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The Wetland Explorer: A digital tool for improved community engagement with water quality modelling for decision-making

Catharina Landström [a,*], Helge Peters [b], Andrew G. Hughes [c], Christopher R. Jackson [c], Andrew A. McKenzie [c], Liam Spencer [c], Rebecca Turnpenney [d], John Bryden [d]

[a] Division of Science, Technology and Society, Department of Technology Management and Economics, Chalmers University of Technology, Gothenburg 412 96, Sweden
[b] School of Geography and the Environment, University of Oxford, South Parks Road, Oxford, United Kingdom
[c] British Geological Survey, Keyworth, Nottingham, United Kingdom
[d] Thames21, The City of London, Guildhall, Aldermanbury Street, London, United Kingdom

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ABSTRACT

Participatory modelling is a way to include local people's knowledge in environmental computer modelling. It has primarily been analysed as a process enhancing scientific understanding and public understanding of science, rarely for generating decision-supporting knowledge in environmental management. This article presents a co-design project creating a digital interface that makes it possible for local communities to deploy the outputs of participatory environmental modelling after the conclusion of the research activity. The empirical context is water management in a location in north London in the UK, a country with an advanced system for community involvement with surface water governance. However, research shows that scientific and technical expertise continue to dominate decision-making, even within organisations designed to include local communities. Hence, the objective of the project was to create a digital tool that would enable community groups to engage with outputs from participatory scientific modelling in the context of water management. A co-design project, in collaboration with the local environmental charity Thames21, focused on making outputs from a previous participatory modelling project comprehensible and open to probing by community groups. The project created the interactive Wetland Explorer tool, a web-based interface for visualisation of modelling results. The Wetland Explorer demonstrates the potential of digital tools for public engagement with scientific models. User feedback from a trial with the tool also points to future research needs. This account of the creation of the Wetland Explorer contributes to the advancement of public engagement with water science in the context of environmental management.

1. Introduction

Public participation in environmental decision-making is a democratic principle enshrined in the Aarhus Declaration and adopted in both national and transnational policies (Fritsch, 2019). The EU Water Framework Directive (WFD) ratified by EU countries in 2000 incorporated the idea of public involvement. The implementation of this ambition differs according to national politics, environmental issues and civil society traditions (Euler and Heldt, 2018). The variation testifies to the importance of national culture for the organisations created to include publics in European water governance over the last two decades. In some countries participation takes the form of polls, inviting individual residents in a geographic area affected by environmental decision-making to vote on issues. In other countries, civil society organisations are invited to comment on proposed environmental interventions. In addition to such 'invited' participation, publics make themselves heard by decision-makers through 'uninvited participation', for example direct action, lobbying or public campaigns (Wynne, 2007). Although the democratic effectiveness and the environmental outcomes of public participation in water governance has been questioned (Rimmert et al., 2020), European publics today are more aware of their right to be involved, and decision makers are more open to public involvement than 25 years ago.

The UK, although no longer a member of the EU, is recognised as a frontrunner with regard to actively involving local publics in water governance. The Catchment Based Approach (CaBA) mandates that civil

* Corresponding author.
E-mail address: catharina.landstrom@chalmers.se (C. Landström).

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society organisations partake in local Catchment Partnerships (CP) in collaboration with more traditional stakeholders such as water utility companies and local authorities (Collins et al., 2020; Rollason et al., 2018). Despite challenges, CaBA has been in place for over a decade and provides an organisational structure that gives substance to abstract ideals of public engagement with water governance.

Any ideas emerging from public participation are measured against scientific knowledge, regardless of the format of the public's involvement or the environmental challenges addressed (Dendler and Böl, 2021). In decision-making related to the water environment scientific knowledge, and the expertise used to translate it into local strategies, are commonly based on computer simulation modelling that involves both scientific and computing skills (Whatmore and Landström, 2011). That all ideas, suggestions and demands are assessed against a baseline in scientific computer modelling disadvantages civil society organisations and community groups who do not have equal access to scientific expertise compared to institutional and corporate stakeholders. As a result, barriers to public participation remain within the organisations intended to promote it, such as CaBA. The epistemic authority of science-based computer modelling in water management prevails in the CPs of the UK.

The uneven access to scientific knowledge and tools has been addressed by, among other things, participatory modelling. A wide range of such projects in different countries have engaged publics in co-production of model-based knowledge about local water problems, for example flood risk (Maskrey et al., 2022). Participatory modelling projects commonly focus on integrating local, experience-based knowledge with scientific knowledge in the modelling process (Hare, 2011). Such transdisciplinary research projects aiming to integrate local knowledge with scientific data and analysis are often scientifically successful. In the UK, participatory modelling projects have co-produced knowledge addressing important local water problems (Lane et al., 2011). Still, the impact of participatory modelling on water decision making remains limited. There are several reasons for this lack of impact, importantly participatory modelling projects primarily focus on integrating local knowledge in the modelling process. Discussions abound about the mutual learning of scientists, stakeholders and publics, as well as of the incorporation of experience-based knowledge in modelling scenarios (Evers et al., 2016; Hedelin et al., 2017, 2021). In contrast there is little analysis regarding the fate of the modelling outputs generated in participatory projects.

