



AUTHORS:

Martin Mickelsson¹
Reuben Thiffulufhelwi²
Paulose Mvulane²
Faye Brownell^{3,4}
Charlene Russell⁵
Heila Lotz-Sisitka²

AFFILIATIONS:

¹Department of Women's and Children's Health, Uppsala University, Uppsala, Sweden

²Environmental Learning Research Centre (ELRC), Rhodes University, Makhanda, South Africa

³Duzi uMngeni Conservation Trust, Pietermaritzburg, South Africa

⁴Amanzi Ethu Nobuntu, Hilton, South Africa

⁵GroundTruth, Howick, South Africa

CORRESPONDENCE TO:

Martin Mickelsson

EMAIL:

martin.mickelsson@uu.se

DATES:

Received: 31 Jan. 2024

Revised: 09 May 2024

Accepted: 25 May 2024

Published: 26 Sep. 2024

HOW TO CITE:

Mickelsson M, Thiffulufhelwi R, Mvulane P, Brownell F, Russell C, Lotz-Sisitka H. Bringing river health into being with citizen science: River commons co-learning and practice. *S Afr J Sci.* 2024;120(9/10), Art. #17795. <https://doi.org/10.17159/sajs.2024/17795>

ARTICLE INCLUDES:

- ☒ Peer review
- ☐ Supplementary material

DATA AVAILABILITY:

- ☐ Open data set
- ☐ All data included
- ☐ On request from author(s)
- ☐ Not available
- ☐ Not applicable

EDITOR:

Floretta Boonzaier

KEYWORDS:

sustainability, citizen science, river commons, co-learning, One Health

FUNDING:

South African Department of Science and Innovation and South African National Research Foundation (128385), Swedish Research Council (2020-04567)



© 2024. The Author(s). Published under a Creative Commons Attribution Licence.

Bringing river health into being with citizen science: River commons co-learning and practice

Human health and well-being are directly and indirectly dependent on the life of river systems. Life in river systems is increasingly dependent on human actions that bring river health into being. Rather than describing river health as thing, problem or management challenge, this paper explores how river health is brought into being, through the citizen science practices of the Amanzi Ethu Nobuntu project in the upper uMngeni catchment in South Africa. The study draws on focal data produced by citizen science practitioners, as interpreted by them in collaboration with partners in the catchment, and their reflections on the meaning(s) of river health and how it came into being. Drawing on the concepts of citizen science as a co-learning process, integrative views of One Health, and commoning as activity, the study offers a rich interpretation on how river health comes into being. The study shows the complex interrelated practices involved, including practices of resolving leaks and pollution challenges, social and community engagement, and the co-learning involved in citizen science practices itself. It offers insight into the social-ecological and ethical-political ontological dynamics of river health commoning activity, thus offering alternatives to reductionist approaches to bringing river health into being, potentially also enriching tools for river health reporting.

Significance:

The significance of the main findings of Sustainability Science Engagement and Engaged Sustainability Sciences includes how citizen science can be key for engaging local communities in sustainability research around sustainability challenges, such as river health, by linking to the health of the people and their everyday engagements with the river. Further contributions include conceptualising sustainability science engagement co-learning processes of being in common around a shared matter of concern, such as bringing river health into being beyond technical specifications. Contributions are also made by highlighting how sustainability science engagement can result in richness in terms of knowing sustainability challenges.

Introduction

Human health and well-being are directly and indirectly dependent on the life of river systems. Life in river systems is increasingly dependent on human actions that bring river health into being. Human health is affected by the health of the rivers and waterways. Rivers are critical not only to human survival but also to human flourishing. From obtaining water for drinking and irrigating crops, we may fish, harvest reeds, have picnics on the river banks or perform cultural and heritage practices.^{1,2} Rivers and their wider catchments have a long history of supporting the social and economic needs of people, other living beings and the biodiversity found in rivers. Today, rivers are degrading, as are catchments and their health, affecting river health and human health. As said by Giordano³:

Degrading water quality can not only infringe upon human health, economic well-being, and the environment but can also effectively reduce the overall availability of the resource itself, integrally linking this particular element of the water resource equation to the more commonly emphasized supply and allocation components. (p. 112).

Context-specific social and biophysical drivers of catchment degradation and loss of river health quality are interlinked.⁴ Health and sustainability challenges are exacerbated by catchment degradation and poor water quality management, resulting in the spread of multi-resistant *Escherichia coli* and cholera infections.¹ One of the challenges in multiple South African catchments is the failure of wastewater treatment works (WWTWs), resulting in raw sewerage leaking into rivers. Wastewater treatment works are experiencing "system failures due to ageing systems and pressure on deteriorating facilities, resulting in raw wastewater discharges into catchments"⁴. This is coupled with pressure on systems due to increasing service demand, poor operation and maintenance and lack of well-trained personnel.⁵⁻⁷

According to the Green Drop report⁷, only 1% of wastewater treatment works scored the required 90% on the eight compliance water treatment factors. It was found that 65.8% of wastewater treatment works are at a high to critical risk to the environment around them.

As an emerging sustainability challenge in Southern Africa and beyond, rivers and their health are part of discussions on the commons (i.e. rivers as part of the common well-being of people and planet).⁷⁻¹⁰ Sweeney and Blaine¹¹ state that:

River systems are the world's ultimate commons. Their waters, which are essential to all life, provide food, water for drinking and bathing, transportation, irrigation, and hydropower. They also have been used throughout human history to carry off our waste, transporting our household, agricultural, and industrial effluents downstream. If we do not overload them, streams and rivers are capable of processing the pollutants we discharge into them while continuing to provide food, clean water, and habitat for wildlife. (p. 755)

Like Sweeney and Blaine's US analysis, South Africa has overloaded its river systems dangerously: the most recent assessment by the South African Department of Water and Sanitation (DWS)² of 364 sites spread across the country, using the South African Scoring System Version 5 (SASS5) method, found that:

Approximately 50% of the sites were in a moderately modified (C category) condition. Few sites (16%) are in AB, B or BC categories [meaning good condition]. These sites are mostly located in the upper reaches of the catchments. Only the Vaal River WMA had no sites in a good (better than C category) condition. Approximately 5% of the sites are in an unsustainable (DE to E) condition, generally located in urban areas and subjected to modified flows and habitat alteration in addition to pollution. (p. 2, our emphasis)

According to the DWS, "upper reaches of rivers tend to be in a better condition, with the state of the rivers deteriorating downstream"^{2(p.2)}. However, the South African National Biodiversity Institute's National Biodiversity Assessment¹² indicates that national monitoring data for river and inland wetland systems are incomplete and insufficient to show trends in ecological condition – an issue which DWS recognises. SANBI assessed the state of the rivers as¹²:

