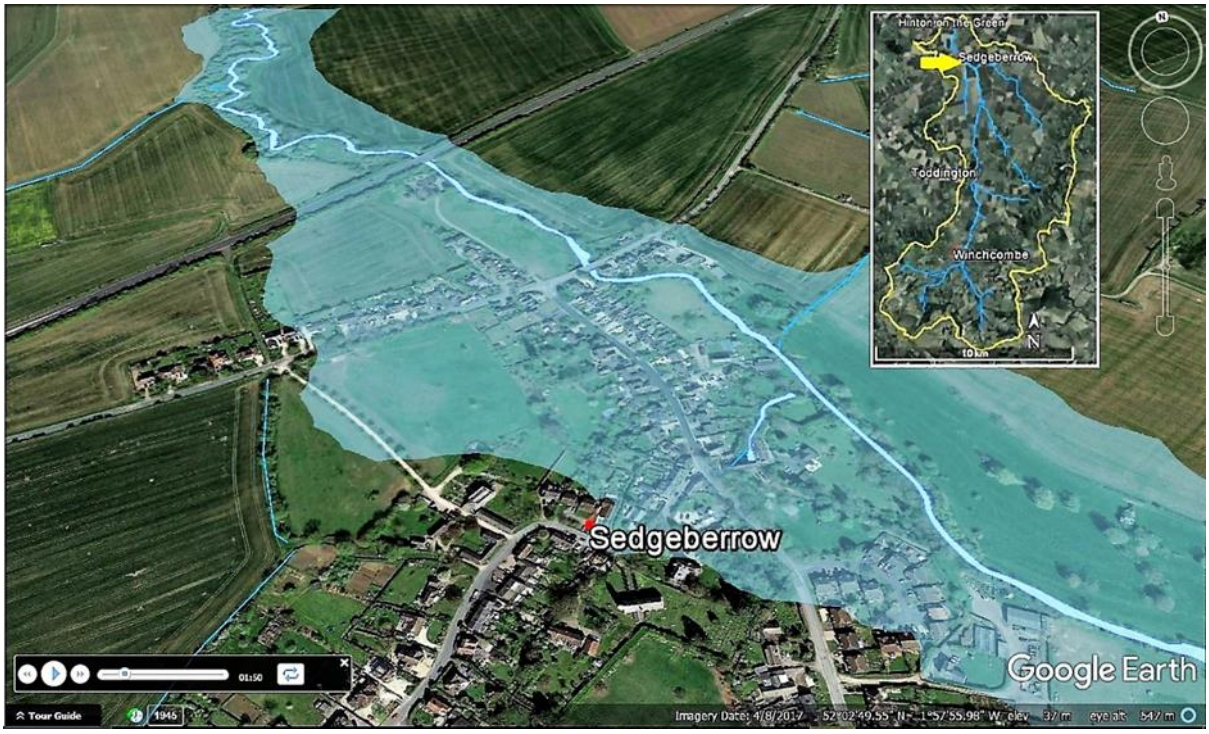


**Figure 2** Screenshot the final developed Google Earth tour, showing flood extent data for the 2007 flood along the River Isbourne at Sedgeberrow, Worcestershire, UK.

## 3. Results

The end user evaluation was undertaken in two settings, with ten participating in a facilitated group in an academic setting and twenty-five participating online. Observations and feedback from the group session revealed that that clear instructions were essential to avoid confusion in the set up and operation of the virtual globe tour. Responses to closed-ended questions in the end user survey were rated on a scale from 1 to 6, and designed to obtain feedback on the usability of the tour, the effectiveness of specific elements, and the helpfulness for communicating both the features and issues of the catchment and the potential for NFM in the catchment. The survey also asked about viewers' perceptions of the impact of NFM on the environment.

Usability ratings in both settings were high for ease of use, visual clarity and level of trust, although they were slightly lower in the online survey. The mean ratings for effectiveness of the tour elements were high in both the group and online surveys. In terms of effectiveness, mean scores were consistently higher (and the variance lower) in the facilitated group than the online group for all the elements. Comments made in free text question responses supported the usability metrics.

Among the online participants there was no notable relationship between age, gender, occupation or experience levels with Google Earth/computers, and ease of use or visual clarity. Those with a higher level of Google Earth/GIS experience gave a mean rating for speed of presentation and the level of trust in the information. Free text comments supported the survey ratings that the tour was helpful for communicating the catchment features including the topography, the ecology, and historical environment. They also commented on the issues of land management change, the complexity of multiple agencies and the potential for using NFM. The results showed that after viewing the tour, participants perceived that NFM would be beneficial to managing flooding and water quality.

## 4. Discussion

The survey results indicate that the Google Earth tour was helpful for demonstrating the catchment features and the issues it faces, with participants commenting positively on the ability to see the flood extent and to understand the influence of the topography and changes in land use. It was also helpful, although to a lesser extent, for improving the understanding NFM techniques and the potential for using it in the Isbourne catchment. Participants commented that the tour demonstrated the complexity of solutions for the issues in the catchment along with the potential number of agencies involved. Supporting findings from previous research (Harwood, Lovett and Turner, 2015; Schroth, Pond, et al., 2011) this research found that the Google Earth tour approach shows good potential as an educational tool for enhancing communication and understanding in collaborative catchment management. It was particularly effective for demonstrating NFM to those with no prior knowledge.