The focus of this paper is the intelligibility and usability of modelling outputs by engaged publics without formal training in scientific modelling. Participatory modelling results in outputs of the same format as scientific modelling. When a participatory modelling project ends, the project team dissolves, and as a result no one is left to transfer the outcomes into the decision-making process. The scientists move on to the next research project and the local participants are often not able to use the scientific outputs. That community representatives participating in scientific modelling projects cannot utilise the model outputs in other contexts, such as local planning is problematic for at least two reasons. Firstly, it implies that the epistemic disadvantage of lay people in water management remains despite in-depth engagement with scientific research. Secondly, it shows that participatory projects are subject to the same challenge of uptake in decision making as scientific projects which have spent time and resources on developing models that are only used once (Horton et al., 2021).

The project analysed in this article was motivated by the notion that in the UK the community groups in the CPs should be able to use the knowledge co-produced in participatory modelling that had addressed questions of concern to local people. The opportunity to pursue this idea was provided by a research project that had connection of local communities with other actors in integrated urban water management as an important objective.[1] This project resumed collaboration with an environmental charity specialising in water challenges in urban environments that had previously participated in a community modelling project. The aim of the new project was to co-create a digital interface that would allow participants without formal training in scientific modelling to engage with modelling outputs. In the following this project is outlined and unanticipated obstacles highlighted. We explain how challenges were addressed and introduce the result – a web interface called the Wetland Explorer. The ambition is to share insights and provide inspiration that can contribute to making participatory modelling more useful for lay participants and have more impact on collaborative environmental governance.

In what follows we first give an overview of participatory modelling and co-design, and then we outline the governance context for the project. This is followed by a presentation of the project and detailed accounts of the co-design process. Finally, we discuss the lessons learned and draw attention to surprises pointing to issues deserving further research.

2. Participatory modelling and co-design

Participatory modelling and co-design are two distinct forms of transdisciplinary collaboration involving scientists, experts and affected publics. While participatory modelling has become widely used in environmental science co-design is more common in environmental engineering.

2.1. Participatory modelling for new knowledge

Participatory modelling invites members of the public to contribute to the generation of scientific knowledge through modelling. Participatory modelling has been used in water science since the 2000s (Voinov and Bousquet, 2010). There is ample evidence of successful projects that have contributed significantly to scientific knowledge (Lane et al., 2011). However, participatory modelling has not been widely adopted in water management.

In water management, modelling is primarily done with proprietary software packages that have been benchmarked and quality tested with regard to technical function and calculations, for example Flood Modeller (2025) and TUFLOW (2025). Such software packages are designed for application of scientific knowledge about water processes in general to water management problems, specific to a location (Landström, 2023; Whatmore and Landström, 2011). In contrast, scientific models are constructed to address scientifically interesting research questions, and although some scientific models are later used by many researchers in

[1] The CAMELLIA (Community Water Management for a Liveable London) programme funded by the Natural Environment Research Council brought together engineering, urban planning, and socio-economic experts with governmental and planning authorities, industry, developers and citizens to understand perceptions of the water system and its challenges. The programme's innovative approach aimed to build deeper engagement to facilitate integrated water management by developing novel methods and visualisation tools that help people see how London's water cycle fits together, how it affects them and how they, in turn, affect it (https://www.camelliawater.org/programme).

different projects, most are still only used in one project, by the scientists creating them as noted already in the late 1990s (Wurbs, 1998). There are several reasons for this, such as the need to develop a model into user-friendly software to make it possible for others than the creators to use it. Scientists developing models rarely have the resources available to turn their scientific code into user-friendly tools. Also, scientists are primarily interested in answering scientific question, not in developing new digital tools. Although both water science and water management rely on computer models to generate knowledge the models used in the respective fields are different (Landström, 2023).

Participatory modelling projects may use existing scientific models, build on existing scientific models or develop entirely new code to fit their purposes (Jensen, 2020). Voinov et al. (2018) note that many different modelling approaches can be deployed in participatory modelling, the determinant for success is the social interaction between scientific modellers and lay participants. This is not surprising as participatory modelling projects are commonly undertaken with the ambition of finding a process that facilitates integration of scientific knowledge and experience-based knowledge. The modelling outputs of participatory modelling have the same format as scientific research using the same model although the questions addressed may be different.

