GC Insights: Lessons from participatory water quality research in the upper Santa River basin, Peru

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Abstract. Here we share four key lessons from an interdisciplinary project (Nuestro Rio) that gathered community perspectives on local water quality in the Rio Santa basin (Peru) utilising a digital technological approach where we collected data via a novel photo elicitation app, supported with a field work campaign. The lessons explored in this article provide insights into challenges and opportunities for researchers considering developing technological tools for encouraging participation and engagement in marginalised communities.

1 Introduction

Water quality, crucial for survival as well as socio-economic and environmental sustainability, is threatened by both natural events and human activities in many regions of the world, and augmented by impacts of climate and land use change (Anderson, 2016; Magnússon et al., 2020; Saleem et al., 2024). Water quality directly impacts the lives of water users (Azevêdo et al., 2022), yet local perspectives, knowledge, and emotions are often not considered (Dextre et al., 2022). Furthermore, water *quality* can be a secondary consideration to water *quantity*, despite being closely intertwined in water insecurity (Clason et al., 2023; Rangecroft et al., 2023). Water quality is a complex, multifaceted issue, which can be judged by indicators such as acidity, clarity, smell, taste, or chemical composition (Flotemersch and Aho, 2021). Some aspects of water quality are visible (e.g. colour, turbidity), whereas others are "hidden" (e.g. heavy metal content) and only detectable by field or laboratory instrumentation and analysis (Flotemersch and Aho, 2021). Whilst water quality variables are commonly measured and monitored through methodologies available in the natural sciences (Saleem et al., 2024), local communities can provide unique information about the state of their ecosystem (Okumah et al., 2020, Richter et al., 2022). Water users not only directly depend

on local water sources, but are also sensitive to changes in water availability, quality, and ecosystems over time, providing insights beyond the temporal and spatial scope of in-situ measurements (Pauly, 1995; Azevêdo et al., 2022). Furthermore, community participation and traditional ecological knowledge can help decision makers to develop feasible solutions and facilitate tailor-made governance that is accepted and implemented by multiple parties (Mistry and Berardi, 2016; Albagli and Iwama 2022, Richter et al., 2022).

In the Nuestro Rio project we developed an app to engage communities and collect local insights on water quality in Peru's Santa River upper basin, addressing the lack of participatory research in the region's water security studies. Our novel data collection tool helped to provide a voice for social perspectives and knowledge within water quality. Here we present the four key lessons from our approach, specifically the advantages and shortcomings of developing and using technology for this purpose. For full details on the methodology and results of the Nuestro Rio project itself, see Rangecroft et al. (2023).

2 Methods

The Santa River is important for water security, both locally and regionally (Baraer et al., 2012; Recharte et al., 2017), but experiences both water quality and availability issues related to glacier retreat and anthropogenic pressures such as pollution, extraction and water governance (Magnússon et al., 2020; Aylas-Quispe et al., 2021). During a short pilot project (2021-2022), we used a multi-method approach to collect local insights on water quality, combining an app for user-uploaded photographs and survey questions, and face-to-face interviews during fieldwork. The Nuestro Rio app was specifically designed to understand local perceptions and identify the drivers of water quality issues. Geolocated photographs of local waters taken by participants were collected through the app, alongside a survey assessing perceptions of water quality and related emotions (see Appendix A). The app was designed in Spanish as the most accessible language for the study region. To aid the launch of the app and to facilitate data collection, in-country researchers also directly communicated with several communities across the upper Santa River basin (Fig. 1). Participants (aged 18+) were invited to engage with the app on tablets (e.g. ownership of smart devices and advanced technological skills were not required), who offered guidance, and translation where needed. Semi-structured interviews were also conducted during field visits with communities using the same questions as the app survey (Appendix A). Quantitative data was analysed using descriptive statistics, and qualitative data coded and analysed using an emergent thematic framework to identify key themes (for more information on the methods and results see Rangecroft et al. (2023)). Throughout this research and community engagement process, key lessons were identified, and are shared here as the focus of this insights paper.

