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The Adaptive Systemic Approach: Catalysing more just and sustainable outcomes from sustainability and natural resources development research

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Abstract

It has become increasingly common to include participatory processes, several academic disciplines, and additional wide-ranging ways of knowing, in using research to tackle the escalating environmental problems of the 21st Century. There are barriers to the success of these efforts. In this paper we present the Adaptive Systemic Approach (ASA). The ASA is designed to provide a clear pathway for research related to sustainability issues, river basin problems and natural resource development, and to deliver change towards improved ecological health and social justice outcomes. The design of the ASA rests on three key concepts: complex social-ecological systems, transdisciplinarity, and transformative social learning, together with Strategic Adaptive Management as the theoretically consistent operational process. We identify logical connections between the concepts and Strategic Adaptive Management so that the ASA emerges as a coherent and practical research and praxis pathway. The ASA process is then outlined to support uptake and wider application. We present findings from ASA praxis in a collaborative African research program considering river basin problems in seven countries, where key contextual learnings led to the recognition of five barriers to effective research impact outcomes: (1) Lack of an integrative conceptual grounding. (2) Participatory stakeholder engagement flawed by epistemic injustice. (3) Inadequate transdisciplinary team building. (4) Insufficient inclusion of learning, reflection, and systemic adaptation. (5) Inflated claims of probable impact in terms of creating change towards improved ecological health and social justice. We reflect on the ways the ASA contributes to breaching these barriers. Early key learnings from ASA praxis leads us to suggest that the ASA has practical value for policy makers, practitioners and researchers seeking pathways for fair and sustainable river management, and more broadly in natural resource development.

KEYWORDS
complex social-ecological systems, epistemic justice, natural resource development, research impact, river basins, social learning, strategic adaptive management, transdisciplinary

1 | INTRODUCTION

In the 21st Century, sustainable development remains elusive, and natural resource development such as water infrastructure construction, has often externalised costs to the environment and vulnerable people (Morandín-Ahuerma et al., 2019). Research outcomes that deliver real impact are also elusive. There is a need for new approaches that provide credible pathways for research to catalyse transitions towards real fairness to people and the environment–social-ecological justice (Swilling, 2019; Wolff et al., 2019). We identify five common barriers that hinder effective impact: (1) Lack of an integrative conceptual grounding. (2) Participatory stakeholder engagement flawed by epistemic injustice. (3) Inadequate transdisciplinary team building. (4) Insufficient inclusion of learning, reflection, and systemic adaptation. (5) Inflated claims of probable impact in terms of creating change towards improved ecological health and social justice. We have drawn on our collective field experience, and the literature, to develop a research approach, the Adaptive Systemic Approach (ASA), designed to overcome these barriers, and have applied the ASA in the context of African river catchments/basins.

Africa is home to some of the world's largest less-developed rivers. There are plans and activities in progress for rapid and continual water infrastructure development, especially large impoundments for reliable water supply and hydropower. These developments have seldom focused on local benefit or ecological sustainability (McCully, 1996). The inevitability of ongoing development, and a vision of development delivering greater ecological sustainability and social equity, drove the authors to design a coherent, *practicable* approach that could underpin fair, inclusive research processes capable of catalysing positive environmental change, with societal benefit.

Taking the step of identifying the ASA as a definable approach derives from a two-step argument:

(i) Domains of academic knowledge There are three clear academic communities of practice regularly engaged with research-based development interventions in natural resource contexts: natural science, social science, and transdisciplinary/complex social-ecological systems (TD-CSES) science. The literatures in these domains overlap to some degree, but the TD-CSES literature, thinking and practice has not deeply penetrated the disciplinary silos of the natural or social sciences. For example, the Editorial in *Nature Sustainability* raised the question from a natural sciences perspective: '*too much and not enough?*' (2021). The Editors draw attention to the volume and repetitiveness of recent submissions concerning water resources sustainability, and call for debate, reflection, and new thinking from the water studies community. Venot et al. (2022) responded with a response letter '*a bridge over troubled water*', pointing to a line of social science research that has seldom found its way into water resources science publications. The ASA speaks precisely into introducing thinking, concepts and practices from the social sciences that are unusual in the natural science and engineering-based water science literature, and vice-versa; and linking both with the TD-CSES domain.

(ii) Taking integrated academic thinking into practice Given the scattered literature in the natural and social sciences and in TD-CSES, the ASA offers a synthesised departure point, and a clear sequence of activities, for multi-disciplinary research teams to move into transdisciplinarity.

We suggest that following the ASA pathway/s offers a real possibility of more sustainable outcomes that are fairer to more people, from managing and developing river basins and their water resources. The ASA specifically addresses the relationship between (i) people with interests in using water resources and who therefore depend on rivers, (ii) people who are responsible for water resources and river management, and (iii) researchers or professional practitioners who seek to use new knowledge to improve the outcomes of using and developing river basin water resources. These groups of people are usually termed 'stakeholders' by natural scientists and 'actors' by social scientists—we use the term 'stakeholders'. Cockburn et al. (2018) describe the interactions between these interacting people as a 'bumpy terrain', catching the uncertainty and challenges that arise in these relationships. We initiated application of the ASA in a large collaborative research programme across 11 universities, in seven African countries, entitled *Unlocking resilient benefits from African water resources* (RESBEN).

The paper presents the design of, and motivation for, the ASA in four sections. The *Conceptual and Theoretical Foundation* provides the logical connection between three selected concepts and an operational process, with a summarised synthesis of each. This is the 'Why?' of the ASA. The ASA describes the ASA process, to guide applications. This is the 'How?' of the ASA. *ASA praxis in Africa* considers what we learned from applying the Adaptive Planning Process phase of the ASA in six RESBEN contexts. These lessons underpin the final section, *Potential to breach barriers*, which reflects on the ASA design in terms of breaching five barriers recognised as hampering effective social-ecological impact from sustainability research.

2 | THE CONCEPTUAL AND THEORETICAL FOUNDATION FOR THE ASA

The aim of the ASA is to increase the likelihood that research into water-related problems of the 21st Century will contribute substantively to both ecological health and social justice—key elements of human wellbeing. We have drawn together three main strands of thinking, and one operational process to assemble the ASA. This logically linked conceptual, theoretical and practical foundation guided the ASA design.

2.1 | Conceptual and theoretical

Complex social-ecological systems: As exemplified by people living in river basins, human society, with its multiple interacting social elements, is intricately embedded within the rest of the bio-physical world, which also comprises multiple interacting biological, physical, and chemical elements. The formal recognition of these social-ecological systems emerged from well-established resilience thinking (e.g., Folke, 2006; Folke et al., 2016). Crucially, social-ecological systems are understood in terms of the fundamental complexity of life-systems on earth (Cilliers, 2000, 2008). This complexity means processes are influenced by scale (Cash et al., 2006), feedbacks, uncertainty, context and the history of the system (Audouin et al., 2013; Preiser et al., 2018). The ASA uses transdisciplinarity to engage with complexity.

