Re-envisioning the Hydro Cycle: The Hydrosocial Spiral as a Participatory Toolbox for Water Education and Management

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Introduction

Earth and biological sciences conceptualise any number of processes as cycles. Children are taught from an early age various organisms' "life cycles", even as it can be argued that individual organism's lives are chronologically linear and populations' far more interconnected than a unidirectional circle. Elements, too, are understood and taught as cycles: Literature frequently refers to multiple cycles such as carbon, nutrient, ozone, nitrogen, and environmental.

Water is no exception. The "water cycle" or "hydrologic (hydro) cycle" is a well-known name and concept. The basic pattern of precipitation, evaporation, and condensation forms the basis of how most people comprehend water. Yet these basic biophysical processes are far more complicated. The systems we have individually categorized influence each other in myriad ways (Linton et al., 2014; McLaughlin et al., 2007). This chapter reviews how the 'classic' hydro cycle was created in Western hydrological sciences, considers hydrosocial relations literature questioning this epistemology of water, introduces the hydrosocial spiral as a new tool for understanding the movement of water, and provides preliminary results from its application. An interdisciplinary team of authors made up of an anthropologist, and artist, and a hydrologist emphasise the dynamic, iterative approach needed to understand water and its movements in our world.

THE 'CLASSIC' HYDRO CYCLE: A LIMITED APPROACH TO WATER ISSUES

Jamie Linton's *What is Water?* (2010) incorporates an extensive review of the history of the hydrologic cycle, providing a helpful distinction between the origins of hydrology as a scientific field and the creation of the diagrammatic depiction of the hydro cycle. The hydro cycle diagram as we think of it today is a modern creation less than one hundred years old, but humans have been considering water for millennia, often in a cyclical fashion. The Hebrew book of Ecclesiastes 1:7 (quoted in Leopold, 1960) alludes to returning flows; similar ideas can be seen in the works of Greek and Roman philosophers and poets (Brutsaert, 2012).

Pierre Perrault can be considered the world's first 'pure' hydrologist. His 1674 book, *On the Origin of Springs,* sought to describe and calculate water in its different forms. Brickner continued this work in 1905, attempting to quantify global water resources (UNESCO, 1971). Around this time, hydrology became more clearly defined as an academic discipline. A 1931 paper by Robert E. Horton called "The Field, Scope and Status of the Science of Hydrology" established the parameters for the science of hydrology. The paper included the first notable diagram depicting water movements and an argument for separating the natural and social aspects of water, sparking discourse around a diagrammatic representation of biophysical water flows. Diagrams varied extensively for the first decade, as hydrologists considered various potential depictions. Eventually, Thorndike Saville coined the term "hydrologic cycle" to describe the depiction referred to here as the 'classic' hydro cycle (Linton, 2010). The United States National Resources Board published early versions of this diagram in 1934 (Linton, 2008), with Mienzer's 1942 textbook including similar ideas.

Today's hydro cycle diagrams look much different than Horton's first depiction in 1931, but surprisingly similar to the one published by the National Resources Board in 1934. Visual changes are more numerous than conceptual alterations: The diagrams found in an average primary school textbook currently look more realistic, but continue to show arrows representing unidirectional flows of water through almost entirely biophysical processes. Compare **Figure 1** (National Resources Board, 1934: 262; from Linton, 2008: 638) with **Figure 2**, the current depiction of the hydro cycle by the United States Geological Survey (US Geological Survey, 2016). The graphics are improved aesthetically and more processes are shown in **Figure 2**, but the two are incredibly close theoretically, especially given the nearly 80 years of modern scientific research separating them. The current hydro cycle depicted by the US Geological Survey can thus be considered the 'classic' hydro cycle.