River ecosystem condition declined by 11% between 1999 and 2011. Of the 222 river ecosystem types assessed, 64% were found to be threatened (43% Critically Endangered, 19% Endangered and 2% Vulnerable). River ecosystem types are also Poorly Protected with only 13% considered Well Protected and 42% Not Protected. The majority of rivers (67% of total river length) are degraded. Tributaries are generally less heavily impacted than main rivers with 38% of tributary length in natural condition compared to 28% of mainstems. The percentage of threatened river ecosystem types is higher for lowland and lower foothill rivers (67%) than for the upper foothills and mountain streams (25%), which is a reflection of multiple pressures accumulating and increasing from river source to sea. (p. 90)

This shows the dire situation in understanding river health, with the SANBI National Biodiversity Assessment commenting on the "generally poor ecological condition of South Africa's rivers, as two-thirds of the total length of rivers is degraded"^{12(p.17)}. Solutions proposed are co-operative governance and cross-sectoral governance and planning, increasing flows to degraded rivers, improved assessment, planning and monitoring, and practical action such as removal of alien invasives to increase flows to degraded rivers, and waste and pollution management, stewardship and education.

Little is said of *how* these and other river commons practices emerge, that is, how river health comes into being. Sweeney and Blaine¹¹ propose three strategies for resolving river commons concerns: education, legislation and incentivisation, while SANBI recognises that "Cooperative governance, research and citizen science are key elements of inland aquatic ecosystems monitoring"^{12(p.94)}. In this paper, we consider mainly the first and aspects of the third approaches proposed by Sweeney and Blaine¹¹ and SANBI's¹² recognition of citizen sciences. We consider how education implemented via citizen science practice coupled with incentivisation (creation of work for unemployed youth) can contribute to the resolution of river commons concerns, through citizen science practices that can potentially bring river health into being.

The Amanzi Ethu Nobuntu project

The paper explores how river health emerged through citizen science and associated co-learning practices in the Amanzi Ethu Nobuntu (AEN) ['Our Water, Our People'] project led by the Duzi-uMngeni Conservation Trust (DUCT) in the upper uMngeni catchment in South Africa. AEN "came

about in 2021, first as the flagship project of the uMngeni Ecological Infrastructure Partnership (UEIP), and later as a legal entity operating as strategic project co-ordination arm of the partnership"¹³. As a networked partnership project, AEN combines citizen science monitoring practices, youth employment and environmental skills development and includes participating organisations mainly in KwaZulu-Natal, South Africa. Building on the 'Enviro-Champs' project, it is informed by the 2002 State of Rivers Report that developed an assessment of the uMngeni river and neighbouring rivers and streams¹ as well as the Ecstatus Monitoring Programme State of Rivers Report 2017–2018². The State of Rivers Report¹ and subsequent assessments show the uMngeni catchment to be rapidly developing with high pressures on water resources, located in a strategic water management area with changing land use, as well as declining water quality affecting supply and quality of water to downstream communities, most notably, the city of eThekweni^{14–16}, one of South Africa's largest cities.

Most reports on river water quality emphasise ecological and managerial perspectives of river health using water quality tests and catchment system analyses, classifying rivers based on their ability to absorb the effects of human activity and provide goods and services. The 2002 uMngeni State of Rivers Report¹ and the Ecstatus Monitoring Programme State of Rivers Report 2017–2018² both segment data based on ecoregions, taking a largely management and expert-oriented stewardship approach. Concerning our interest in how river health comes into being, not much insight is given to how local communities relate to the river and what value these ways of relating bring to them or the river. The report emphasises the importance of education, offering a historical view of the catchment, and noting how cultural and use values are intertwined. The 2002 and 2017–2018 report's emphasis on ecological and managerial dimensions of river health forwards a notion of river health as a referent to being clean, pristine and natural, with similar patterns evident in science-based water quality and catchment assessment reports.^{17–19}

Broadly, notions of community engagement, encounters with and uses of the river and people's experiences of what river health means are largely underdeveloped in understandings of how river health comes into being. Most official reporting on river health sees communities either as causes of deteriorating river health or 'stewards'. Conceptualisations of river health are mainly based on externally measured inputs and outputs from the river, that is, what impacts a river system can absorb and the goods and services that a particular river system offers. Not much attention is given to the actual needs and views of local communities in constructing meaning(s) of river health. The river becomes privileged, not the river commons, that is, people's being and becoming *with* rivers, socially, politically and ecologically.^{10,20}

Giving time and space for citizen science praxis through co-learning and experiences with rivers, AEN developed the notion that to address the state of South Africa's rivers, it is necessary to work and learn together for the common good by employing and empowering local community citizens to become champions of their river environments, that is, Enviro-Champs.^{7,21} Engaging communities (youth working partners), AEN operationalises citizen science tools through supported learning processes, enabling people living with the river daily to engage in monitoring and management practices of the upper uMngeni, and thus contributing to bringing river health into being.^{7,21}

Between October 2020 and August 2021, the project, as a pilot by the Department of Science and Innovation and UEIP, with DUCT as implementing agent and funded through the Presidential Employment Stimulus Programme employed 500 youths as Enviro-Champs. These youths were spread among UEIP regional partner NGOs, including GroundTruth, a consultancy organisation supporting advancement of citizen science and development of citizen science tools.^{21,22} Twenty graduates were employed and split between a field engagement and fieldwork training team (River Rovers) and a data management and reporting team (Data Detectives). Graduates were supported by secondary teams from partner organisations with capacity-building, data analysis and monitoring from DUCT, GroundTruth and Environmental Learning Research Centre (ELRC) at Rhodes University. Throughout the