Transdisciplinarity: Transdisciplinary research has evolved to mean research that transcends the boundaries between (i) societal and academic actors and their knowledge systems, and (ii) academics from different disciplinary domains (Cockburn, 2021; Wolff et al., 2019). Since complex problems have multiple concurrent, causative drivers, no single intervention is likely to shift the problem, and multiple concurrent interventions are difficult to orchestrate. Interventions in complex systems are likely to trigger both intended and unintended consequences, because of the multiple elements and feedbacks involved. Bernstein (2015) notes '…research that can be described as transdisciplinary is also aimed at creating engaged, socially responsible science'. Dimensions of responsibility include an emphasis on equitable partnerships with stakeholders (van Breda & Swilling, 2019), attentiveness to social-ecological ethics (Cockburn & Cundill, 2018; Odume & de Wet, 2019), and epistemic justice—fairness related to what and how we know (Fricker, 2007). Bringing people, their knowledge, and their ways of knowing together, is therefore closely linked to understanding transformative social learning. Working in a transdisciplinary manner is sufficiently compelling that it is likely to become 'a way of being' (Rigolot, 2020).

Social learning: Social learning is the process by which people learn effectively and collectively from each other in ways that influence themselves and their wider networks (Reed et al., 2010). Social learning can drive transformation, creating conditions for change by resolutely confronting deeply established conventions like those related to hierarchies of power, gender, and ethnicity (Bengtsson, 2019). Wals (2007) and Fleming (2018) point to transformative social learning as an explicit requirement for 'sustainability competence'. Conscious, iterative, reflexivity is a hallmark of processes that foster transformative social learning (Burt et al., 2018; Lotz-Sisitka, 2018; Lotz-Sisitka et al., 2015).

2.2 | Practical

Strategic Adaptive Management (SAM): Strategic Adaptive Management is the practical, operational driver of the ASA, and is applied sensu Rogers and Luton (2011) and Palmer, Rogers, et al. (2018) as a process of planning and managing adaptively. It provides clear guidance for operational management actions and is founded in thinking consistent with the conceptual strands of the ASA: complex social-ecological systems, transdisciplinarity and transformative social learning (Palmer, Rogers, et al., 2018). For example, Cundill et al. (2012) explicitly link systems thinking and social learning to the adaptive management of complex social-ecological systems. SAM builds on a co-created vision and objectives hierarchy to set up the development and implementation of management actions supported by reflective co-learning among practitioners (Roux et al., 2022).

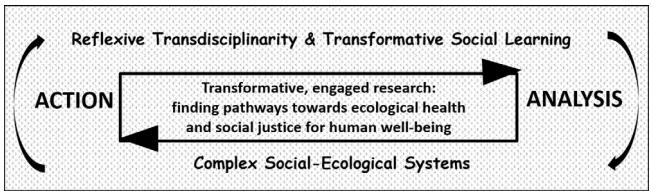

FIGURE 1 A generic representation of the way the ASA functions.

The ASA process is fundamentally an iterative, dynamic relationship between action and analysis (Figure 1).

Action represents SAM activities undertaken through the sequential and concurrent ASA phases (Figure 2), which are transdisciplinary and participatory. Many of them are workshop events with opportunities for social learning, while others are research-focussed data collection. Early on, participants decide what indicators of progress towards project goals will be collectively monitored during activities, for later evaluation. As researchers and stakeholders undertake project activities, they contribute reflexive responses, which are also used in participatory monitoring and evaluation. These activities generate new knowledge and participants move into *analysis*—a collaborative engagement with new and diverse knowledge, using qualitative and quantitative methods. Both action and analysis are opportunities for co-learning and trust-building. Through cycles of engagement, as participants monitor and reflect on indicators of change, they become alert to trajectories that are either positive (which reinforce the mode of intervention), or negative (which call for reassessment of actions).

In this kind of work, it is unlikely that the social-ecological system itself will change in clearly measurable ways in the 3- to 5-year timeframe of research projects. Indicators are therefore selected to demonstrate the system is on a trajectory of change towards the long-term outcomes of improved social justice (e.g., livelihoods) and ecosystem health. It is likely that tangible systemic shifts would require stakeholders to take on persistent practice related to the new knowledge. This approach is contrary to directed, linear, top-down interventions that have seldom delivered just and sustainable outcomes. People within the complex systems need time to practise and accept new ideas.

3 | THE ASA

The elements of the ASA theoretical framing are not new (Palmer, Munnik, et al., 2018). The creativity in the ASA is in integrating

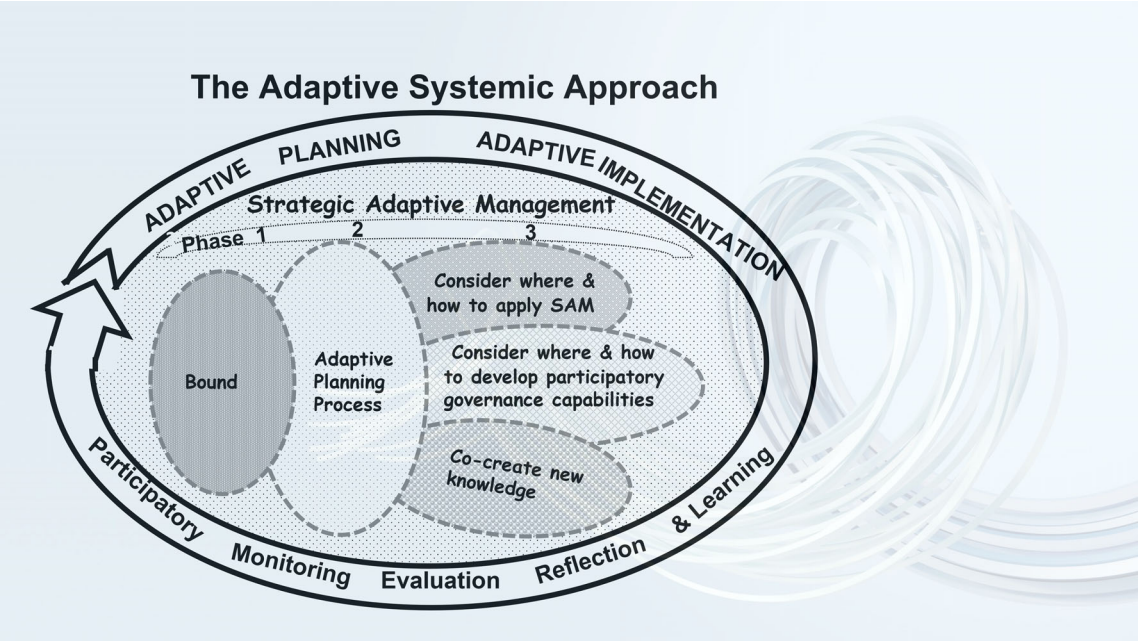

FIGURE 2 Schematic of ASA showing phases of the process and learning cycles, with iterations indicated in a forward spiral.

three core concepts, and associated ways of thinking, into a *practical, theoretically sound, research practice* that increases the likelihood of just and sustainable river and natural resource development and use.