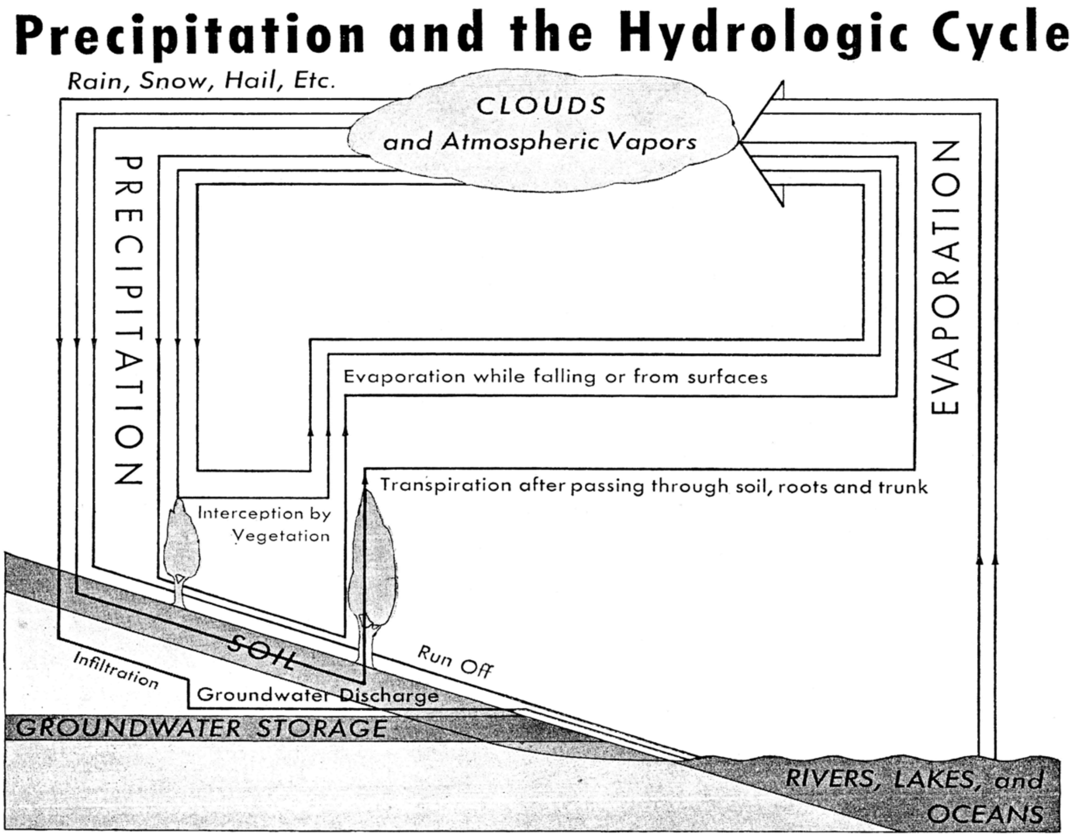

Figure 1. Hydrologic Cycle, National Resources Board, 1934.