Arguably participatory modelling differs little from other scientific modelling projects in their relative lack of impact, as results end up in scientific journals and reports that remain largely unread (McLellan, 2021). The limited uptake of participatory modelling outputs in water management often disappoints the participating publics who hoped that the knowledge generated would be used as evidence in decision making (Howard and Irani, 2019). Discussions about how participatory modelling could become more relevant for environmental management have focussed on the scientific quality of the modelling outputs. While this could possibly make it easier to justify the use of participatory modelling in decision-making the fate of scientific models without participatory features indicates that there could be significant challenges trying to increase uptake in this way. Another possibility is to make it possible for the lay participants in modelling projects to engage with and utilise the model outputs generated more extensively. This requires follow-on activities after the conclusion of a participatory modelling project.

2.2. Co-design of usable tools

Participatory modelling can be understood as collaborative research, which means scientists working together with lay people, who have experience-based knowledge of a problem, with the purpose of creating new knowledge. To make this new knowledge usable in the sense of turning knowledge into community capacity, a more design focussed process is needed. While design can involve extensive research, design departs from knowledge-making as a goal in itself because it is a knowledge practice that aims at, in a classic definition, "changing existing situations into preferred ones" (Simon, 1996: 111). Co-design is commonly used in urban design and environmental engineering and involves collaboration with local communities with the aim to create new objects or systems that can benefit the environment and the community, for example urban green spaces (Bell et al., 2024). The notion of co-design indicates concrete outcomes intended for local use after the end of the co-designed project. Co-design offers a conceptual approach to discuss how participatory modelling can be developed to enable further use of outputs by lay participants after completion of the scientific project.

The co-design of digital tools can also draw inspiration from the multitude of visualisations that have made public communication of scientific knowledge and data more feasible (Allen, 2018; Li and Molder, 2021; Riggs et al., 2022). Viewing the outcomes of participatory modelling as information that is to be presented in a way that is comprehensible to people without scientific modelling expertise, there are many examples to learn from such as maps contextualising the processes captured in the data sets. Visualisations can be static, showing the state of the environment in the mapped area at a particular time or dynamic, illustrating change. Story-maps add written narratives and photographs to place the environmental data in historical and cultural context (Pons Izquierdo, 2023). Dynamic visualisations allow the viewer to manipulate the display of data to explore the processes of interest to them.

It may be tempting to assume that the model visualisations created in participatory modelling would be usable by the participants. However, Phipps and Rowe (2010) explain that scientific visualisations are difficult for non-scientists to understand. Allen (2018) highlights the complexity of communicating scientific data in a study with focus groups. He argues that "visual brokerage", involving experts in other areas than the science, and considering the social context of the knowledge presented is crucial.

There is general agreement among science and environmental communication experts that, challenging as it may be, making environmental science outputs comprehensible to non-scientific audiences remains important. Stephens et al. (2017) emphasise the value of effective visual communication of scientific knowledge for the use of scientific information in planning and decision-making. To allow the public to engage with environmental governance and management effectively it is necessary to provide tools that enable non-scientists to understand the scientific knowledge claims about processes and places that matter to them. To become intelligible to non-scientists visualisations must be designed with the knowledge and understanding of the user as a starting point. This makes co-design an approach that can inform the creation of effective visualisation tools.

The project detailed in the following was motivated by an ambition to increase the capacity of community groups to engage with scientific and participatory modelling of water quality in urban rivers and the potential effects of constructed wetlands (Selin et al., 2017). The point of departure was a participatory modelling project in which scientists had collaborated with a local environmental organisation to model the impact of constructed wetlands in north London (see below). After the completion of the participatory modelling project, we realised that the local organisation could not use the modelling outputs since the involvement of the scientists who explained the numbers and graphs had ended. This alerted us to the wider issue of unequal access to scientific knowledge in co-governance arrangements and the limited ability of non-scientists to use open environmental data and modelling. Hence, we embarked on the co-design of a digital tool that could display the outputs from the participatory modelling in a way that would be comprehensible to those involved with the project and that could be used locally for communicating modelling results in discussions about the construction of new wetlands in the locality. In addition to the wider questions about useful participatory modelling, this project also connects to practical issues about the ability of community organisations to use scientific knowledge when they get involved in collaborative governance and management systems, such as the UK CaBA.

3. Participatory modelling and community use of model outputs in the CaBA governance context

Water management in the UK is as in many other countries complex and dispersed across a wide range of actors with different purposes and mandates (Pahl-Wostl et al., 2020). The Catchment Based Approach (CaBA) was launched in 2015 as a mechanism to bring diverse stakeholders together in Catchment Partnerships (CP) responsible for long term planning in a hydrologically coherent geographical unit (Collins et al., 2020). The CPs comprise public agencies, such as the Environment Agency, private water utility companies, local authorities and community groups. CaBA mandates that the CPs have a civil society organisation acting as the catchment host, which guarantees the involvement of organisations representing local communities.