The ASA is designed to use co-produced knowledge, embedded in local capabilities, to encourage stakeholders to participate in adaptive river basin/natural resource governance, for local social and ecological benefit. In this paper we write in terms of an engaged research program related to problems in river/water catchment/basin development. The ASA is applicable in other natural resource contexts. We now describe each of the ASA phases and associated activities, referencing the underpinning details of practice.

3.1 | The ASA Phases

The ASA is undertaken as a set of phases (Figure 2), taking Strategic Adaptive Management (SAM) as the primary practical scaffolding and operational process. The SAM elements of Rogers and Biggs (1999), Kingsford and Biggs (2012) and Palmer, Munnik, et al. (2018), are disaggregated and expanded and stakeholder engagement proceeds iteratively, with repeated interactions, where insights into a new way of working are generated.

As shown in Figure 2, the ASA requires, and is 'held by', iterative strategic adaptive learning cycles (the encircling arrow) that include adaptive planning and adaptive implementation, interspersed with participatory monitoring, evaluation, reflection and learning (P-MERL). In an ASA project, sets of activities are initiated in three phases. In the initial phase, the project scope is **Bound** in social and biophysical dimensions. The next phase comprises one or more **Adaptive Planning Process** facilitated workshops with researchers and project stakeholders. The process then moves into a more dispersed phase of activities that build knowledge and practice: (1) Researchers may work with individual, or groups of, participants to **explore the application of Strategic Adaptive Management (SAM)** in the project as a collective of stakeholders, and/or in the participating stakeholder organisations. (2) Since participants are likely to include both government and non-governmental stakeholders, researchers may **facilitate the development of participatory governance capabilities** among stakeholders. (3) **New knowledge is co-created** in the project, through collective activities, and researchers may also undertake specific, supporting, specialised research. Phases may overlap through time, with flexibility in initiating phases. Continuing strategic adaptive learning cycles of ASA praxis are possible.

3.2 | Strategic adaptive learning cycles

Applying the ASA requires engaged researchers to adopt an iterative working style in which they are attentive to collective adaptive planning which includes: recognising indicators of progress related to the project plan; co-learning while planning, monitoring indicators; reflecting on progress and learning; and adapting the plan as needed (the arrowed circle, that spirals forward, in Figure 2). The inclusion of participatory monitoring, evaluation, reflection and learning (P-MERL) (Human, 2019; Rosenberg & Human, 2018) in the iterative cycle, pays explicit attention to embedding social learning in the ASA, and to a deepened expansion of conventional log-frame monitoring and evaluation. Cockburn et al. (2018) highlight participation, reflection and learning as functionally essential for monitoring and evaluation to become effective in delivering complex sustainability project outcomes.

3.2.1 | ASA Phase 1–Bound

System bounding is a foundational step in systemic approaches (Weaver et al., 2017) and includes: identifying research boundaries in social (who) and biophysical (where) dimensions; recognising boundaries as permeable and open to outside influence; and allowing for nuanced contextual considerations. Stakeholders (or actors), include people related to a problem through being impacted, having governance responsibilities or simply having an interest. For example: local residents, civil society, non-governmental organizations, representatives of private enterprise, representatives from institutions at all relevant levels of government, and researchers. The bounding phase includes (i) desk-top gathering of relevant documents and existing datasets, (ii) establishing stakeholder relationships, and (iii) co-developing a common understanding of: the project purpose (including developing research questions); the existing governance system for natural resource protection and use; and the meaning and practice of P-MERL.

3.2.2 | ASA Phase 2–Adaptive Planning Process

Rogers and Luton (2011) developed the Adaptive Planning Process as a futures-focussed process necessary for adaptive management—hence *Strategic* Adaptive Management. In the ASA, the stakeholder engagement that was initiated in the "Bound" phase is collectively formalised in a facilitated Adaptive Planning Process workshop (Palmer, Rogers, et al., 2018). During the ongoing RESBEN project we have found that travel distances, no-shows, and other discontinuities mean that the Adaptive Planning Process workshop may have to be repeated, to bring in 'missing' stakeholders. When this occurs, the research team focuses on securing overlapping representation at subsequent workshops and representing views from previous workshops. The research team strives to have at least one event where all the most active stakeholders meet one another. Meeting together fosters the recognition that everyone has some valuable knowledge to contribute (a central tenet of transdisciplinarity), and stakeholders experience a facilitation style that emphasises equal respect for all participants (Palmer, Rogers, et al., 2018)—which challenges the inherent power imbalances in many contexts of water resources development (Cleaver, 2012).

In a collective process of planning water resource management in a small town and its river basin, Ralekhetla (2018) probed the epistemic justice of the Adaptive Planning Process. Epistemic *in*justice means: a wrong done to someone in their capacity as a knower (Fricker, 2007). The corollary, epistemic justice, involves respecting people as knowers without prejudice, or contextual exclusion, and ensuring they are enabled to speak and listen, using a sufficiently common vocabulary. The Adaptive Planning Process workshop was designed to be attentive to epistemic justice. One mechanism of equalising participation is to ask each person to write down their top three contributions to a question. Then to randomly request individuals to share their top idea, going around all participants, until everyone has contributed, and all ideas/contributions have been captured. Contributions are captured in real time on large sheets, in the participants' own words, so everyone watches their own contribution/s written up, kept, and referred to. Everyone experiences contributions being elicited irrespective of (e.g.) gender, age or hierarchy, and experiences being listened to accurately and attentively. Participants' reflections spoke of experiencing being respected (Ralekhetla, 2018). An experience of respect is not sufficient to ensure epistemic justice, participants from varying backgrounds, institutions or language groups, may need prior engagement and co-learning to ensure they have a sufficiently comprehensive vocabulary and understanding to fairly voice their knowledge. In this regard, 'Learning Words' work sessions, as practised in the Eastern Cape learning site (Palmer et al., 2022), are recommended in conjunction with ASA workshops.

In an Adaptive Planning Process workshop, the first activity is to record the immediate concerns (worries) that each stakeholder has regarding the project problem-space. It becomes clear the workshop timeframe is insufficient to address each of the concerns, but everyone has seen their top-of-mind worries recorded. The group is then facilitated into following the Adaptive Planning Process. At the end of the workshop participants back-check to assess whether an implemented set of actions (based on an objectives hierarchy), are likely to have addressed the identified concerns.

Having focussed on a troubled present, stakeholders are encouraged to mentally 'jump into a desired future' and to collectively craft a vision of their context with the project problem effectively addressed. This vision becomes the overarching goal of a hierarchical set of planning objectives. Stakeholders then explore their shared and differing *values*, to enhance the trust-building necessary for grappling with conflict over contested issues, which can arise in the future (Pollard et al., 2014; Ratner et al., 2017).