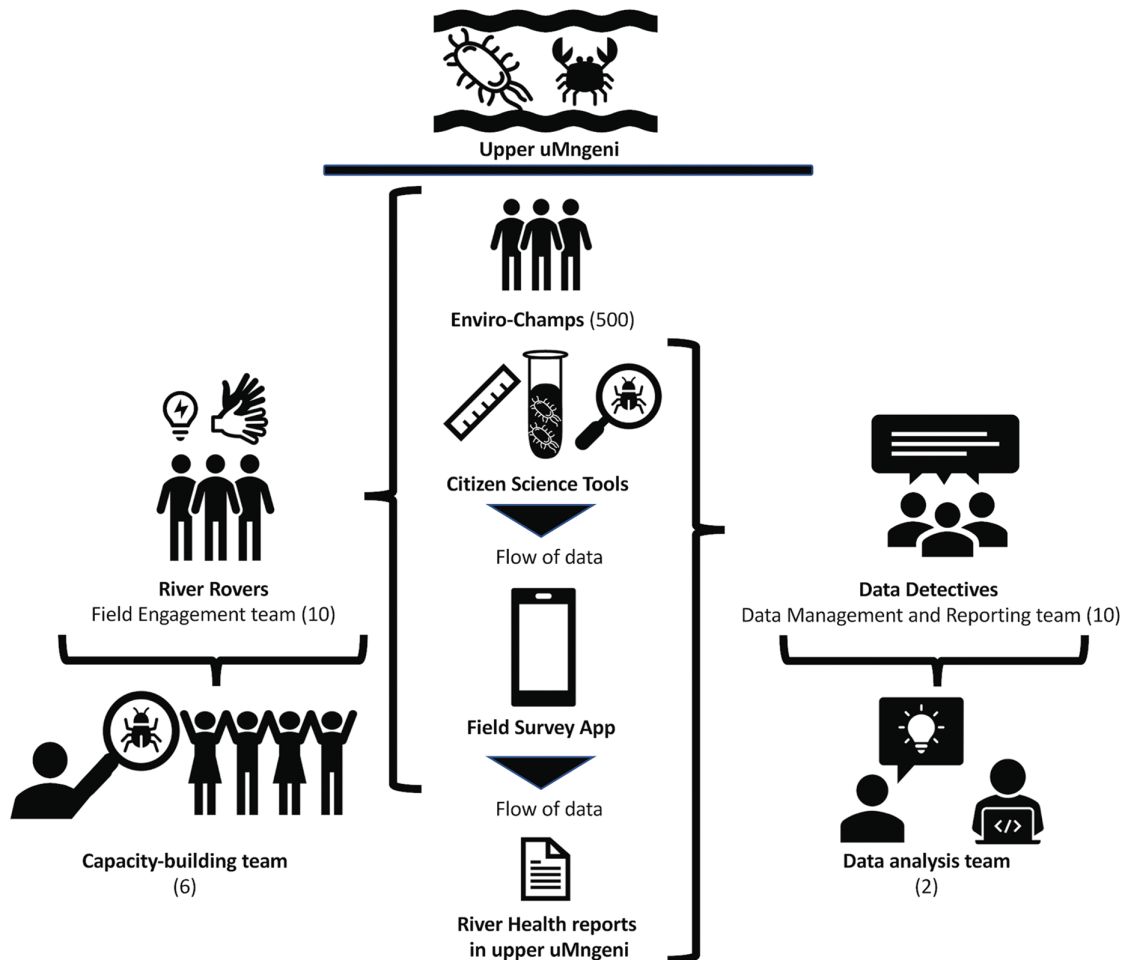


Figure 1: Amanzi Ethu Nobuntu project structure.

project, Enviro-Champs and graduates worked with a custom-designed application (Field Survey App) in capturing monitoring data, which were systematically managed and analysed using documented work plans, resulting in reports as outlined in Figure 1.

Drawing conceptually on a challenge to the universalistic approach to health as detached from context, the paper assumes a praxeological (practice-oriented) approach; the question is not *what river health is* but rather *how a 'healthy' river comes into being through co-learning and practice*.^{23–25} We investigated how river commoning practices come into being through knowledge co-creation in addressing health challenges of humans, animals and the environment in the upper uMngeni, supported by citizen science tools. Additionally, our investigation sought to also potentially contribute to novel conceptualisations of river health as shared experiences and relationships, that is, where river commons are privileged. This paper draws on citizen science engagement in this period specifically while forming part of an ongoing expansive social learning research project into the scaling of citizen science praxis in South Africa, in partnership with DUCT and GroundTruth6 through interactions and collaborative learning(s).

Citizen science tools are key components of global water quality efforts, such as the UNEP Global Environment Monitoring System for freshwater²⁶ and the World Water Quality Alliance²⁷. In the South African context, citizen science tools have been used in water quality monitoring of groundwater²⁸ and aquatic ecosystems and clean-up activities²⁹ as well as in biodiversity monitoring³⁰. Citizen science can occur along a continuum of participation and co-learning, from citizens being used to capture data for scientists (with minimal co-engaged learning) to citizens actively engaging in co-constructing the scientific praxis through co-engaged learning (co-designing tools used, reporting practices and validity of practice).³¹ Citizen science tools can also be co-designed,

developed, used, refined and redeveloped by scientists in interaction with citizens. The latter characterises the AEN citizen science context, with high levels of commitment to co-learning and improvement of tools via processes of engaged practice and co-learning.^{21,32} This provided an analytical vantage point for the study's empirical praxis; that is, we could not interpret it as a 'fixed' or over-determined praxis, but rather as a co-emerging, reflexive practice. In this phase of the AEN, the Field Survey App was piloted and tested (through praxis) as a monitoring and reporting tool, capturing complex datasets from a range of other monitoring tools (e.g. water quality tests) to strengthen systematic reporting in a catchment context.

Methods

The practices we refer to emerged from capturing citizen science-based monitoring data produced mainly by Enviro-Champs supported by River Rovers and through the Field Survey App. This produced a second type of data, involving sense-making and interpretation by the Data Detectives of the incoming data. Designed at the initial stages of the project, data management and analysis plans, co-produced with River Rovers and Data Detectives, guided the analysis process. This produced the empirical foundation of the study, which we continued to engage with via supportive reflective online engagements and contact-based workshops. Subsequent citizen-science practices informed revised plans in an iteratively developed co-learning process.

Figure 2 shows the AEN multidimensional approach to citizen science practice, involving project documents (data management and data analysis plans), citizen science tools (clarity tubes, miniSASS test kits, etc.)^{22,33,34} and technologies (health and safety equipment)^{21,35}. These tools were activated through in-field training and support for citizen science practices, including miniSASS monitoring activities



Figure 2: Inter-related multidimensional citizen science practices involving diverse actors.

(tests ecological health through indicator species), community engagement and reporting findings through the Field Survey App. Monitoring practices and data co-creation were enacted by EnviroChamps supported by River Rovers in the upper uMngeni catchment. The data were reflected on collectively by River Rovers, Data Detectives, DUCT, GroundTruth and Environmental Learning Research Centre teams in reflection workshops. Throughout the project, *inter-related multidimensional citizen science practices involving diverse actors* used meaning-making encounters to operationalise, reflect and improve project documentation, technologies and techniques as river health practices emerged, as shown in Figure 2.

Conceptual framework for analysis

The paper utilises a conceptual framework based on citizen science as social learning and agency formation process^{21,31,36-38}, river commons^{10,39,40} and One Health⁴¹⁻⁴⁴.