Although the CaBA is more heterogenous, local and inclusive than previous governance regimes, scientific knowledge and expertise is still critical for decision making and long-term planning. While it is obvious that decisions must be made based on sound scientific understanding of environmental processes the role of science could disadvantage the civil society representatives in the CPs. Water utility companies, government agencies and local authorities have access to in-house scientific modelling expertise as well as the resources to commission technical consultants. In contrast, community organisations can only hope that some of their volunteers possess the required skills to engage with relevant scientific knowledge.

CaBA and the CPs have been subjects of academic studies in many fields and there are in-depth social science analyses of the framework (e.g., Waylen et al., 2023). These studies agree on the uniqueness of the CaBA model for governance of environmental water by involving civil society organisations in the core structure. Although encountering many challenges, the CaBA CPs are still firmly in place after more than a decade, and they are in many ways successful in bringing heterogenous actors together for the benefit of surface water environments (Foster, 2021). There are around 100 CPs in England (Collins et al., 2020) and of the 28 CPs in the River Thames catchment 10 are hosted by Thames21, a London-wide civil society organisation.

Thames21 (T21) is a registered charity with the mission "to improve the quality of life of people in the community by enhancing waterway environments" (Thames21, 2025). In 2023 T21 had 35 staff (many on time-limited contracts) who engage residents in different locations around London in a wide variety of activities to bring them closer to the water in a literal as well as a metaphorical sense. T21 arranges local activities ranging from litter picking and river restoration in London rivers, to activities for school children, to citizen science monitoring of water quality. T21 also produce an extensive range of information materials for the wider public.

T21 chairs the River Partnerships in London (RiPL) a collaboration bringing together the CPs in the Greater London area (Thames21, 2025a). Many of the London CPs feature three partners with city wide presence – Thames Water, the Environment Agency and T21. Thames Water (TW) is one of the largest water utility companies in Europe, it provides more than 10 million users with water and sewage services (Bayliss, 2019). The operation of TW is regulated by the UK Government body Ofwat, which is tasked with controlling the cost of water to consumers. The Environment Agency (EA) has a dual role as both expert adviser and regulator (Environment Agency, 2025). It is a public agency under the auspices of the Government Department for the Environment, Food and Rural Affairs (Defra).

The CPs draw extensively on scientific knowledge. As mentioned above, the larger corporate and institutional collaborators in the CPs acquire scientific knowledge and expertise through in-house teams, by commissioning consultants and collaborating with university researchers. In contrast the community stakeholders involved do not have reliable access to relevant scientific knowledge. Participatory modelling has the potential to reduce this imbalance by providing community groups with a more equitable access to scientific knowledge and expertise to collaboratively investigate matters of concern to them.

A participatory modelling project with T21 in 2017 in which the scientists used the INCA model (Whitehead et al., 1998) provided scientific analysis of the potential of constructed wetlands to improve water quality in north London rivers (Thames21, no date). This project strengthened the knowledge base for the collaboration of T21 and the local government body, the Borough of Enfield, on constructing wetlands in the area and evolved into a new strategy for community modelling that aims to empower communities to protect their local rivers. However, community modelling in this sense is hampered by the complexity of scientific models and requires the involvement of a scientific modelling expert (Landström et al., 2019). To increase the usability of participatory modelling outputs a new project with academic researchers and T21 was initiated with the ambition to make computer model outputs more accessible to interested lay people with local knowledge. The new project drew inspiration from the co-design field as it envisioned a new digital interface for the model outputs generated through participatory modelling (Bell et al., 2024).

4. Creating a tool to make modelling results intelligible

A key methodological premise for the co-design of a digital interface in the project was that the intended audience were familiar with the locality, the water environment, the water quality issues and the management processes. In contrast to research that aims to recruit participants representing the general public, the project was informed by principles insisting that those affected by a problem should participate in research (Whatmore, 2009). Another premise was that the digital interface was intended for use in group settings and a prompt for the discussion of ideas that the participants could explore together. The benefit of collective engagement with science is discussed by Roth and Lee (2002) in relation to citizen scientists learning about the research they participated in. These two premises guided the choice of what information to include in the web interface. For example, there could be references to shared knowledge of local issues that were independent of the scientific modelling. One such topic was wetland construction; T21 and the local borough council had investigated wetlands as a measure to improve urban environments (Stefanakis, 2019). There was a detailed guidance document about wetland construction on the borough council website and T21 had worked extensively with wetlands and was very knowledgeable regarding funding possibilities and on engaging local people with the construction process. This context was crucial for understanding the choice to model wetland impacts on water quality in rivers in north London in the first place. To those involved with these activities it made sense but to people elsewhere it would not be an obvious choice to model the impacts of constructed wetlands on the rivers in question.