Stakeholders progress to share diverse perspectives on, and knowledge about, the problem context. Together, they consider and discuss social, technical, economic, environmental and political factors (Kingsford & Biggs, 2012; Pollard et al., 2014), which, together with values, constitute a VSTEEP analysis. The VSTEEP considerations allow stakeholders to identify the existing elements of their problem system that must be supported to progress towards the vision, and the contextual threats to the system. Both aspects influence the identification of objectives that will enable progress. Stakeholders then pause and connect to P-MERL: they consider potential indicators of project outcomes, thinking through practicalities of monitoring (what, when, how often, by whom), to support demonstrating progress towards the vision; and reflect on their social and individual learning.

Shifting the intractable problem-space towards an improved state requires stakeholders to identify agreed actions. The intention to act collaboratively is signified by co-building an 'objectives hierarchy' or plan to achieve the vision (Palmer, Rogers, et al., 2018; Rogers & Luton, 2011). For example, a foundational objective of building trust among stakeholders is necessary to meet a higher-level objective of developing participatory governance capability among stakeholders not previously exposed to governance skills. Stakeholder- and

governance-mapping is also required for developing participatory governance capability.

Ongoing engagement is required to: refine the objectives hierarchy, establish who will take responsibility for implementation, and undertake monitoring (which indicators will be monitored to track progress, by whom, and how stored/made accessible). The workshop opens up these possibilities, but the work of Strategic Adaptive Management has only just begun.

3.2.3 | ASA Phase 3–Building knowledge and practice

After the Adaptive Planning Process workshop/s the project moves into a more dispersed phase of activities that build knowledgeable practice.

Exploring the application of Strategic Adaptive Management

Engaged researchers move into a phase of connecting with stakeholders—as individuals or organisations—to encourage them to apply Strategic Adaptive Management in their organisations—particularly in relation to the problem context of the project. The project itself can also run on the basis of Strategic Adaptive Management. This phase often includes setting some more modest goals, that can be met within the project duration—and can also elicit enthusiastic stakeholder buy-in. Establishing communication among stakeholders is vital and setting up social-media platforms has proved useful.

Participatory governance capability development

The outcome of local people becoming more able to engage in the governance of natural resource development or use, and to be involved in decisions regarding problems they experience, is not easy to achieve (Cleaver, 2012; Porter & Birdi, 2018). Multiple relationships and causal factors are at play (Pollard et al., 2014). The ASA provides a pragmatic start and foundation, which can be built on into the future.

In Phase 1, BOUND, researchers should have scoped the relevant river basin or natural resource governance system, identifying who (individuals and institutions) makes which decisions, about what, when, and with whom. After the Adaptive Planning Process workshop/s, engaged researchers can begin to build on this governance map, using a range of methods that strengthen relationships among stakeholders (Blackstock et al., 2015; Denney et al., 2018). The relational focus of the ASA does not prevent conflict and contestation, rather it builds a foundation for negotiation, and seeking consensus or at least a record of what stakeholders can all consent to. Stakeholders experience 'the best way for me to get what I want, is to work to ensure that others get what they want' (Professor Kevin Rogers *pers. comm*., Rogers & Luton, 2011).

Local residents in, for example, remote parts of river basins, do not always have the skills and vocabulary to easily enter land and water governance spaces and institutions. The ASA provides occasions for those with formal governance responsibilities to meet and collaborate with those experiencing land and water issues. Relationships are built, and trust can emerge. In one of the research projects out of which the ASA was conceptualised (Cockburn et al., 2018), Palmer et al. (2022) co-developed with stakeholders a participatory governance Capability Pathway. The Capability Pathway describes a set of skills, and the processes, that are required for local people to become more included and influential in the management of the landscapes where they live.

The Capability Pathway focuses first on building equitable knowledge and vocabulary concerning the project. Learning the vocabulary of government officials, natural resource managers, a range of users, and different researchers takes time. If this 'knowing' skills development is neglected, epistemic injustice is a likely consequence, because it is easier to exclude the knowledge of people who are less articulate. It is here that multi-lingual contexts may require effective translation, and activities that are facilitated in a local language. The Capability Pathway focus moves to developing skills in both listening and speaking, with groups of people whose activities are conventionally separated (e.g., people in government and people who live in the river basin). These foundational steps facilitate institutional arrangements that allow for participation. The goal is for local people to become actively involved in planning and management decisions.

Co-creating new knowledge

Researchers and stakeholders learn together, from each other, throughout an ASA-based project—co-creating new knowledge. In addition to the process-based learning there can also be new research addressing specific aspects of the problem space. In the RESBEN project we undertook focussed research addressing aspects of both biophysical and social questions—paying close attention to the mechanisms of building transdisciplinary collaboration in teams who were more used to siloed discipline-based research.

4 | ASA PRAXIS IN AFRICA

The application of the ASA is currently being collaboratively researched in six African countries by 11 university research teams, in the RESBEN project. Additionally, three established South African research sites offer opportunities for co-learning. Here we demonstrate how the ASA has informed the overall RESBEN design (Figure 3), and consider the context of each of the country-based projects (Table 1). We also acknowledge the huge impact of COVID-19 on RESBEN, particularly in terms of travel restrictions, group and individual isolation, and unstable project funding. The disruptions of this historic period challenged the adaptive capacity of the ASA to the full.

4.1 | RESBEN design

Each country-based project focused on a river basin problem phrased as an ASA research question. Q1: *How is water being used to whose*