Rivers and their health have emerged as part of discussions on the commons, with calls for moving beyond commons as static resources and towards emerging relationships of 'being in common' with both the social and the ecological.^{10,20,40} Lotz-Sisitka⁴⁰ draws attention to how Linebaugh³⁹ shifts commons to the verb, 'commoting'. She articulates how commoning becomes a process of expansive⁴⁵, and potentially transformative learning, as people work together to shape commoning practices/activities in response to social-ecological challenges. Linebaugh³⁹, as cited in Lotz-Sisitka⁴⁰, argued that:

to speak of the commons as if it were a natural resource is misleading at best and dangerous at worst – the commons is an activity and, if anything, it expresses relationships in society that are inseparable from relations to nature. It might be better to keep the word as a verb, an activity, rather than as a noun, a substantive. (p. 65)

Lotz-Sisitka further draws on Archer⁴⁶ and Bhaskar and Hartwig⁴⁷ explaining that commoning processes are influenced by interacting activity-specific generative mechanisms, such as power relations, democratisation processes, shifts in epistemological ownership as enacted in citizen science practices, oriented within learning orientation(s)^{31,32}. Commoning, as activity and process, was useful in analysing how river health practices were coming into being via co-learning and contextualising the meaning(s) of river health as people encountered river waters in their local communities and the setting of the upper uMngeni. This also reflects an open process knowledge

perspective which "understands information and knowledge systems as operating in an open space composed of multiple and diverse patterns of hybrid social–ecological practices and configurations, inevitably embedded in specific times, spaces and contextual conditions"^{48(p.71)}.

One Health⁴² highlights how the health of life on land and in water is interconnected, with links between human activity, ecological change and health for all^{42,43,49}. There is thus a plurality of ways of knowing and addressing river health causes and symptoms as part of an enriched perspective.⁴⁴ Health is seen as interconnected with social life, economics and politics, with human health linked to nature. The concept of One Health helped in analytically mapping the social and ecological aspects of river health.^{41,44}

We drew on these three concepts in an integrated way, seeking insight into how *'healthy' river comes into being through co-learning and practice*. To limit the scope analytically, we selected 'focal data' from the citizen science monitoring, reporting and reflections that offered insight into the question. This involved analysis of monitoring data submitted via the Field Survey App, shared mainly through Data Detectives' reflections on the data. The Data Detectives produced reports, which they thematically analysed and grouped in terms of different kinds of engagements with river health (e.g. social engagements, technical problems in the form of leaks, waste, river ecologies and working with the fieldwork practice tools). The reports were collectively reflected on online and in contact workshop settings, where understandings and expressions of river health surfaced.

Analysis of focal data

Data Detectives reports

Together with Data Detectives, the reports they compiled were analysed. As indicated earlier, reports were based on river monitoring data generated by River Rovers and Enviro-Champs. Reports focused on river health challenges among communities living with the upper uMngeni (alien clearing, solid waste, sewage and water leaks), social aspects of river health engagement and aspects pertaining to the citizen science learning and practice process (use of field survey app and citizen science tools), respectively. The results of this analysis are outlined in Figure 3 and elaborated below.

First, Data Detectives indicated that understanding and bringing river health into being necessitated contextualisation, expressed as a need for better social data and social engagement capacity for co-creating river health. However, the Field Survey App social data functionality was limited,



Figure 3: Data Detectives reports showing aspects of bringing river health into being.

Table 1: Reflection sentences offered by River Rovers and Data Detectives in the reflection workshop on what river health is for them

River health in upper uMngeni is for me ...		
...generating data on river characteristics and turning quantitative data into meaningful qualitative data and outputs	...the same state/condition	...an issue that still needs to be looked at or monitored for effective solutions to be made
...see the state or Health of our rivers has been the greatest motivator of the work that I do	...a great initiative towards the promotion of environmental health	...cleaner rivers, more exotic species, a natural state, no pollution, HEALTHY PEOPLE
...means healthy ecosystems	...is shaping the mindset of communities and the youth in ways that are eco-friendly and aware of their behaviour towards the environment	...complex
...the first step towards cleaning and preserving the waters of South Africa	...work in progress	...about seeing a change in the state of <i>the rivers in a positive way, and it would be great to have to see our rivers restored and to find stoneflies in all our rivers</i>
...environmental consciousness	...means healthy ecosystems	...in a poor condition through the industrial and communal unsustainable activities. It is also a work in progress numerous partners doing different activities to improve the conditions
...crucial for sustainability	...promoting ecologically literate communities for a sustainable future	...environmentally conscious people taking action, people-centred/ community-centred (not abstract)

hence the dotted line in Figure 3. Second, they indicated that bringing river health into being required giving attention to two kinds of leaks regularly reported on by the River Rovers and Enviro-Champs: (1) sewage leaks from sewer holes, burst municipal pipes and faulty residential pipes; and (2) water leaks from leaking community taps, faulty pipes and pipelines. Third, they identified solid waste in the form of medical waste, disposable diaper waste and building waste as being detrimental to bringing river health into being. Figure 3 shows links between leaks and waste because, sewerage leaks flow directly into rivers in most cases, and water leaks flow through waste carrying contaminants and high levels of nutrients into the rivers prompting the growth of alien invasive plants. According to River Rovers and Data Detectives, bringing river health into being requires river commons rehabilitation practices to arrest alien invasive species that outcompete indigenous vegetation and affect flows and levels of rivers, damaging the river ecosystems and river commons potential.

Reflections on bringing river health into being also focused on the fieldwork by River Rovers and Enviro-Champs in monitoring, reporting

and reflecting on river health, which they saw as key to bringing river health into being (hence the flow in Figure 3).

Workshop reflection data

The second focal data analysed were reflections from the May 2022 workshop held at uMngeni Valley. The participatory workshop involved River Rovers and Data Detectives, DUCT staff and members of the GroundTruth and Environmental Learning Research Centre teams. The purpose was to reflect on the 8 months of citizen science learning and practice in the AEN project and to conceptualise activities related to monitoring and reporting. Following individual reflections on how their practices had contributed with value to the AEN project, graduates were paired to share their reflections and jointly address how their practices have contributed river health of the upper uMngeni. From these paired discussions, the participants each articulated a sentence, '*River health in upper uMngeni is for me....*' Eighteen statements were shared on the board by River Rovers and Data Detectives (see Table 1) and formed the basis for a co-created concept of river health in the upper uMngeni, discussed further below.