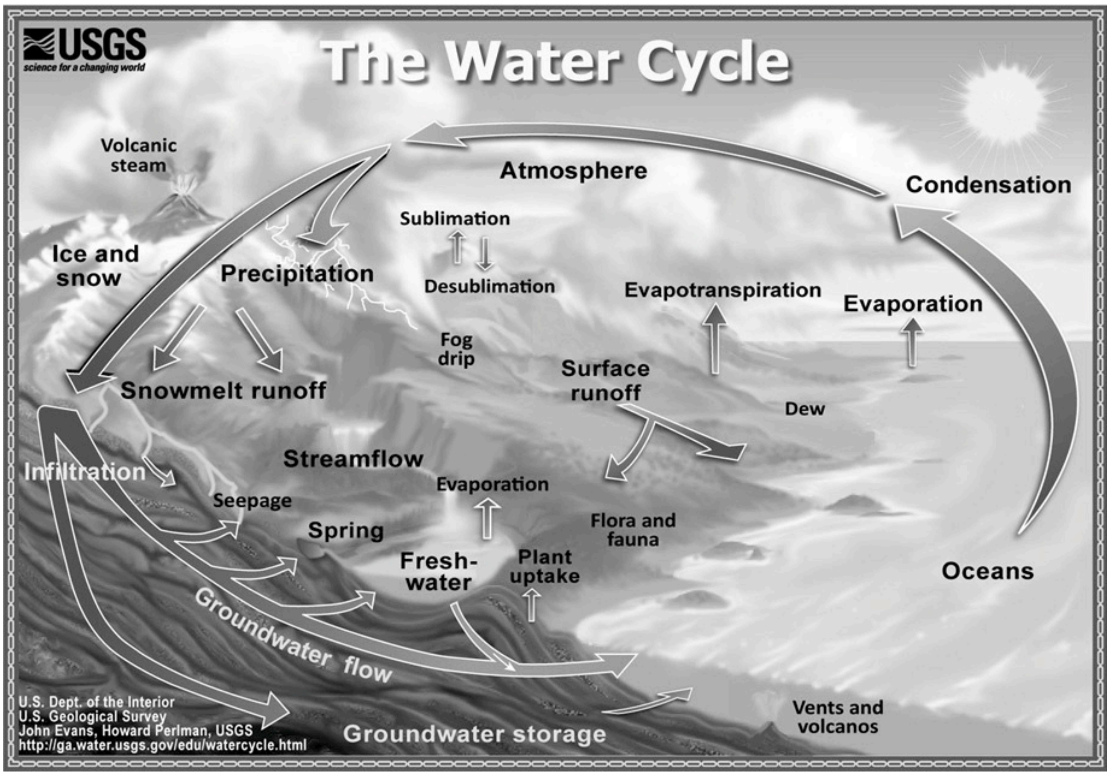

Figure 2. The Water Cycle, US Geological Survey, 2016.

Since the 1934 publication of the US National Resources Board's hydro cycle diagram, various versions of the classic hydro cycle have been used in teaching natural sciences. There has been relatively little research on students' knowledge and perspectives of the hydro cycle (Shepardson et al., 2009), though it is taught in most classrooms as part of science curriculums, and so widely accepted that a basic understanding of the classic cycle is necessary for what Cockerill refers to as "water literacy" (2010: 151). Cockerill posits that not understanding the basics of hydrology (e.g., believing that the planet could literally run out of water) decreases people's willingness and capacity to take action or change habits around water use. Cockerill ran a program in North Carolina 'translating' hydrology and scientific knowledge to make it accessible for a general audience, reinforcing the classic hydro cycle.

Nor is this emphasis limited to Western classrooms. Taiwo et al. (1999) explored how the hydro cycle is understood by schoolchildren in Botswana, arguing that schooling "positively influenced" children's perceptions of the hydro cycle while the "'untutored ideas the children brought to school'" (e.g., "clouds are made by gods") negatively influenced their knowledge of water. Viewing the classic hydro cycle as the only 'accurate' understanding privileges Western epistemologies of water. Through these approaches, the hydro cycle has become a part of colonisation and globalisation processes, yet another means through which indigenous forms of environmental knowledge are marginalised.

Of course, not all educators adhere to this limited approach. Davies and Seimears (2008) suggest that "unpacking" the multiple components of water (chemistry, biological function, societal uses, etc.) is necessary for teaching. Students, teachers, and groups can then pull ideas and issues together. Similarly, Eisen et al. (2009) use water as a case study for interdisciplinary teaching; their paper provides a guide for two water modules that combine the literature, art, philosophy, and science of water.

In many ways, pedagogy and educational practice are reflections of broader public discourse. Public participation around water-related discourses influences their knowledge of and interactions with water (Fosen, 2012). For example, Moran (2008) discusses how people's engagement with composting toilets and greywater systems in their homes can motivate and catalyze policy around sustainability, while hidden, unacknowledged septic systems in the ground do not help improve awareness. At the same time, Stenekes et al. (2006) urge against supporting rhetoric that blames "public ignorance" and "cultural bias" for the failure of programs like water recycling, believing that this produces and reinforces a dichotomy between lay and expert opinions around water issues.