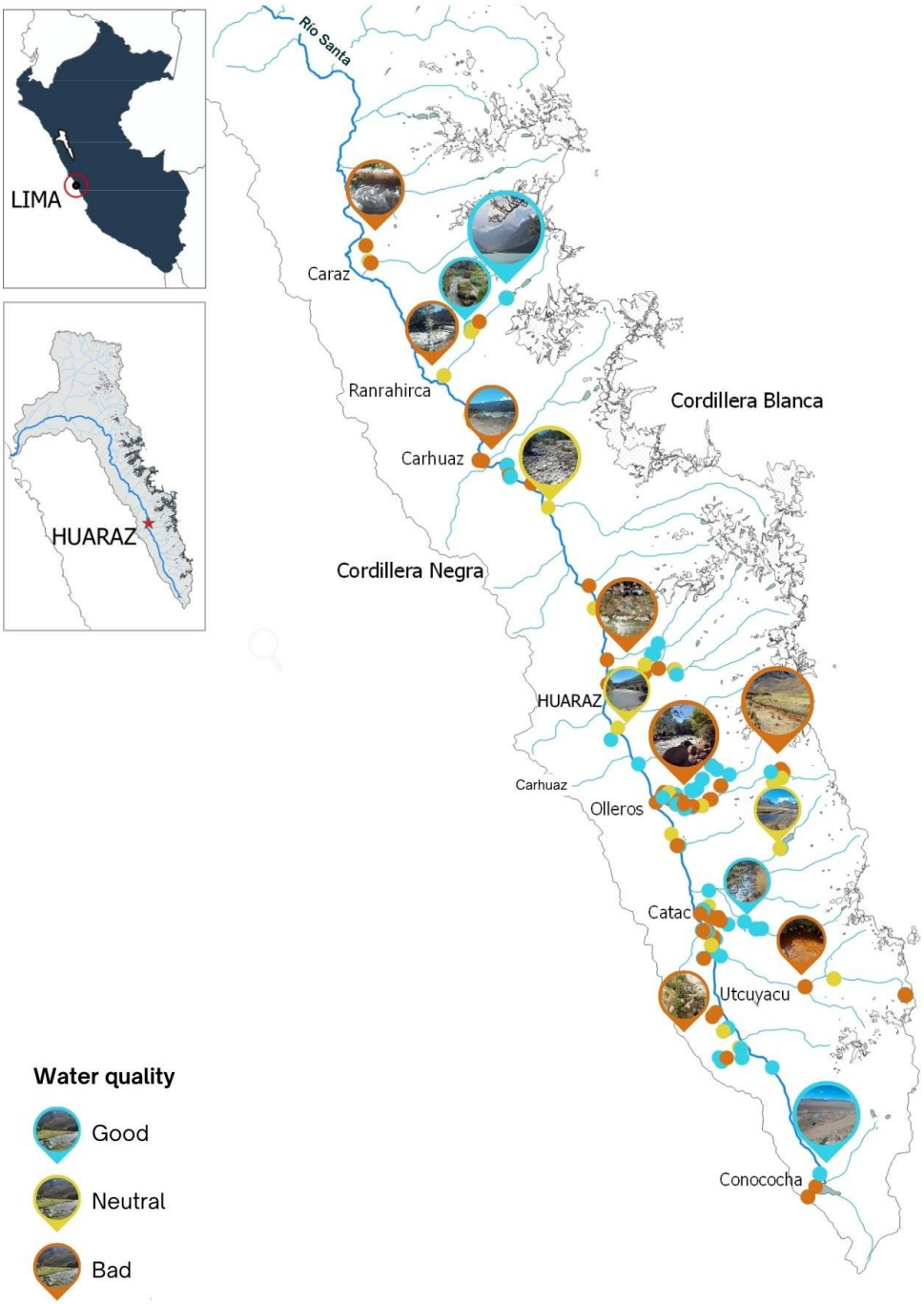

Figure 1: Map of perceived water quality (collected via the Nuestro Rio app) across the study area of the upper Santa River basin, Peru. Point colour represents the participant-rated water quality (good, neutral, bad), and examples of photos from participants are shown. Note that this figure is simplified to illustrate the project concept, and is not a representation of our full, in-depth research findings.