Table 1 shows the following dynamics of bringing river health into being. The view that river health is a process was prominent. This process was reflected as involving the monitoring practices, as well as engaging communities within a people-centred approach to river commoning. The data also show that bringing river health into being requires healthy ecosystems and the need to move the river from one condition (bad) to another (more favourable) condition. Bringing river health into being also involves restorative practices, co-creating solutions, environmental consciousness / ecological literacy, and advancement of environmental health, healthy ecosystems, healthy people and healthy communities generally.

Discussion and synthesis of the findings

Through the reflective analysis of Data Detective reports (Figure 3), and thematic analysis of the workshop reflection data (Table 1), river health in the upper uMngeni, when enacted via the citizen science co-learning practices, encompasses emergent social-ecological and ethical-political dynamics of bringing river health commoning activity into being as reflected in Figure 4.

The combined social-ecological^{48,50-56} and ethical-political⁵⁷⁻⁶¹ dynamics of bringing river health into being can be articulated as the ontological foundations of river health commoning activity and its emergence.

River health does not exist separate from the practices of people who are in relationships with the river. River health needs to come into being through the ontological foundations outlined earlier; it is always an emergent relation, enacted through practices of people in time and place with their rivers and the conditions of the rivers. River health is thus a river commoning activity that can be brought into being by citizen science and co-learning in catchments.

As seen in the data and analysis from the AEN citizen science co-learning reflective research, river health commoning activity comes into being in place with rivers, through complex relational practice patterns, involving diverse practices, as shown in Figure 5. Figure 5 illustrates this with the metaphor of an expansive river commoning activity 'flower' of river health emergence in the upper uMngeni. The flower metaphor shows the possibility for flourishing with river health and how it can be brought into being in multidimensional ways, supported by the social-ecological and political-ethical ontological foundational dynamics articulated earlier. River health is thus brought into being along with the health of the people living with and alongside the river as part of the overarching relational concept of One Health in which the ecosystem health of life on land and water is interwoven with human health and activities.

The ontological enactments that brought river health into being from the Data Detectives reports occupy the lower three petals, while the enactments resulting from the workshop analysis are represented in the upper five petals. These enactments bring river health into being through

preserving and returning rivers to natural states, and through the creation of healthy ecosystems and healthy people, with the latter ontological enactment potentially in relational tension with the first, as seen in the prevalence of medical waste from human consumption. River health was also brought into being through the practice of critically engaging complexity and developing the citizen science capabilities of communities and youth towards eco-friendly practices. The potential for bringing river health into being through such ontological enactments is expanded by experiential encounters constituted through the multi-layered iterative engagements as outlined in Figure 3, where diverse actors were involved in mobilising and using citizen science tools in a reflexive co-learning approach. This resonates with the concept of river health futures as involving a concept of collective and co-engaged learning with social-ecological ontologies in relation.^{10,20}

Our research shows how river health commoning activity can emerge through ontological enactments in citizen science co-learning practices where an open system view of knowledge and contextualised meaning-making is the norm rather than the exception.⁴⁸ The commoning activity of river health as part of the AEN project emerged as an open-ended co-creation process where the 'health' of the river emerged through citizen science and associated co-learning practices conducted in the upper uMngeni. River health was brought into being beyond the waters, following citizen science practices, coming to encompass leaking pipes, solid waste, alien invasive vegetation, community engagement, water and sanitation infrastructure, and the co-learning and practice involved in using citizen science tools.

Conclusion

We started this paper with an observation that reports of ongoing deterioration of river health tend to focus more on technical information and data on the state of the river. We recognise these as being crucial for an understanding of river health. However, we sought to enrich and broaden how river health is reported on and understood. We worked with the question of how river health is brought into being through citizen science and co-learning processes in the upper uMngeni catchment, where citizen science innovation is taking place in the AEN project involving young people who were employed as River Rovers, Data Detectives and Enviro-Champs.

Through collaborative analysis, we showed that exploring how to bring river health into being offers an ontologically rich perspective on river health, involving social-ecological as well as political-ethical ontological dynamics, and inter-related multidimensional practices that are non-exhaustive in nature. The analysis shows that citizen science tools and practices, when mobilised in co-engaged ways where co-learning is also valued, can bring river health into being and also help in articulating what river health might mean in our communities and catchments.

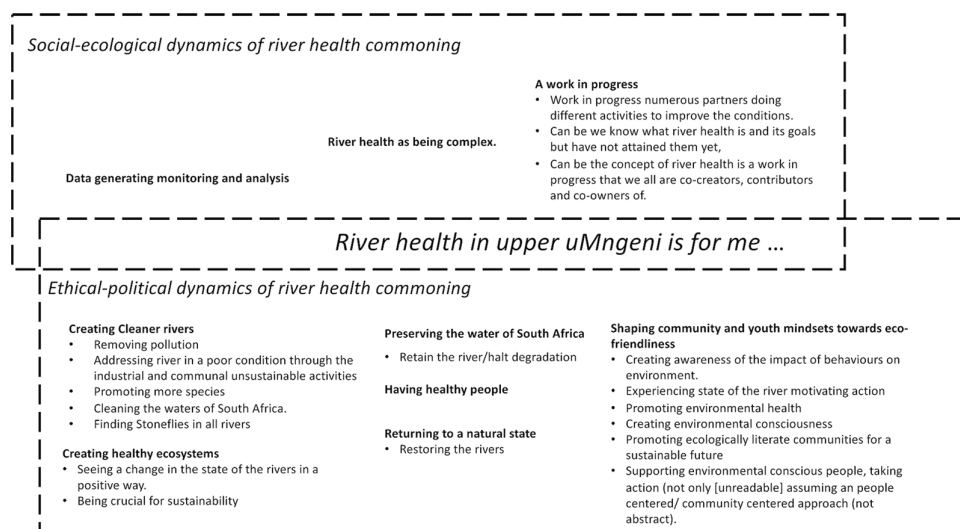


Figure 4: Social-ecological and ethical-political dynamics of river commoning activity (bringing river health into being).