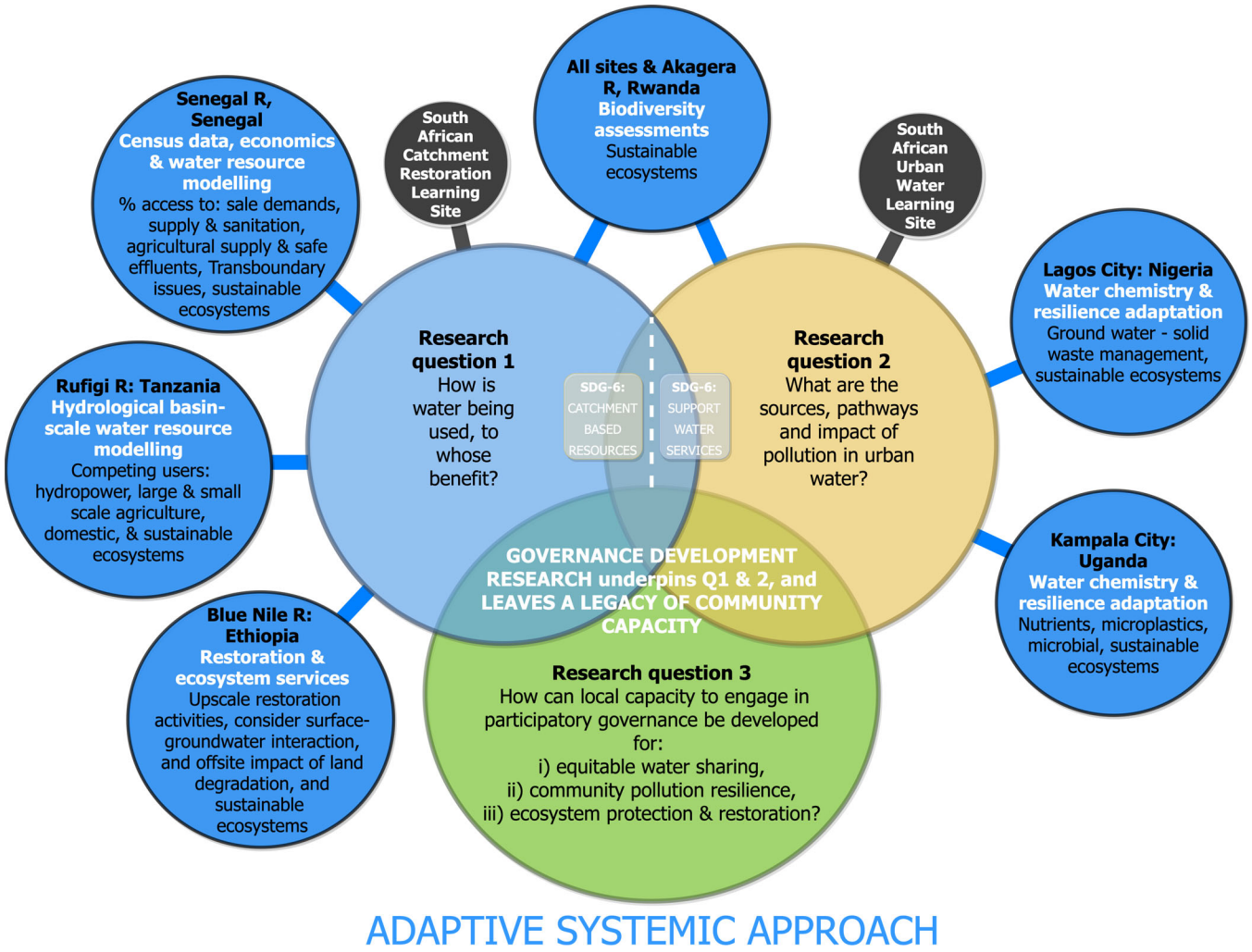

FIGURE 3 The original ASA RESBEN project design. At the centre is the motivating goal of seeking to create local change in the context of SDG 6 (Clean Water and Sanitation). A third learning site was added in the early stages of RESBEN.

benefit?–in the Blue Nile River, Ethiopia; Rufiji River, Tanzania, and Senegal River, Senegal. Q2: *What are the sources, pathways and impacts of pollution affecting local, vulnerable communities?*–in two city freshwater systems, ground water in Lagos, Nigeria and a river canal of Lake Victoria in Kampala, Uganda. Spanning both these questions, in Rwanda the focus was the value of aquatic biodiversity in the Akagera River basin, and the use of biomonitoring in river basin management. In all six country-based projects, researchers investigated Q3: *The ways local participatory governance capability can be developed*. The RESBEN country-based projects are supported by 'learning sites' in South Africa where existing research is complementary. Figure 3 illustrates the RESBEN project design.

RESBEN design was functional as well as structural. At the start of the RESBEN project, researchers concurred in aspiring to ethical research, where we seek to avoid extractive behaviour avoiding situations where stakeholders contribute generously without even feedback on the value of their contribution. We acknowledge researchers' careers will be advanced and students will graduate. In balancing this, we take care to communicate clearly with stakeholders the time frames and realities of beneficial outcomes and impacts likely to accrue on the ground. The problems will not be 'solved'. Stakeholders in each context will have met, experienced respectful social co-learning and will have been exposed to the idea of the ways complex social-ecological systems work–and therefore the advantages of practising Strategic Adaptive Management.

4.2 | RESBEN project contexts and early ASA learning

In Table 1 we thumbnail the biophysical and management context of the country-based projects and the learning sites, and identify a key learning that emerged from each. In Table 2 we go on to demonstrate how the key learning that emerged in a specific place, was recognised in the other sites. (Further comparative details are provided as supplementary material, in a Supplementary Table of country-based stakeholder engagement processes).

These key learnings are:

TABLE 1 RESBEN project and learning site contexts and key early learnings.

Country, project location and references	Core river basin management and societal issues	Relevant current management activities	Key early learnings from using the ASA in RESBEN
Ethiopia			
Blue Nile River: The Aba Gerima and Debre Yacob watersheds are in the Lake Tana basin and are typical of the Ethiopian highlands. Hurni et al. (2005) Gashaw et al. (2020)	Widespread loss of vegetation cover has contributed to excessive surface run-off, accelerated rates of soil erosion, and conflict over water resources. Project activities were disrupted by national political conflict.	Landscape restoration activities, and restricted grazing have enabled communities to use shallow ground wells more sustainably for domestic uses and higher market value crop production.	*Take account of context-specific complexity, including politics*. Political uncertainty alerted teams to the need for flexibility in the number, timing, and form of Adaptive Planning Process workshops.
Senegal			
Senegal River: Lake Guires is contiguous with the transboundary Senegal River—a vital freshwater water resource within Senegal. Seck et al. (2009)	Challenges include inequitable water access, pollution, lack of stakeholder involvement and coordination among water management initiatives and policies.	With a long history of transboundary water resource management and development, the Senegal River has been cited as a successful model of transboundary water governance.	*Develop stakeholder connectivity as an essential foundational process*. The ASA in Senegal uncovered gaps in stakeholder connectivity and demonstrated the value of extensive, often direct and personal stakeholder engagement, and the use of social media 'Whatsapp' groups.
Tanzania			
The Great Ruaha River Catchment (GRRC) in south-west Tanzania is the largest catchment of the Rufiji Basin. The catchment is the site of intensive multi-water use. Yang and Wi (2018)	Intense competition between water users including large and small-scale irrigation users (upper reaches), natural and protected ecosystems (middle reaches), and hydropower generation (lower reaches).	There is inadequate management and monitoring of the competing water demands, water allocation and use; and preferential allocation of water-use permits to large-scale users. Water competition may worsen with planned large-scale agricultural and hydropower development	*Do not underestimate the power of vested interests*. There is clearly a gap between what is theoretically and practically possible in relation to more equitable water allocation. Although biophysical research has developed scenarios for more equitable water allocation, there are clear political and institutional barriers.
Rwanda			
The transboundary Akagera River between Rwanda and Tanzania is impacted by sediment transport that impacts water quality and aquatic biodiversity. Wali et al. (2011) Zaky et al. (2018)	Elevated suspended sediment and turbidity provide a motivation to include bioassessment, including citizen science, as a participatory pathway into national water resources management protocols.	At present there is only physico-chemical water quality monitoring in Rwanda. The formation of river catchment-based committees, and community members exposed to linking their local knowledge to formal biomonitoring, provides the opportunity for developing both biomonitoring and participation.	*Experienced facilitation is necessary*. Exposure to experienced ASA thinking and practice enabled the biodiversity specialist research team to catalyse practical outcomes for researchers, local community members and government officials.
Nigeria			
The city of Lagos, at the mouth of the Ogun-Osun River, is mainly supplied by groundwater from the Coastal Plain Sands Aquifer. There is significant urban surface- and ground water pollution linked to inadequate sewage and solid waste management exacerbated by poor drainage systems. Olufemi et al. (2010)	Lagos residents, particularly in lower-income areas such as Bariga and Ojota, are exposed to poor water quality and resultant water-related health and amenity risks.	In situ groundwater pollution is intractable, and conventional pump and treat approaches do not protect Lagos residents from the intimate surface-groundwater linkages that lead to every-day exposure.	*Be imaginative when drawing in government stakeholders*. Government officials are busy and often difficult to secure in direct engagement. The Lagos team ran a course in ground water quality management for government officials with the ASA workshops as part of the course—offering a direct value for participation. Involving youth participation was also an innovation.