As Fosen, Moran, and Stenekes et al. demonstrate, public discourse does not stay stagnant over time, nor does academic discourse. The result is that many issues surrounding water that academics and research explore are not adequately conveyed by the classic hydro cycle. This is not to say that all hydrologic research is inevitably flawed, but rather that *the possibility exists*. Barnes (2001) reminds us that the dominant theories leading academic disciplines change over time. The classic hydro cycle was created in a time when epistemological theorising was dominant. However, Barnes suggests that hermeneutic theorising is gaining prominence in economic geography, focusing on interpretive and reflexive thinking and work. As underpinning theories and assumptions change in a discipline, so too should primary teaching and communication tools. The next section will review how thinking around water is changing in a number of disciplines, as scholars and practitioners place more emphasis on the dynamic interactions between human society and ecosystems.

TOWARD A MORE HOLISTIC APPROACH: HYDROSOCIAL RELATIONS

While the classic hydro cycle has been a powerful tool for teaching and communication, its gaps are indeed many. Phrases like the "hydro-illogical" cycle (Wilhite, 2011) show that scholars now consider the classic model inadequate, and perhaps even harmful. Today's water knowledge is different than knowledge dominant as recently as the 2000s, let alone the 1930s. Beck's 1984 "Topic of Public Interest: Water Quality" reflects on how post-war management impacted the collection and availability of empirical data and thus academics' ability to pay more attention to individual behaviour, pollution, and the like. His work serves as another reminder that our awareness has expanded since the hydro cycle was first conceptualised and created: The classic cycle cannot be expected to retain its power or accurately reflect what we know about water today.

This is not to say that we now know everything, or that a 'perfect' depiction of water movement could be created. Beven highlights just how difficult hydrologic modelling is, acknowledging that in hydrology, the non-linearity, fluxes, and storages of water are hard to know entirely. "The closure problem [boundary fluxes of mass, energy, and momentum in a watershed] is a scientific Holy Grail: worth searching for even if a general solution might ultimate prove impossible to find" (2006, 609).

Perhaps most obviously missing from the classic hydro cycle are humans: The vast majority of diagrams do not include a single individual or societal influence, appearing as animal- and human-free landscapes. This remains the case even though humans use, disrupt, redirect, and recycle water flows in a multitude of ways. Concepts like the "precipitationshed", which refers to the upwind land and ocean from which rain in one area evaporated, recognise that actions in one area impact water availability, quality, and flows in other areas. Local actions have global impacts; global trends affect local issues – even as we continue to "lack an adequate understanding of how the overall system works" (Vörösmarty et al., 2004: 513). In the introduction to the "Geographies of Water," Fonstand (2013) points out that many of these human-induced changes are not new, but neither are they fully known. It is clear we need to better understand and respond to the connections between humanity, hydrologic flows, and ecosystems.

There is a "complex web of interaction" featuring a great many feedbacks in human-environmental relations (Harden, 2012). Castree (2002) sees a society-environment nexus (a networked series of connections) rather than dichotomy, shaped by a dialectical synthesis between humans and their environment. Other scholars engaged in socio-hydrology (Swyngedouw, 2006), explore how "water and society make and remake each other over space and time" through the hydrosocial cycle (Linton, et al., 2014; Linton and Budds, 2014), or posit the socio-cycle of water use and management (Turton, 1999). These versions of the cycle include "a flow not only of H_2O, but also one that is saturated with all manner of power relations" (Swyngedouw, 2006: 15; see also Swyngedouw, 2009). These schools of thought are more fully detailed in Schmidt's "Historicising the hydrosocial cycle" (2014).