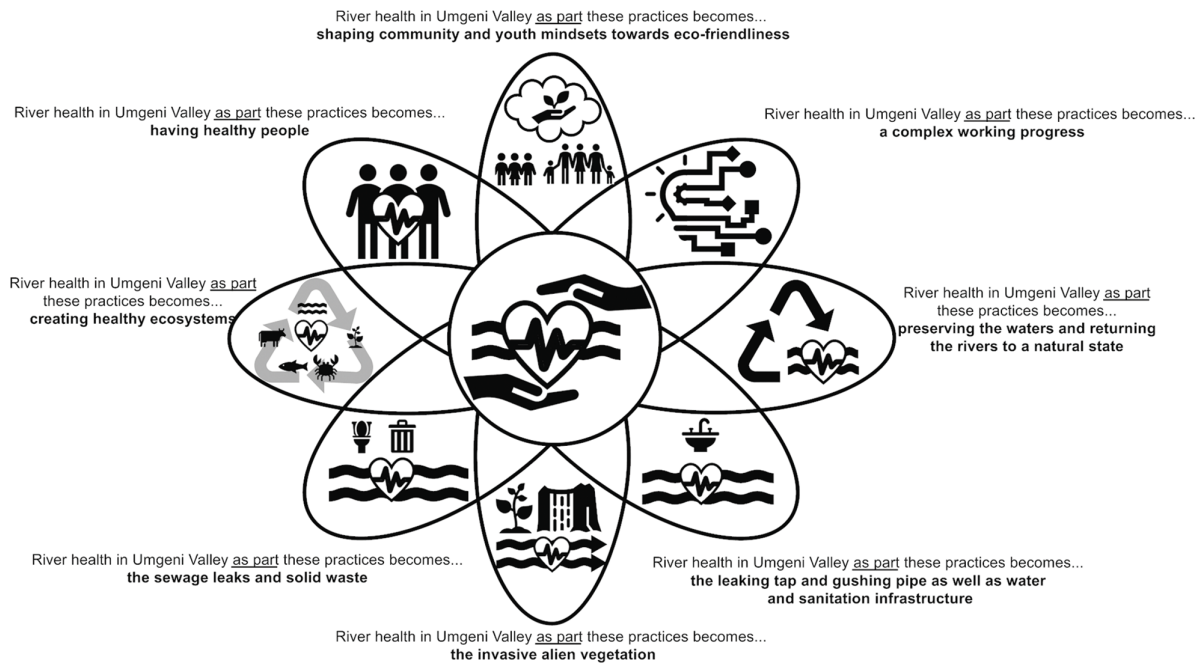


Figure 5: The expansive commoning activity of river health in the upper uMngeni.

Our study shows that the river health commoning activity, from the AEN project, emerged as an open-ended co-creation process between River Rovers and Enviro-Champs, Data Detectives and River Commons partners, around the 'health' of the river. This extends the notion of river health beyond technical specifications, to the notion of river health as an emerging commoning activity, requiring co-learning, citizen science practices and community engagement. Through this, the sharing of responsibility for river health can be realised by all in the catchment as they come to understand meaning(s) of river commoning activity. It offers extended support for managers who, in most technical river health reports, are given responsibility for river health through expert stewardship.

In conclusion, the paper highlights possibilities of imagining futures where healthy river ecosystems are interwoven with people's health and participation. The AEN project shows that our human health is linked to our rivers, and river health in the practice of citizen science becomes a point of intersection for the health of humans, animals and the environment between the riverbanks and beyond.

Acknowledgements

This project would not have been possible without the many who participated in it. In particular, we acknowledge the co-leadership of Andrew Fowler who co-ordinated the AEN project with F.B. Additionally, Maletje Mponwana, Preven Chetty and P.M. were part of our AEN support team at the Environmental Learning Research Centre at Rhodes University. We especially would like to recognise the analytical contributions of the Data Detectives team from the AEN project: Akosua Awuah, Bongani Mkhize, Kimara Moodley, Nondumiso Mahlanze, Sanelisiwe Mncube, Sindiswa Mthlane, Tanisha Curtis, Thembelihle Memela, Yolanda Hansraj and Zanele Makhaya.

Funding

The research was conducted as part of the Amanzi Ethu Nobuntu (AEN) ['Our Water, Our People'] project. The project was piloted by the Department of Science and Innovation and uMngeni Ecological Infrastructure Partnership. Duzi-uMngeni Conservation Trust was the implementing agent, and the project was funded through the Presidential Employment Stimulus Programme employing 500 youths as Enviro-Champs. Enviro-Champs were spread among UEIP regional partner NGOs, including GroundTruth, a consultancy organisation

supporting the advancement of citizen science and the development of citizen science tools.

This project was supported with part funding from the Department of Science and Innovation / National Research Foundation Community of Practice on Social Learning and Sustainable Development (Grant UID: 128385). Funding for the lead author was provided through a Postdoctoral Research Fellowship from the Vetenskapsrådet (Swedish Research Council), grant number 2020-04567.

Declarations

We have no competing interests to declare. We have no AI or LLM use to declare. Ethical approval was granted by the Rhodes University Education Faculty Ethics Committee for a low risk study under the research programme 'Citizen-Based Water Quality Monitoring National Review' which was conducted in a partnership between Rhodes University's Environmental Learning Research Centre, the Duzi Umngeni Trust and GroundTruth: approval number: 2019-0536-2030. All ethical procedures were adhered to. The researchers explained the research to participants and ensured that participants understood the purpose of the research and that the information they provided would be treated confidentially and used solely for the purposes of the research. Moreover, where the materials collected are used for publications such as this, it was communicated that no personal names or details of the participants' identities would be revealed.

Data availability

The data supporting the results of this study are available upon request to the corresponding author.

Authors' contributions

M.M., R.T., P.M.: Conceptualisation, methodology, data collection, data analysis, writing – the initial draft, writing – revisions. F.B.: Conceptualisation, project leadership, project management, funding acquisition. C.R.: Conceptualisation, methodology, data collection, writing – revisions. H.L.-S.: Conceptualisation, methodology, data analysis, writing – the initial draft, writing – revisions, project leadership, project management, funding acquisition. All authors read and approved the final manuscript.

Author information

The lead author and visiting postdoctoral fellow M.M. PhD scholars R.T. and P.M., and principal investigator H.L.-S. form part of the Rhodes University Environmental Learning research team, while partners F.B. and C.R. are from participating organisations.