Additional research could further investigate the importance of the interactive features, identified as a key benefit of the virtual globe tour (Lovett et al., 2015), by comparing the experience with that of a pre-recorded video version. The potential for adding audio commentary with MP3 files could also be explored. More effort could be made to obtain the views of under-represented participant groups, which was not possible within the time limitations in this research. Alternative landscape visualisations tools could be compared with virtual globe tours to gain further insight into user preferences for the communication of catchment features and NFM, considering levels of realism and interactivity. The use of mobile computing and smartphones coupled with augmented reality (AR) technology to enable a multi-sensory on-site experience not achievable online, should also be examined (Gill and Lange, 2015).

## 5. Acknowledgements

The authors would like the Isbourne Catchment Group and survey participants for their support during this project.

## 6. Biography

Kate Smith graduated from the University of Leeds in 1990 (BSc Hons Geography) and worked in a range of finance and administration roles before returning to education. Kate submitted a thesis for a MSc by Research at the University of Gloucestershire in December 2017 (awaiting results). She is interested in the application of GIS in catchment management and sustainability issues.

Robert Berry is a Research Fellow specialising in the application of GIS in environmental and rural research. His research interests include the use of participatory GIS and 3D landscape visualisation in collaborative environmental management, quantitative spatial data modelling using open source software and programming tools, and mixed-methods/qualitative GIS.

Lucy Clarke is a Senior Lecturer in Physical Geography specialising in fluvial geomorphology and GIS. Her research interests include understanding the hydrological and geomorphological impact of NFM interventions, exploring the role of community engagement with flooding, the use of photogrammetry and image analysis to investigate landscape change.

## References


Berry, R., Higgs, G., 2012. Gauging levels of public acceptance of the use of visualisation tools in promoting public participation; a case study of wind farm planning in South Wales, UK. Journal of Environmental Planning and Management 55, 229–251. https://doi.org/10.1080/09640568.2011.591925

Clarke, L., Short, C., Berry, R., 2016. Isbourne Catchment Project: Scoping Study (Final Report), Report to Isbourne Catchment Partnership & Environment Agency. University of Gloucestershire, Cheltenham.

Cook, B., Forrester, J., Bracken, L., Spray, C., Oughton, E., 2016. Competing paradigms of flood management in the Scottish/English borderlands. Disaster Prev and Management 25, 314–328. https://doi.org/10.1108/DPM-01-2016-0010

Environment Agency, 2014. Delivering benefits through evidence, Working with natural processes to reduce flood risk. Environment Agency.

Gill, L., Lange, E., 2015. Getting virtual 3D landscapes out of the lab. Computers, Environment and Urban Systems 54, 356–362. https://doi.org/10.1016/j.compenvurbsys.2015.09.012

Harwood, A.R., Lovett, A.A., Turner, J.A., 2015. Customising virtual globe tours to enhance community awareness of local landscape benefits. Landscape and Urban Planning, Special Issue: Critical Approaches to Landscape Visualization 142, 106–119. https://doi.org/10.1016/j.landurbplan.2015.08.008

Lovett, A., Appleton, K., Warren-Kretzschmar, B., Von Haaren, C., 2015. Using 3D visualization methods in landscape planning: An evaluation of options and practical issues. Landscape and Urban Planning, Special Issue: Critical Approaches to Landscape Visualization 142, 85–94. https://doi.org/10.1016/j.landurbplan.2015.02.021

Pitt, M., 2008. Review: Stakeholder participation for environmental management: A literature review.

Ramsbottom, D., Sayers, P., Panzeri, M., 2012. CCRA Risk Assessment for the Floods and Coastal Erosion Sector: UK 2012 Climate Change Risk Assessment. Defra, London.

Rouillard, J.J., Ball, T., Heal, K.V., Reeves, A.D., 2015. Policy implementation of catchment-scale flood risk management: Learning from Scotland and England. Environmental Science & Policy 50, 155–165. https://doi.org/10.1016/j.envsci.2015.02.009

Schroth, O., Pond, E., Campbell, C., Cizek, P., Bohus, S., Sheppard, S.R.J., 2011. Tool or Toy? Virtual Globes in Landscape Planning. Future Internet 3, 204–227. https://doi.org/10.3390/fi3040204

SEPA, 2015. Natural Flood Management Handbook. Scottish Environmental Protection Agency.

Sheppard, S.R.J., Cizek, P., 2009. The ethics of Google Earth: crossing thresholds from spatial data to landscape visualisation. J. Environ. Manage. 90, 2102–2117. https://doi.org/10.1016/j.jenvman.2007.09.012

Wentworth, J., 2011. POSTNOTE 396 December 2011 Natural Flood Management. The Parliamentary Office of Science and Technology, London.

Wilkinson, M.E., Quinn, P.F., Barber, N.J., Jonczyk, J., 2014. A framework for managing runoff and pollution in the rural landscape using a Catchment Systems Engineering approach. Science of The Total Environment 468–469, 1245–1254. https://doi.org/10.1016/j.scitotenv.2013.07.055

Wissen, U., Schroth, O., Lange, E., Schmid, W.A., 2008. Approaches to integrating indicators into 3D landscape visualisations and their benefits for participative planning situations. Journal of Environmental Management, Our Shared Landscape: Design, Planning and Management of Multifunctional Landscapes 89, 184–196. https://doi.org/10.1016/j.jenvman.2007.01.062