That the digital tool was intended for use in groups was, on the one hand, informed by research showing the value of collective activities for public engagement with science (Selin et al., 2017). On the other hand, creating a tool for use by groups expressed the idea that civil society organisations would take responsibility for such tools. Digital tools require maintenance, and somebody must take responsibility for their upkeep. Initially it was thought that T21 could take ownership of the digital tool after the completion of the project if it was considered useful for explaining the importance of urban wetlands to the wider local community. This turned out to be a misunderstanding of the cost of software maintenance beyond the context of scientific research projects. It became clear that such maintenance demands more in terms of software expertise and funding than an environmental charity has the capacity for, requiring established systems to be in place that guaranteed longevity and reliability of operation.

4.1. Co-designing a digital interface

Bringing together social scientist, natural scientists and T21 staff who worked in the concerned area of London the co-design project started with an update of the participatory modelling results from 2017 adding new data and information about wetlands that had been constructed. The natural scientists set up the model using knowledge and ideas supplied by T21 and the water management experts in the local council. The INCA model was calibrated and run with different scenarios representing different options for future wetland construction and both historical and projected future climate. The modelling update finished with the publication of an article in a scientific journal (Bussi et al., 2022).

The next step was to involve visualisation and software experts in discussions with the project team (composed of academics from different fields in natural science, social science and computing) to clarify what the digital tool needed to do. The software development team consisted of two professionals from one of the partner organisations, [removed for anonymization]. The software was written in the Shiny[2] package of the R scripting language and it took approximately 20 days to complete an initial prototype. These specialists worked in conjunction with other parts of the BGS to ensure that the web interface could be delivered reliably over the internet. In this process it became clear that the graphical user interface (GUI) of the scientific INCA model had two aspects, one for inputting data and one for visualising the results from the different model runs. The model user was to input data and set the parameters to initiate model runs, actions that require a level of scientific knowledge and modelling experience. The previous participatory modelling with INCA had showed that this is not something that a lay user could do and get a reliable model output.

This insight amounts to the first transformation of the scientific model into a tool enabling lay people to engage with models. We could clearly see that the setting up aspect of the model used in the participatory project was not conducive to manipulation by non-experts. Discussions within the academic project team clarified the difference between using the model to analyse water quality dynamics in the catchment of interest and using the visual interface to engage with modelling results. The former can be understood as scientific representation of the physical environment and the latter as public engagement with science. It would be unrealistic to think that the intended lay user would input data or set parameters of the model because doing that requires expert knowledge about water quality. Hence, a decision was made to separate running the model from displaying outputs and the interface would focus on the latter. The focus of the new interface would be to visualise the results of previous model runs in ways that made sense to lay persons with experiential knowledge of the modelled water environment. The entire project team met to discuss what would make the model exercise "useful". The team discussed constructing scenarios that demonstrated the effects of interventions, to demonstrate the impacts of wetlands. Further discussions in the academic project team gave initial guidance to the software experts to include a map and a diagram to display data in different ways depending on what the user requested via a control panel.

When the software experts had created an initial GUI prototype that visualised the flows and levels of pollutants in the rivers for the different scenarios as a map and as a graph showing variations in time, the research team organised an online workshop[3] with T21 and a few invited guests from other environmental organisations, to gauge first impressions. Fig. 1 shows the first prototype and Fig. 2 the final version of the interface and in the following we detail how the three main visual components evolved in the co-design process.

In the first collaborative workshop the interface prototype sparked many questions and comments among the intended users. Overall, the reception was positive, the three components – controls, map and graph were found to convey the relevant information. However, it was found that each of the components required further work to become useable by non-scientists.

The interaction in the workshop demonstrated the meeting of three areas of expertise – scientific modelling, software design, local water environment and community engagement with it. The initial design of the interface was inspired by input from these three domains which made it possible for the participants to make their expertise understandable to each other. This facilitated explication of the interpretation of the visualisations and discussion of how they could be improved. In subsequent workshops the interface was revised with regard to all three components, in ways that responded to questions raised.

This workshop marked the shift from participatory modelling to co-design in the construction of the model interface. Assuming the place of model users, experts on local environmental stewardship "stood in" for community members, contributing design requirements that they considered would improve community members' ability to use the model in a participatory setting. Responding to the prototype, the T21 experts co-created the model interface by engaging in a shared exploratory enquiry with modellers and software designers that imagined possible scenarios of use and linked those to future design requirements (Engholm, 2020). Linking the improvement of the intelligibility of the model interface to the purposeful uses of community participants that the model would eventually equip, the modelling team moved from describing a catchment scientifically towards co-designing a tool for improving the local water environment.