References

- Water Research Commission (WRC). State of rivers report: uMngeni river and neighbouring rivers and streams. Pretoria: WRC; 2002.
- South African Department of Water and Sanitation. State of rivers report. river ecoStatus monitoring, 2017–2018. Pretoria: Water Research Commission; 2019.
- Giordano MA. Managing the quality of international rivers: Global principles and basin practice. *Nat Resour J*. 2003;43(1):111–136.
- Itzkin A, Scholes MC, Clifford-Holmes JK, Rowntree K, van der Waal B, Coetzer K. A social-ecological systems understanding of drivers of degradation in the Tsitsa river catchment to inform sustainable land management. *Sustainability*. 2021;13(2), Art. #516. <https://doi.org/10.3390/su13020516>
- Masindi TK, Gyedu-Ababio T, Mpenyana-Monyatsi L. Pollution of sand river by wastewater treatment works in the bushbuckridge local municipality, South Africa. *Pollutants*. 2022;2(4):510–530. <https://doi.org/10.3390/pollutants2040033>
- Obasa AE, Botes M, Palk AC. Collective responsibility during a cholera outbreak: The case of Hammanskraal. *S Afr J Bioeth Law*. 2023;16(3):99–104. <https://doi.org/10.7196/sajbl.2023.v16i3.1250>
- Lotz-Sisitka H, Ward M, Taylor J, Vallabh P, Madiba M, Graham M, et al. Alignment, scaling and resourcing of citizen-based water quality monitoring initiatives. Pretoria: Water Research Commission; 2022.
- South African Department of Water and Sanitation (DWS). Green drop progress assessment report. Pretoria: DWS; 2023.
- Shin G. How Ostrom's design principles apply to large-scale commons: cooperation over international river basins. *Rev Policy Res*. 2022;39(5):674–697. <http://doi.org/10.1111/ropr.12457>
- Boelens R, Escobar A, Bakker K, Hommes L, Swyngedouw E, Hogenboom B, et al. Riverhood: political ecologies of socationature commoning and translocal struggles for water justice. *J Peasant Stud*. 2023;50(3):1125–1156. <https://doi.org/10.1080/03066150.2022.2120810>
- Sweeney BW, Blaine JG. River conservation, restoration, and preservation: rewarding private behavior to enhance the commons. *Freshw Sci*. 2016;35(3):755–763. <https://doi.org/10.1086/687364>
- South African National Biodiversity Institute. National biodiversity assessment 2018: The status of South Africa's ecosystems and biodiversity – synthesis report. Pretoria: SANBI; 2019.
- Duzi-uMngeni Conservation Trust (DUCT). Amanzi Ethu Nobuntu (AEN) [homepage on the Internet]. No date [cited 2023 Jul 11]. Available from: <http://s://amanziethunobuntu.co.za>
- Namugize JN, Jewitt G, Graham M. Effects of land use and land cover changes on water quality in the uMngeni river catchment. *South Africa Phys Chem Earth, Parts A/B/C*. 2018;105:247–264. <https://doi.org/10.1016/j.pce.2018.03.013>
- Namugize JN, Jewitt GPW. Sensitivity analysis for water quality monitoring frequency in the application of a water quality index for the uMngeni River and its tributaries, KwaZulu-Natal, South Africa. *Water SA*. 2018;44(4):516–527. <https://doi.org/10.4314/wsa.v44i4.01>
- Schütte S, Schulze RE. Projected impacts of urbanisation on hydrological resource flows: A case study within the uMngeni Catchment, South Africa. *J Environ Manage*. 2017;196:527–543. <https://doi.org/10.1016/j.jenvman.2017.03.028>
- Dallas HF. A preliminary evaluation of aspects of SASS (South African Scoring System) for the rapid bioassessment of water quality in rivers, with particular reference to the incorporation of SASS in a national biomonitoring programme. *S Afr J Aquat Sci*. 1997;23(1):79–94. <https://doi.org/10.1080/10183469.1997.9631389>
- Mangadze T, Taylor JC, Froneman WP, Dalu T. Water quality assessment in a small austral temperate river system (Bloukrans River system, South Africa): Application of multivariate analysis and diatom indices. *S Afr J Bot*. 2019;125:353–359. <https://doi.org/10.1016/j.sajb.2019.08.008>
- Oberholster PJ, Botha A-M, Cloete TE. Biological and chemical evaluation of sewage water pollution in the Rietvlei nature reserve wetland area. *S Afr Environ Pollut*. 2008;156(1):184–192. <https://doi.org/10.1016/j.envpol.2007.12.028>
- Boelens R, Forigua-Sandoval J, Duarte-Abadía B, Gutiérrez-Camargo JC. River lives, River movements. Fisher communities mobilizing local and official rules in defense of the Magdalena river. *J Leg Plur Unoff Law*. 2021;53(3):458–476. <https://doi.org/10.1080/03066150.2022.2120810>
- Graham M, Taylor J. Development of citizen science water resource monitoring tools and communities of practice for South Africa, Africa and the world. Report no. TT 763/18. Pretoria: Water Research Commission; 2018.
- Graham PM, Dickens CWS, Taylor RJ. MiniSASS - a novel technique for community participation in river health monitoring and management. *Afr J Aquat Sci*. 2004;29(1):25–35. <https://doi.org/10.2989/16085910409503789>
- Boll T, Müller SM. Body boundary work: Praxeological thoughts on personal corporality. *Hum Stud*. 2020;43(4):585–602. <https://doi.org/10.1007/s10746-020-09555-2>
- Mol A, Law J. Embodied action, enacted bodies: The example of hypoglycaemia. *Body Soc*. 2004;10(2–3):43–62. <https://doi.org/10.1177/1357034x04042932>
- Mol A. The body multiple: Ontology in medical practice. Durham, NC: Duke University Press; 2002. <https://doi.org/10.1215/9780822384151>
- Warner S. GEMS/Water exploring citizen science to fulfil 50-year-old objectives [webpage on the Internet]. c2024 [cited 2023 Jul 11]. Available from: <https://wedocs.unep.org/20.500.11822/44803>
- United Nations. Progress on ambient water quality [document on the Internet]. c2018 [cited 2023 Jul 11]. Available from: <https://gemstat.org/wp-content/uploads/2018/11/632-progress-on-ambient-water-quality-2018.pdf>
- Goldin J, Mokomela R, Kanyerere T, Villholth KG. Diamonds on the soles of their feet: Groundwater monitoring in the Hout Catchment, South Africa. *J Educ Sustain Dev*. 2021;15(1):25–50. <https://doi.org/10.1177/09734082211014435>
- Graham M, Taylor J, Ross-Gillespie V, Dithale N, Mahood K. A revised adopt-a-river programme: Stakeholder input on the institutional and financial frameworks with a focus on an implementation strategy report to the water research commission [document on the Internet]. c2016 [cited 2023 Jul 11]. Available from: <https://www.wrc.org.za/wp-content/uploads/mdocs/KV%20354-16.pdf>
- Huntley BJ. Building biodiversity knowledge: Mobilising citizen science. In: Strategic opportunism: What works in Africa: Twelve fundamentals for conservation success. Cham: Springer Nature; 2023. p. 71–91. https://doi.org/10.1007/978-3-031-24880-1_7
- Vallabh P, Lotz-Sisitka H, O'Donoghue R, Schudel I. Mapping epistemic cultures and learning potential of participants in citizen science projects. *Conserv Biol*. 2016;30(3):540–549. <https://doi.org/10.1111/cobi.12701>
- Donoghue RO. Clarifying environmental education: A search for clear action in southern Africa. *South Afr J Environ Educ*. 1993;13:28–38.
- Taylor J, Graham M, Louw A, Lepheana A, Madikizela B, Dickens C, et al. Social change innovations, citizen science, miniSASS and the SDGs. *Water Policy*. 2021;24(5):708–717. <https://doi.org/10.2166/wp.2021.264>
- Pattinson NB, Russell C, Taylor J, Dickens CWS, Koen RCJ, Graham PM. Digital innovation with miniSASS, a citizen science biomonitoring tool. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on Digital Innovation; 2023. <https://hdl.handle.net/10568/134498>
- Graham PM, Bruton SM, Gibixego A. Reassessment of the mini-SASS biomonitoring tool as a resource for environmental education in the river health programme and cross-linking to with the national curriculum statement. Vol. 639. WRC report no. KV240/12. Pretoria: Water Research Commission; 2012.
- Dickinson JL, Shirk J, Bonter D, Bonney R, Crain RL, Martin J, et al. The current state of citizen science as a tool for ecological research and public engagement. *Front Ecol Environ*. 2012;10(6):291–297. <https://doi.org/10.1890/110236>
- Swan M. Crowdsourced health research studies: An important emerging complement to clinical trials in the public health research ecosystem. *J Med Internet Res*. 2012;14(2):e46–e46. <https://doi.org/10.2196/jmir.1988>