TABLE 1 (Continued)

Country, project location and references	Core river basin management and societal issues	Relevant current management activities	Key early learnings from using the ASA in RESBEN
Uganda			
The Nakivuno channel in Kampala feeds into Lake Victoria. Organic and inorganic materials are regularly dumped in the channel, impacting the lives local of residents and water quality in Lake Victoria Banadda et al. (2009) Note: The key learning in this case was not related to the bio-physical or resource management context, but rather in relation to the functioning of the research team.	Vulnerable communities in low lying areas of Kampala city live within metres of the Nakivuno channel and are routinely exposed to contaminated water.	Government stakeholder relationships were already well-developed, and the innovation as the direct connection with stakeholders experiencing problem, in a context where research proved additional knowledge and a catalytic facilitated process.	*As the ASA is implemented using the generic design, regular 'reality checks' and appropriate adaptations are needed.* RESBEN in Uganda was radically disrupted by the untimely passing of research leader, Professor Banadda. In an abrupt 'reality check', timelines were extended, and deliverables modified for the Ugandan project. Experiences from other countries were shared for rapid catch-up, and students supported. Mutual care fostered trust among the large multi-country teams.
SA learning site: Cape Town			
The learning site is focuses on the Stiebeuel River–a small tributary of the Franschhoek River in Cape Town. It receives urban effluent and flows through an informal settlement with inadequate sanitation, and on into an area of high-value fruit production. Winter et al. (2023)	Water quality management is deteriorating in South Africa. The Cape Town research team is investigating nature-based water remediation, and is seeking to bring together farmers, local residents and to draw in government officials.	The weak and deteriorating water governance and water infrastructure development and maintenance leaves many water users in an institutional vacuum.	*It is possible to introduce social science elements of the ASA into natural science-focused research portfolios.* The Adaptive Planning Process was the first step towards broadening a bio-physical research programme into a CSES consideration of the study site, and in the process, mobilising stakeholders.
SA learning site: KwaZulu-Natal			
The montane grasslands of the Upper uThukela River catchment support protected areas, forestry, commercial and subsistence agriculture. This critical bulk water source landscape is degraded, with biodiversity loss, water insecurity, and inequitable water resource benefits for residents. (Henriksson Malinga et al., 2018) (Turpie et al., 2021)	Resident rural communities struggle with severe erosion, depleted and/or contaminated water sources, biodiversity loss and alien plant invasion, inadequate or absent water supply infrastructure, poor communal land management–including overgrazing, and a lack of coordination and collaboration among catchment stakeholders.	In the absence of government interventions, a multi-stakeholder catchment partnership is being established to coordinate the scattered initiatives for alien clearing, spring protection, biodiversity conservation, and restoration–developing a collaborative, co-learning network.	*ASA workshops foster confidence in collaborative action.* Workshop facilitation that is sensitive to epistemic justice catalysed experiences of collective inclusivity and strengthened the formation of the catchment partnership.
SA learning site: Eastern Cape			
The Tsitsa River catchment is a largely natural rangeland under communal grazing, with vegetation cover loss and extensive erosion. The learning site is associated with the Tsitsa Project which provides a working example of many of the ASA elements. Integrated. activities link researchers, communities and land and water institutions. Cockburn et al. (2018) Palmer et al. (2022)	Rural communities face similar problems to those in the Upper uThukela River catchment. The government-sponsored, research-based landscape restoration Tsitsa Project explicitly aimed to link restoration to sustainable livelihood development and the emergence of a resilient social-ecological system with equitable access to ecosystem services.	The Tsitsa Project funding was terminated early, and currently there are no government-funded restoration or livelihood development interventions. The ASA design drew on the Tsitsa Project experience while it was still active, and in RESBEN particular attention has been paid to moderating stakeholder expectations.	***'Learning words' work sessions are a valuable addition to ASA workshops.*** Creating a common vocabulary so that stakeholders can understand and learn from each other is a practical way to foster epistemic justice and is a useful prelude to ASA workshops.

Note: Each site-generated learning was later recognised in the other contexts (Table 2).

1. Take account of context-specific complexity, including politics.
2. Develop stakeholder connectivity as an essential foundational process.
3. Do not underestimate the power of vested interests.
4. Experienced facilitation is necessary.
5. Be imaginative when drawing in government stakeholders
6. As the ASA is implemented using the generic design, regular 'reality checks' and appropriate adaptations are needed.
7. It is possible to introduce social-science elements of the ASA into natural science-focused research portfolios.
8. ASA workshops foster confidence in collaborative action.
9. 'Learning words' work sessions are a valuable addition to ASA workshops.

There were also key learnings that were immediately evident across all the country-based projects and learning sites:

10. An ASA-based project can initiate change towards social-ecological justice, however material changes in ecosystem health and social indicators will take sustained practice. Exposure to the possibilities of more equitable engagement, and positive trajectories of change are demonstrable.
11. Participant feedback affirms the ASA opening opportunities for stakeholders to speak and be heard.
12. Using a home-language as the primary medium in workshops, with translation into English where needed (rather than the reverse), as well as empathetic facilitation, sensitive to epistemic justice, were critical elements of content communication and trust-building.
13. Although all RESBEN researchers contributed to ASA design, large gaps and differences in conceptual thinking and practical experience became clear. It requires active training and mentorship to expand and deepen ASA competence.