3. Key lessons

3.1 The importance of in-person engagement

Engaging directly with participants during fieldwork proved valuable, outweighing financial and time expenditures. This hands-on approach helped avoid research fatigue by focusing on the quality rather than the quantity of interactions. The majority of the 350 data entries were the result of direct community engagement in the field. Participant engagement is known to be a challenge for citizen science and participatory data collection (Fraisl et al., 2022), which was reflected in the poor participation rate outside of the field activities. Direct in-person interactions can address potential obstacles, whether they relate to limited access to, or familiarity with, smart devices (as discussed in section 3.2) or issues of trust. Although the app's use of Spanish potentially posed a barrier in areas where Quechua is the dominant language, our in-field researchers facilitated communication by translating materials to and from Quechua (Rangecroft et al., 2023). Additionally, in-person interactions enabled us to clarify survey questions and research objectives through informal dialogues (see section 3.4).

3.2 Challenges of digital (in)accessibility

Considering potential barriers such as device availability, technological familiarity, and limited internet access is critical when introducing an app for data collection in a diverse community setting. Originally, we planned in-person training sessions, but due to COVID-19 we had to transition to training videos and online workshops, which may have limited the potential for recruitment outside of community-specific fieldwork. This change highlights the importance of designing technology with the target audience's needs in mind, potentially through co-developing apps with participants (Daum et al., 2019). Such a participatory process however requires extended research project periods, particularly for complex, transdisciplinary projects such as Nuestro Rio. A large portion of the local population of our study area either lack smartphones or are not tech-savvy, an issue intensified by factors of demographics, intersectionality and poor reception. Even in urban areas with better internet service, we observed low uptake, possibly due to inadequate engagement incentivises. Future research could further disentangle motivations for participation in regions where technology is a limitation, as well as regions where it is not a limitation, while deliberate training strategies are also recommended (e.g. online, on-site, handout instructions) (Martin et al., 2021; Fraisl et al., 2022).

3.3 Need for co-produced knowledge and solutions

Sustainable approaches to water management requires understanding how communities perceive and manage their resources, a facet often overlooked in research (Steinwender et al., 2008; Dean et al., 2016; Okumah et al., 2020). Our work indicated a community desire for engagement and openness to co-design of solutions, in addition to a desire to communicate their perceptions to local and regional decision makers. Local communities are often not included in decision making processes around management of water resources in this region (Dextre et al., 2022), yet engaging with communities can be an entry point to inclusive resource management. Furthermore, engaging local people in the decision-making process itself can

empower individuals and communities to influence water governance processes and also strengthen acceptance and support for new resource management policies (Okumah et al., 2020; Albagli and Iwama, 2022). The positive reception to our project, particularly from participants familiar with being overlooked in past research, emphasising the importance of incorporating local expertise continuously throughout the research process for genuine global collaboration and ensuring equitable participation, especially in projects involving North-South dynamics. Furthermore, in project design and delivery it is vital that we return the knowledge generated to the participants who helped build it, however this can be extremely challenging in projects with limited funded time.

3.4 Complexity of "water quality" as an environmental concept

The term "water quality" was variously interpreted by participants, frequently necessitating clarification during fieldwork, particularly in rural settings. This variation might stem from ambiguous communication of research objectives, or different cultural and linguistic understandings of water. For instance, some languages might have specific terms for unique types of water or aspects of water quality that lack direct translations. This nuanced understanding underscores the importance of face-to-face interactions and the potential for qualitative data methods to bridge the comprehension gap between participants and researchers. Whilst a Quechuan-Spanish translator assisted field-based data collection to support use of preferred language, translation was not possible for participants engaging with the app independently. Language and worldview are thus other key considerations, given indigenous perceptions of and emotions related to water, in addition to the importance of water beyond its role as a physical resource (Tipa, 2009; Azevêdo et al., 2022).