38. O'Donoghue R, Shava S, Zazu C, editors. African heritage knowledge in the context of social innovation. Learning contributions of the regional centres of expertise on education for sustainable development. Yokohama: United Nations University-Institute of Advanced Studies (UNU-IAS); 2013.
39. Linebaugh P. The Magna Carta manifesto: Liberties and commons for all. Berkeley, CA: University of California Press; 2008. <https://doi.org/10.1525/9780520932708>
40. Lotz-Sisitka H. Education and the common good. In: Jickling, B, Sterling S, editors. Post-sustainability and environmental education. Cham: Springer; 2017. p. 63–76. https://doi.org/10.1007/978-3-319-51322-5_5
41. Roger F, Caron A, Morand S, Pedrono M, de Garine-Wichatitsky M, Chevalier V, et al. One Health and EcoHealth: The same wine in different bottles? *Infect Ecol Epidemiol*. 2016;6(1), Art. #30978. <https://doi.org/10.3402/iee.v6.30978>
42. Zinsstag J, Schelling E, Crump L, Whittaker M, Tanner M, Craig S. One Health: The theory and practice of integrated health approaches. Wallingford: CAB International; 2021.
43. Lapinski MK, Funk JA, Moccia LT. Recommendations for the role of social science research in One Health. *Soc Sci Med*. 2015;129:51–60. <https://doi.org/10.1016/j.socscimed.2014.09.048>
44. Vroegindewey G. Beyond three circles: A broader view of One Health. *Adv Small Anim Med Surg*. 2017;30(2):1–3. <http://dx.doi.org/10.1016/j.asams.2017.01.001>
45. Engeström Y. Studies in expansive learning: Learning what is not yet there. New York: Cambridge University Press; 2016. <https://doi.org/10.1017/CBO9781316225363>
46. Archer MS, editor. Introduction: Other conceptions of generative mechanisms and ours. In: Generative mechanisms transforming the social order. Cham: Springer International Publishing AG; 2015. 1–24. <https://doi.org/10.1007/978-3-319-13773-5>
47. Bhaskar R, Hartwig M. Enlightened common sense: The philosophy of critical realism. Abingdon: Routledge; 2016. <https://doi.org/10.4324/9781315542942>
48. Tåbara JD, Chabay I. Coupling human information and knowledge systems with social–ecological systems change: Reframing research, education, and policy for sustainability. *Environ Sci Policy*. 2013;28:71–81. <https://doi.org/10.1016/j.envsci.2012.11.005>
49. Collignon P, Beggs JJ, Walsh TR, Gandra S, Laxminarayan R. Anthropological and socioeconomic factors contributing to global antimicrobial resistance: A univariate and multivariable analysis. *Lancet Planet Heal*. 2018;2(9):e398–405. [http://dx.doi.org/10.1016/S2542-5196\(18\)30186-30184](http://dx.doi.org/10.1016/S2542-5196(18)30186-30184)
50. Cassidy A, Bresalier M, Woods A. One Health in history. In: Zinsstag J, Schelling E, Crump L, Whittaker M, Tanner M, Craig S, editors. One Health: The theory and practice of integrated health approaches 2nd ed. Wallingford: CAB International; 2021. p. 1–15.
51. Hinchliffe S, Ward KJ. Geographies of folded life: How immunity reframes biosecurity. *Geoforum*. 2014;53:136–144. <http://dx.doi.org/10.1016/j.geoforum.2014.03.002>
52. Berkes F, Folke C, Colding J. Linking social and ecological systems: Management practices and social mechanisms for building resilience. Cambridge: Cambridge University Press; 1998.
53. Berkes F. Environmental governance for the anthropocene? Social-ecological systems, resilience, and collaborative learning. *Sustainability*. 2017;9(7), Art. #1232. <https://doi.org/10.3390/su9071232>
54. Berkes F, Colding J, Folke C. Navigating social-ecological systems: Building resilience for complexity and change. Cambridge: Cambridge University Press; 2002. <https://doi.org/10.1017/CBO9780511541957>
55. Folke C. Social–ecological systems and adaptive governance of the commons. *Ecol Res*. 2007;22(1):14–5. <https://doi.org/10.1007/s11284-006-0074-0>
56. Colding J, Barthel S. Exploring the social-ecological systems discourse 20 years later. *Ecol Soc*. 2019;24(1), Art. #2. <https://doi.org/10.5751/es-10598-240102>
57. Stetsenko A. Research and activist projects of resistance: The ethical-political foundations for a transformative ethico-onto-epistemology. *Learn Cult Soc Interact*. 2020;26, Art. #100222. <https://doi.org/10.1016/j.lcsi.2018.04.002>
58. Bhaskar R, Danermark B. Metatheory, interdisciplinarity and disability research: A critical realist perspective. *Scand J Disabil Res*. 2006;8(4):278–297. <https://doi.org/10.1080/15017410600914329>
59. Santos B de S. Epistemologies of the South: Justice against epistemicide. Boulder, CO: Paradigm Publishers; 2014. <https://doi.org/10.1086/678449>
60. Bhaskar R. A realist theory of science. London: Routledge; 2008. <https://doi.org/10.4324/9780203090732>
61. Bhaskar R. Scientific realism and human emancipation. London: Routledge; 2009. <https://doi.org/10.4324/9780203879849>