4.2. *An iterative process of revisions*

Fig. 2 shows the finished Wetland Explorer that was created in an iterative process of trials, discussions and revisions. The three main components of the interface, the controls, the map and the graph were revised several times.

The controls sparked questions about the wetland and climate scenarios that the interface user could select and combine and about the variables displayed in the first version – river flow and the concentration of nitrate, phosphorus, and ammonium, and amount of sediment in the water. It was not obvious how the values of these substances impacted on water quality which is a compound feature and lived experience. It became clear that more information about all the components was needed and a tab with background information was added. We also realised that the visualisation of the sediment value did not provide much benefit. The numbers displayed had no physical reference, and as a result the decision was made to remove sediment value from the interface. This shows that models are not nec transparent to scientists who are not familiar with them.

Questions about the map disp included whether the clickable dots for showing data represented actual positions in the physical environment and if they could be named. This was an important issue that demonstrated the distance between the model and the environmental processes. We are used to the elements of a map signifying observable features of a landscape. This was not the case here, the model elements made into clickable dots on the map in the interface were theoretical constructs (related to how the model structure divides the overall catchment). The clickable dots on the map originate in analysis of surface water movement across a landscape simulation based on scientific data sets, not on observable environmental features. That environmental models are not necessarily isomorphic representations of observable processes is a fact that tends to get lost in everyday practices involving the use of scientific models. When a model has been established as trustworthy in a practice, through testing and benchmarking, it is very common for people using it regularly to refer to it as if it was an indexical representation of the physical system. This was something that the academic team wanted to prevent occurring with the interface; hence a suggestion to name the dots using official or colloquial place names in the section of the map that was modelled was rejected. To emphasise the constructed-ness of the model an explanation of how it was set up to simulate the water system in the locality was added on a tab in the info section of the interface. The interface was intended for use in groups led by a person who had been trained to use it by the T21 staff involved in the co-design process and providing written information for the trained user to prepare with was considered useful.

A third component in the interface also required substantial revision. In the first version the graph opened with an overview of the entire nine-year time-series of data that had been modelled which was something that the scientists took for granted that everybody wanted. A scientific analysis starts with overviewing the data available and, if necessary, complementing it with more data. This did not make sense to the local experts. They wanted a display of data that would make sense in terms of experience, such as a year or 18 months, which would let the user relate

[2] pkgs.rstudio.com/shiny/

[3] Covid restrictions were in force, preventing an in-person meeting at this time.