5 | CONCLUDING REFLECTION: POTENTIAL TO BREACH BARRIERS

In this special issue addressing *human-river relationships in the 21st century*, attention is paid to the challenge of ensuring that the river ecosystems on which people depend, remain healthy and functional into an era of unprecedented change. Given that we have been unable to protect aquatic ecosystems well up to the present, this is indeed a challenge. The narrative of local people benefitting least from water resources development or being most at risk from pollution is a common theme in the places where the ASA is being trialled. Across Africa, connected river health and human wellbeing issues are apparent. It is into this challenging context that we have offered the ASA.

Using research team experience and reflections on the key learnings and generic recognitions from ASA practice in RESBEN (Tables 1 and 2), we have identified five barriers that decrease the likelihood of research delivering outcomes of improved ecological health and social justice. We conclude by showing how the barriers emerged from the key learnings, and reflect on how RESBEN practice has informed insights into the ways the ASA can breach—if not eliminate—these barriers, benefitting more sustainable river basin management.

5.1 | Lack of an integrative conceptual grounding

This barrier is informed by key learnings 7 and 13.

Selecting concepts and synthesising them into the ASA conceptual framing provides both a validated theoretical foundation, and a point of reference to check the coherence of the elements of practice. The design of the ASA rests on three key concepts: complex social-ecological systems, transdisciplinarity, and transformative social learning. We have described their logical connections, with supporting literature, and have provided an integrated conceptual framing of the approach.

The literature that influences river basin management comes mainly from the natural and engineering sciences, with social science literature less influential. These streams of knowledge are generally published in different arenas. The TD-CSES literature draws the two streams together and the ASA explicitly places the synthetic conceptual framing into a practical and inclusive process.

5.2 | Participatory stakeholder engagement flawed by epistemic injustice

This barrier is informed by key learnings 2, 3, 5, 8, 9, 11, and 12.

Participation is a deep and broad topic and paying attention to epistemic in/justice is an aspect of participation that is easily overlooked. Participatory stakeholder engagement can remain a tick-box exercise that pays scant attention to fairness to all participants. Being attentive to epistemic justice involves ensuring participants have sufficient knowledge and vocabulary, and feel sufficiently respected, to contribute freely and productively. The ASA emphasises facilitation techniques that pay explicit attention to creating experiences of respectful inclusivity as a mechanism of embedding epistemic justice. The use and development of river basins globally is inequitable—converting the remote term 'epistemic justice' into sensible practice serve to counter-balance inequity.

5.3 | Inadequate transdisciplinary team-building

This barrier is informed by key learnings 4 and 13.

Transdisciplinarity has become a 'buzz word'. It is easy to promise and challenging to deliver. Research teams that aspire to 'make a difference' may not recognise the effort required to do so. Deep consistent practice is hard in all the transdisciplinary dimensions: integrating diverse academic disciplines and knowledge forms, seeking to shift intractable complex problems, and engaging in socially embedded practice. Current academic structures and performance criteria do not support the time and effort it takes to become sufficiently informed

TABLE 2 A comparison across countries of ways in which three of the key learnings that emerged in specific countries (Table 1) were applicable in each of the countries and learning sites. Data drawn from the Adaptive Planning Process (APP) phase of the Adaptive Systemic Approach (ASA). (SAM - Strategic Adaptive Management)

Key Learning 1. Take account of context-specific complexity, including politics.	
Ethiopia	The initiating APP was considerably delayed due to distance between government offices and communities, and lack of peace and security in the northern part of the country. The delay resulted in engagement re-design positive two-day learning exchange APP between two communities, with government officials also involved.
Senegal	The ASA process worked well as designed. A one-day initiating APP had strongly positive feedback from participants.
Tanzania	Understanding the nature of varying levels of power of different stakeholders in decision making around water resources allocation was a critical aspect of facilitating stakeholder participation in the APP.
Nigeria	A one-day initiating APP worked well, with positive feedback from a wide range of participants. Establishing that careful facilitation would enable participation, resulted in meaningful collective participation from diverse stakeholders. Team feedback indicated that a 2-day workshop would work better.
Uganda	The initiating APP was considerably delayed due to the death of the Principal Investigator. The delay led to learning from other projects and a well- attended APP with diverse stakeholders.
Rwanda	Distance, accessibility of workshop location, and communication difficulties influenced the absence of government and community participation in the initial APP. This stimulated careful adjustments in planning the next engagement.
South Africa: Cape Town	The APP was adopted late in RESBEN and was ultimately adopted after seeing the ASA practiced in the country-based RESBEN projects.
South Africa: KwaZulu-Natal	Some government department officials, particularly water service operators and coordinators, did not approve of participatory approaches in the development of local community-based water supply solutions, and were difficult to engage with. Water-related rights and mandates are contentious issues.
South Africa: Eastern Cape	The APP was initiated with the Department of Water and Sanitation, and low inter-department trust with the Department of Environment, Forestry and Fisheries, the rehabilitation funder, impaired uptake of APP outcomes into the Tsitsa Project (Palmer et al., 2022).
Key Learning 2. Develop stakeholder connectivity as an essential foundational process.	
Ethiopia	The Ethiopian team was initially led mainly by an established natural scientist. With the active involvement of an experienced social science researcher, engagement was re-imagined and accelerated. The APP was successfully adapted as a learning exchange between communities in two sub-catchments, to explore how best to manage their catchments into post-COVID-19 times, so as to re-ignite restoration maintenance and compliance.
Senegal	After the APP researchers and stakeholders agreed that co-ordinated communication in relation to identified natural resource challenges was the first action to be implemented. To do so the research team took responsibility for initiating this by identifying relevant actors and sending them a bio-physical and stakeholder database and mapping out degradation factors.
Tanzania	Tanzania applied learning from Senegal and implemented co-ordinated communication through stakeholder mapping and regular contact via in-person engagements, WhatsApp messages, emails and phone calls. One researcher was delegated responsibility for stakeholder engagement.
Nigeria	Nigeria also followed the Senegal example and co-ordinated communication is underway. A local, active Whatsapp group worked particularly well.
Uganda	After the appointment of a new Principal Investigator, coordinated stakeholder communication emerged steadily, using all effective modes.
Rwanda	To encourage participation and buy-in into the next phase of engagement, focused on SAM, the research team is employing communication strategies tailored to different stakeholder groups, based on their context, culture, role and interests. Direct personal engagement with government bore fruit.
South Africa: Cape Town	The APP workshop itself and local media were used to communicate with stakeholders.
South Africa: KwaZulu-Natal	APP was introduced into an existing stakeholder engagement process late in RESBEN. Learning from RESBEN, the APP provided a clear structure and direction to the process that was otherwise not much appreciated by the participants. Through the introduction of APP, the communication with stakeholders became more consistent and included knowledge sharing which has sparked collaboration among participants.
South Africa: Eastern Cape	The Tsitsa Project employed a dedicated catchment coordinator responsible for sustained, regular, engagement with regular government (national, regional, local and traditional), NGOs and communities.
Key Learning 3. As the ASA is implemented using the generic design, regular "reality checks" and appropriate adaptations are needed.	
A generic "reality check": the whole RESBEN project was disrupted firstly by COVID-19, and then by the shocking UK 50% budget cut for 2021, with no guarantee of resumed funding. (Funding was restored later in 2022.)	