4. Recommendations for future participatory environmental research

The lessons learned from this project offer important considerations for design of future community engagement for co-production of knowledge and solutions around environmental issues, especially using digital technological approaches. A shift away from heavy reliance on monitoring and modelling data for environmental assessment, and towards a more holistic approach, covering insights from the natural and the social sciences, is required for equitable and sustainable resource management (Drenkhan et al., 2023). The Nuestro Rio experience highlighted that while digital methods expand reach, in-person interactions are vital for deep engagement. Collaborative design with local partners from the outset ensures sensitivity to local contexts and enhances community buy-in. In many contexts, digital-only approaches cannot encapsulate the deeper understanding obtained through participant-researcher dialogue. It is also essential to consider and address logistical challenges in data collection, including accessibility (geographic, technologically, and linguistic); embedding research and researchers within communities; catering to community needs; and grasping the driving factors behind participation. Effective communication along the community-research-policy-management continuum requires careful consideration of how data are understood and valued. Researchers must also be mindful of the time required to build trust and co-design research effectively (Rangecroft et al., 2021). Finally, there is also an important distinction to be considered here between citizen science and

participatory research for giving participants *agency* in influencing decision-making (Albagli and Iwama 2022; Illingworth, 2023).

Author contribution:

All authors are part of the Nuestro Rio project team, and enabled the research through various contributions. The manuscript was developed from insights discussed in project meetings and conversations related to other project outputs. SR & CC led on manuscript preparation with editing contributions from IR, CK and RMD. RMD prepared the manuscript figure.

Competing interests:

The authors declare that they have no conflict of interest.

Ethical statement:

The research was conducted with ethical approval from the University of Plymouth. Considerations of good ethical practice included gaining informed consent for participation, only including participants aged 18 or over, and ensuring the anonymity of data. Other areas of good ethical practice included the dissemination of results and outputs back to involved communities and participants where possible.

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Appendix A: **Nuestro Rio survey**

[Please note that this is the English translation for Appendix 1; the original questions on the Nuestro Rio app were in Spanish]

START

[Participant to take photo of water]

SECTION 1 – About your photograph

Q1: What is this river or stream called? (Do you have any other names for it?) [open text]

Q2. On a scale of (1) "very bad" to (5) "very good", how would you rate the water quality of the river or stream?

1 Very bad

2 Bad

3 OK (Neutral)

4 Good

5 Very good

Don't know

Q3: Why do you think the water quality of the river or stream is like this? There is no right or wrong answer, we just want to hear your opinion. If you are not sure, please just write "I don't know". [open text]

SECTION 2 – Your photograph

What do you feel when you see the water of the river or stream? For each of the following moods, please record how you feel on a scale of (1) Not at all, to (5) Extremely.

Q4. ANGRY?

1. Not at all

2. A little

3. Neither yes, or no (Neutral)

4. Very

5. Extremely

Don’t know

Q5. AFRAID?

1. Not at all

2. A little

3. Neither yes, or no (Neutral)

4. Very

5. Extremely

Don’t know

Q6. HAPPY?

1. Not at all

2. A little

3. Neither yes, or no (Neutral)

4. Very

5. Extremely

Don’t know

Q7. SAD?

1. Not at all

2. A little

3. Neither yes, or no (Neutral)

4. Very

5. Extremely

Don’t know

Q8. SURPRISED?

1. Not at all

2. A little

3. Neither yes, or no (Neutral)

4. Very

5. Extremely

Don’t know

SECTION 3 – About you

Q9. Where do you live (name of place)? [open text]

Q10. What is your age? [open text]

Q11. Please indicate your gender: [multiple choice]

Male

Female

Choose not to identify

Other

Q12. What is your MAIN occupation – CHOOSE ONE [multiple choice]

Agriculture/livestock

Teaching

Student

Commerce/business

Public administration (Civil servant)

Mining (or related)

Transport

Household work

Other

Other please specify (Optional) [open text]

END