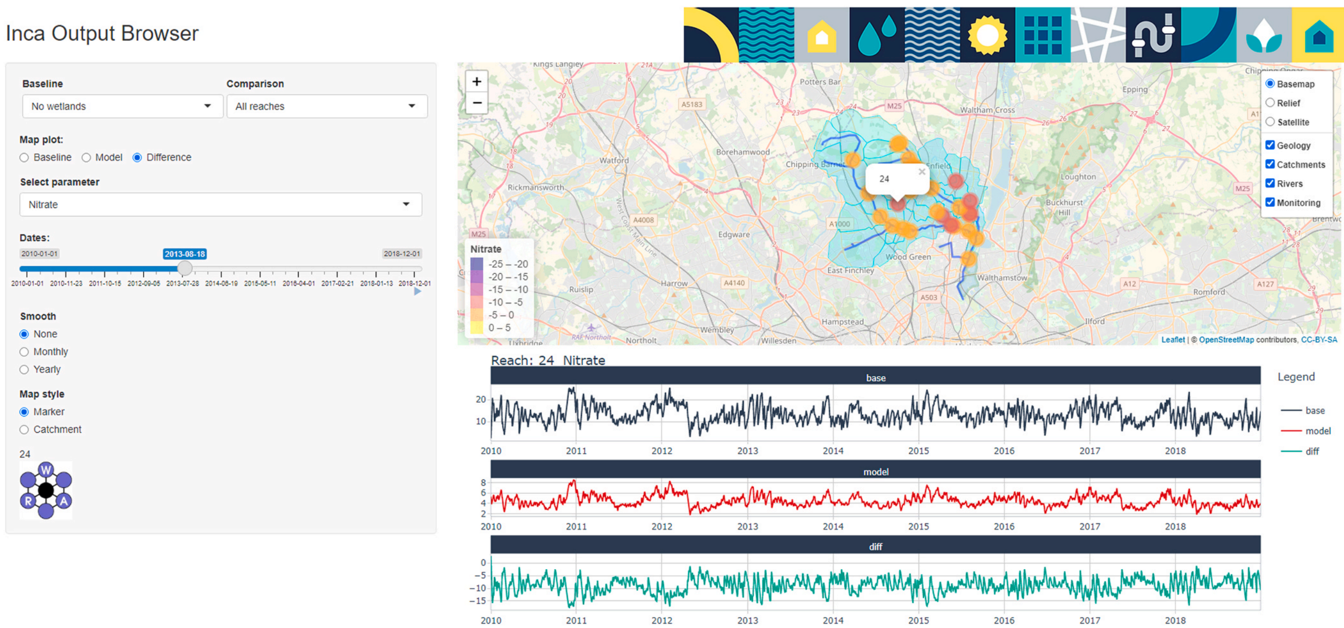

Fig. 1. Screenshot of the first interface prototype. On the left-hand side are controls allowing the user to select a baseline and a comparison scenario. The map can be manipulated to show baseline values, model values or the difference between the two for the parameter selected. The user can also select the timeline and display of the graph displayed beneath the map.

Fig. 2. © 2025 CAMELLIA. The Wetland Explorer web interface. The controls through which the user manipulates the display of information (scenarios and parameters) are on the left-hand side. The map with clickable dots representing the sub-catchments is on top right. Below that is the graph that display time series with an arrow indicating the physical meaning of the values displayed to the immediate left there are also options for the graph to show statistics or profile for the selected sub-catchment. The actual Wetland Explorer, with interactive features and animations can be accessed at: Removed for anonymization.

the curve to seasons. Another revision required related to the fact that there was no indication of whether the values plotted in the graph were problematic or not. The T21 participants insisted that visual indicators must be added to communicate what consequences for the water quality in the rivers different numerical values implied. A numerical value does not as such communicate if there is a problem with water quality to a person without scientific knowledge. For non-scientists to be able to use the interface to see what difference the constructed wetlands could make it was necessary to have something that showed if a change is for the better or worse to understand how much a positive change a particular wetland scenario indicated. This is an issue that brings attention to the potential problem of making the science look too easy and unambiguous (Scharrer et al., 2017). The scientists in the project were very cautious about making it appear as if the amount of one particular substance in the water would translate into a negative impact on water quality in the river since there are many complex interactions of elements in play. To clarify the relationship between water quality indictors and the health of a river arrows were added to the graphs to show whether an increase or decrease in the value were good or bad.

The interface went through several iterations of workshops followed by revisions and was finally comprehensible to the non-scientists (including the social scientists). After a training session to familiarise themselves with the controls and the behaviour of the interface, which we together had named the Wetland Explorer, the T21 staff were ready to try it out with a small group of local people who were interested in the participatory modelling and the tool.

4.3. The Wetland Explorer meets a local public

When the T21 staff were confident that they could use the Wetland Explorer we asked them to organise a trial session with local volunteers. Some of the volunteers had partaken in the first participatory modelling project in 2017. There were also participants who were involved with a local group working with the Pymmes Brook, one of the modelled rivers. This group had been engaged with previous community modelling led by T21. Other participants joined the trial workshop because they were interested in science and modelling, particularly in relation to local water issues.

Overall, the trial went very well; the experienced T21 users confidently took the lead and explained what it was possible to do with the Wetland Explorer, how to use the controls and how to interpret the results. The participating local volunteers said that they found the interface useful and expressed interest in continuing to probe it on their own after the introduction provided. Everybody agreed that the interface would be valuable for explaining the argument for constructing wetlands to the wider community. In this regard the interface achieved the objectives of the research team, however, the discussion of what the tool could be used for also took us in an unanticipated direction.

As mentioned, some of the participating volunteers had been involved with the original participatory modelling project in which the scientific model was set up to process data from the local rivers a few years before. The updated modelling data displayed in the Wetland Explorer were not enough to satisfy their interest but led them to ask about how the modelling knowledge it conveyed could be used in practice. Could the modelling indicate where a new wetland should be placed to get the best effect? Could it indicate which type of wetland would have the best effect in a particular place? These questions surprised the academic team who acknowledged that they were highly relevant but beyond the ability of the interface to address because it visualised modelling results from a pre-defined set of scenarios. In-depth reflection on this turn of questioning brought with it a realisation that the questions also point to new issues in the field of public engagement with environmental science in the context of environmental governance.

At this point in the development of the tool, the project team was interacting with a public that had become very well informed about the issues and the scientific modelling. While they recognised that the Wetland Explorer would be valuable for informing and discussing with people who had little or no previous engagement with water issues, wetlands or scientific modelling they also wanted more. They wanted the scientific models to answer questions that would allow them to convince decision makers and potential funding agencies of the value of implementing their specific desired water management measures in the local area by pointing to model more detailed predictions of the expected effects.