(Continues)

TABLE 2 (Continued)

Key Learning 3. As the ASA is implemented using the generic design, regular "reality checks" and appropriate adaptations are needed.	
Ethiopia	The APP is designed to be a crucial moment of interchange and co-learning among stakeholders. Armed conflict exacerbated COVID-19 travel restrictions. The possibility of communities facing fines was a barrier to immediate linking with government officials. Planning also took account of rainfall seasonality which affected access to remote sites.
Senegal	In the early stages of RESBEN, Senegal envisaged working at the trans-boundary multinational scale of water sharing among Senegal River water users. With COVID-19, the project was successfully scaled back to water quality issues in the Guiers Lake. Appropriate stakeholders for the adapted challenge participated in the APP, and co- developed objectives and activities they agreed to implement.
Tanzania	The APP workshop process and guide to facilitation is designed to "even out" power imbalances among stakeholders. It was clear that while this was effective in the workshop, actual water access would continue to be driven by power. Attentiveness to power characterised by unequal access to resources, capabilities and rights continues as a primary focus of the Tanzanian team.
Nigeria	After an initially broad urban pollution focus, a "reality check" led to a focus on two specific urban waste sites, where active stakeholder support was a positive factor.
Uganda	The untimely passing of Prof Noble Banadda (Principal Investigator) was the biggest "reality check". The whole RESBEN team across all countries recognised the need to reschedule, replan and pay particular attention to supporting Ugandan student research assistants. As a result, the ASA in Uganda progressed well with strongly participative APP and SAM node workshops, and active community engagement with site clean-ups.
Uganda	The Rwandan "reality check" was that understanding both the implications of the ASA conceptual framing, and practical implementation of the ASA, required close and active mentorship of all the team members.
South Africa: Cape Town	The Cape Town team did not focus on the ASA and RESBEN during COVID-19. When in-person RESBEN training meetings re-started they realised the value of using the APP.
South Africa: KwaZulu-Natal	first "reality check" related to adapting to COVID-19. Many events were shifted online, but local rural stakeholders who did not have access to the internet were engaged at their location as soon, and often, as possible. Their voices forced the "reality check" that equal access to clean water is an urgent priority that cannot be fully addressed without the participation of the absent water service providers.
South Africa: Eastern Cape	The broadly inclusive Tsitsa Project APP was not well linked to later village level engagement with restoration site selection. This emerged too late to redress. The team realised how easy it is to miss critical links in community involvement.

across disciplines to find methodological and intellectual coherence. In RESBEN, the project research teams initially came from science and engineering disciplines. Social science researchers were actively included, and integration was more challenging than initially anticipated. Project teams learned the work needed to motivate and assemble stakeholders, and the program team gathered to co-learn about specific ASA processes such as running an Adaptive Planning Process workshop and engagement with stakeholders to initiate problem-related Strategic Adaptive Management. Conscious commitment to ASA practice drove the emergence of a continental-scale team of transdisciplinary researchers. We will not move into fair systemic river basin use and management without drawing in the widest range people and knowledge, and we will need effective, competent transdisciplinary teams as facilitators.

5.4 | Insufficient inclusion of learning, reflection, and systemic adaptation

This barrier is informed by key learnings 1 and 6.

There is a difference between efficient and effective. Engineering modes of practice in river use and management lean heavily towards prioritising efficiency. The ASA includes processes and practices that take time and can be conventionally dismissed as inefficient. Drawing on experience in the Tsitsa Project (Palmer et al., 2022) the RESBEN team committedly invested time in formally collecting individual and collective reflections using formal reflection to co-learn as a team and with stakeholders. The ASA conceptual framing illustrates the iterative nature of effectively engaging among researchers and stakeholders, throughout a project in cycles of action, reflexive social learning, analysis, and adaptation between iterations. Linking each step to participatory monitoring and evaluation, using reflection, and learning also embeds an iterative adaptive process. A word search of this paper reveals repeated use of 'process, learn, adapt, reflect, time and just'. This is the foundational vocabulary of the ASA. The 21st century river basin use, and management calls for taking time to be effective.

5.5 | Inflated claims of probable impact in terms of creating change towards improved ecological health and social justice

This barrier is informed by key learning 10.

The ASA uses participatory governance development as a mechanism for creating relationships that could support ongoing actions toward ecological health and social justice in relation to natural resource development and use. There is generally some form of formal natural resource governance in a study area, and the stakeholders will generally include people who have governance responsibilities,

and people directly experiencing a problem related to the resource (e.g., lack of access to land and water, landscape degradation, pollution). The iterative stakeholder engagement creates opportunities to build trust among stakeholders and to open possibilities of developing participatory governance institutions or processes. Institutional transformation is necessary for 21st century river basin use, and management.

6 | CONCLUSION

We recognise that the ASA is not a panacea that eliminates barriers—but rather a coherent process that supports consistent reflection on a practice of adapting to barriers. The barriers identified are likely to be common and ongoing, and there will be others—it is the recognition of complexity, connectedness, the powers of social learning and a commitment to adaptation that are the key characteristics of ASA practice. We therefore argue that when ASA-based research interventions end, the embedded habits (Rogers et al., 2013) from co-learning, and possibly participatory governance institutions, will remain, building platforms for effective river basin use, management and further research. We have communicated a carefully designed, theoretically and conceptually sound, integrated approach, the ASA, that we suggest increases the likelihood of 'research with impact'. Furthermore, the ASA will benefit policymakers in natural resource development, and research-funding bodies in supporting research to support natural resource development, exactly by providing a clearly defined and well-founded process that increases likelihood of positive social and ecological impact beyond the life-span of the research and/or development intervention.

AUTHOR CONTRIBUTIONS

Carolyn Palmer: Conceptualization, Methodology, Validation, Investigation, Data curation, Writing—original draft preparation, Visualization, Supervision, Funding acquisition; James Akanmu, Tena Alamirew, Yazidhi Bamutaze, Noble Banadda, Frances Cleaver, Serigne Faye, Isa Kabenge, Alioune Kane, Ezechiel Longe, Joel Nobert, Vanessa Speight, Venuste Nsengimana, Kevin Winter, Sally Weston: Conceptualization, Methodology, Validation, Investigation, Writing—review and editing, Project administration, Funding acquisition; Zerihun Woldu: Conceptualization, Methodology, Validation, Investigation, Writing—review and editing, Supervision, Project administration, Funding acquisition; Jane Tanner: Conceptualization, Methodology, Validation, Investigation, Data curation, Writing—review and editing, Visualization, Supervision, Project administration, Funding acquisition.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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