5. Discussion: science for engaged publics?

Discussions about the usefulness of science or the actionability of scientific knowledge commonly focus on the relationship between university science and government policy. From the perspective of scientists and science funding agencies the objective has been to increase the uptake of knowledge and tools generated by the environmental sciences among policy makers (Holmes and Clark, 2008). This has prompted a multitude of events premised on the idea that face-to-face interaction of scientists and people in stakeholder institutions would promote knowledge transfer from science to policy, often with the involvement of expert agencies. There are also many funding opportunities for knowledge transfer to and from science to businesses with the aim of mutual learning. Some schemes focus on enabling individual scientists or persons in the societal organisation to join a scientific project or an organisation respectively to promote more mutual understanding that will lead to increased use of science and science better fitted to society's needs. Very few activities address the use of environmental science by civil society organisations or grassroots groups.

Civil society organisations are emerging as a distinct category of social actor in relation to public engagement with environmental science and governance, but the understanding of their specificity is still limited (Llorente et al., 2021). There is relevant long-time discussion about the politics of engagement - is the public to be engaged only for scientific products and expertise to increase legitimacy? The democratic qualities of participatory activities have been discussed by social scientists for decades (Chilvers and Kearnes, 2016). So far there has been no consideration of what happens when the public successfully understands, engages with and participates in science, through activities such as participatory modelling.

Our experience of a participating, engaged and knowledgeable public asking for more actionable science points to a new issue. When publics have become engaged with science and understand how it could address some of the questions relevant to them, they want knowledge that helps them reach their goals. This is after all what science aims to do for policy makers, public institutions and businesses, which historically have been able to sponsor or direct research to address their needs (Fuchs et al., 2023). When publics are invited to participate in local water management and governance by civil society organisations and governance structures such as CaBA we must expect them to look to science for tools that they can use to promote their agendas. As noted above, the statutory stakeholders in CPs have in-house scientific expertise, the means to commission consultants and capacity to collaborate with research scientists on projects addressing questions of interest to them, which provides them with actionable scientific knowledge. That organised publics and their local volunteers would want the same when they understand that science can provide knowledge on the relevant scale is only logical. If water management and governance in the CaBA system is to be based on sound science all involved actors must have access to scientific knowledge addressing questions relevant to them. This raises new challenges for science policy and funding agencies.

6. Conclusion

The project co-designing the Wetland Explorer was prompted by a realisation that community groups engaging with scientists in participatory modelling projects could not use the model outputs after the completion of the project when the involvement of the scientists had finished. This was identified as a problem in relation to the ability of local community groups to participate in collaborative water governance. The UK CaBA system secures space for community representatives to participate in governance but the reliance on science-based expertise in the decision-making disadvantages local environmental organisations.

In collaboration with the environmental charity Thames21, a team of social and natural scientists and software experts built on a previous participatory modelling project to create a digital tool that would enable exploration of the model outputs by lay people. The co-design process resulted in the Wetland Explorer which was successfully trialled with T21 staff and volunteers demonstrating the possibility of making scientific models more useful for local communities.

However, engaging with the Wetland Explorer prompted the involved public to ask for more actionable scientific modelling. This request highlights continued inequitable access to scientific research by different actors in co-governance systems despite attempts at including local publics in participatory modelling. It also points towards improving the co-design process in future attempts at making participatory modelling useful to local participants. While modelling is a key aspect in water management and scientific analysis of problems and interventions its value for local volunteer action may be limited. While the T21 experts gave highly valuable advice on the usability of the model interface during the prototype stage, the challenges of the model on the part of community members surfaced too late in the co-design process. Future projects could aim for more extensive involvement with local publics earlier on in the co-design process. This realisation notwithstanding, collaboration between scientific modellers and charities such as T21 remains vital for engaging local publics and enhancing their capacity to use scientific knowledge for affecting the planning decisions that impact local environments. Further research on the relationships between science, publics and decision-making is needed to clarify how scientific research could support new participatory environmental governance more effectively. Such research needs to consider how digital tools intended for use by the public could be supported and maintained after the conclusion of research projects.

CRediT authorship contribution statement

Catharina Landström: Conceptualization, Investigation, Methodology, Supervision, Writing – original draft preparation, Writing – review & editing. **Helge Peters:** Investigation, Methodology, Writing – review & editing. **Andrew G. Hughes:** Investigation, Visualization, Writing – review & editing. **Christopher R. Jackson:** Resources, Visualization, Writing – review & editing. **Andrew A. McKenzie:** Software, Visualization. **Liam Spencer:** Software, Visualization. **Rebecca Turnpenney:** Supervision, Writing – review & editing. **John Bryden:** Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

No data was used for the research described in the article.

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