In opposition to Horton's vision of the hydro cycle as unbiased by scholars, Budds (2009) points to the wealth of literature arguing that physical assessments are not neutral and that studies are shaped by users' understandings. In "Privatizing Water, Producing Scarcity: The Yorkshire Drought of 1995", Karen Bakker (2000) challenges conventional interpretations of the Drought, arguing that drought can be understood as the *production* of scarcity through the combination of meteorological modelling, demand forecasting, and corporate restructuring and regulation. The work of Budds, Bakker, and similar authors argues that the classic hydro cycle is the product of human framing rather than external, static, biophysical fact. Because of this, Budds (2009) argues that we need to consider both socio-political factors as well as geoclimatic ones in analysing waterscapes. We need to understand "the ability and limits of freshwater ecosystems to respond to human-generated pressures" in the midst of "altered hydrological regimes" (Naiman and Turner 2000: 958).

Natural scientists are beginning to do that reframing, considering quantitative hydrological science in a social context (see Sivapalan's 'socio-hydrology', 2012). According to Wesselink et al. (2016) socio-hydrology has the potential to bridge the gap between quantitative and qualitative measurements and may provide a baseline for hydrosocial analysis.

GRAPHICAL GRAPPLING: THE UEA HYDRO CYCLE WORKING GROUP

Building on the emerging hydrosocial scholarship, a Hydro Cycle Working Group was convened by the Water Security Research Centre at the University of East Anglia. The interdisciplinary team included anthropologists, engineers, historians, and hydrologists from around the world with a mandate to identify gaps in the classic hydro cycle, determine which missing elements were most critical to communicate, and explore the creation of a new illustrative diagram more holistically capturing the way water moves.

The Group's discussions resulted in a list of some fifty geophysical aspects and more than seventy political, economic, and social considerations that would need to be included in a nuanced model of planet-wide hydrology (see **Figure 3** for a partial list of these issues). Research also demonstrates that various relatively simple alternative hydro cycles have been proposed by water activists and scholars. Consider a version of the hydro cycle focused on recycling processes (**Figure 4**), the idea that "water flows uphill to money" illustrated by Kate Ely (**Figure 5**) or exchanging hydro cycles visualising the concept of virtual water as envisaged by Francesca Greco (**Figure 6**).

Figure 3. Non-Exhaustive List of Elements to Incorporate in Hydrosocial Models (generated by the Hydro Cycle Working Group)

Political, Economic, Cultural Aspects	Geophysical Aspects
Aesthetics Agriculture Biodiversity and environmental concerns Bioenergy Colours of water (blue, green, grey, etc.) Cloud seeding Consumption patterns Consumptive vs. Non-consumptive uses Corporate vs. national vs. regional vs. household vs. individual uses of water Dams Ecosystems goods and services Efficiency Gains, losses, and the paracommons Fisheries and aquaculture Industries Metaphysical and Spiritual Issues Outflow Political borders Pumping Quality Pollution (acid rain, ocean plastics, etc.) Recreation (water parks, swimming, etc.) Recycled water Manufactured reservoirs Rural vs. Urban use Securities (food, water resources, state, energy, community, economic, etc.) Transport Waterways Users and sectors Virtual water Use in services 'Water flows uphill to money' Water-Energy-Food Nexus Wastewater attitudes	Advection Aquifer storage and recovery Climate change Condensation Deep percolation Erosion and Geological processes Estuaries Evaporation Glaciers Groundwater Hydrofracking Hyporheic zone and flows Infiltration Interception Macropores and flow Ocean storage Plant Uptake Precipitation (rain, snow, sleet, hail, etc.) River discharge Rivers, Lakes, Streams, Seas, Oceans Runoff Saltwater intrusion Snowmelt Soil and rock drying, wetting, cracking, freezing, thawing, etc. Soil moisture Springs Storage Sublimation Subsurface flows Terrestrial and Aquatic ecosystems Wetlands, Coral reefs, etc. Thermal stripping Transport Vapour, liquid, ice Water table

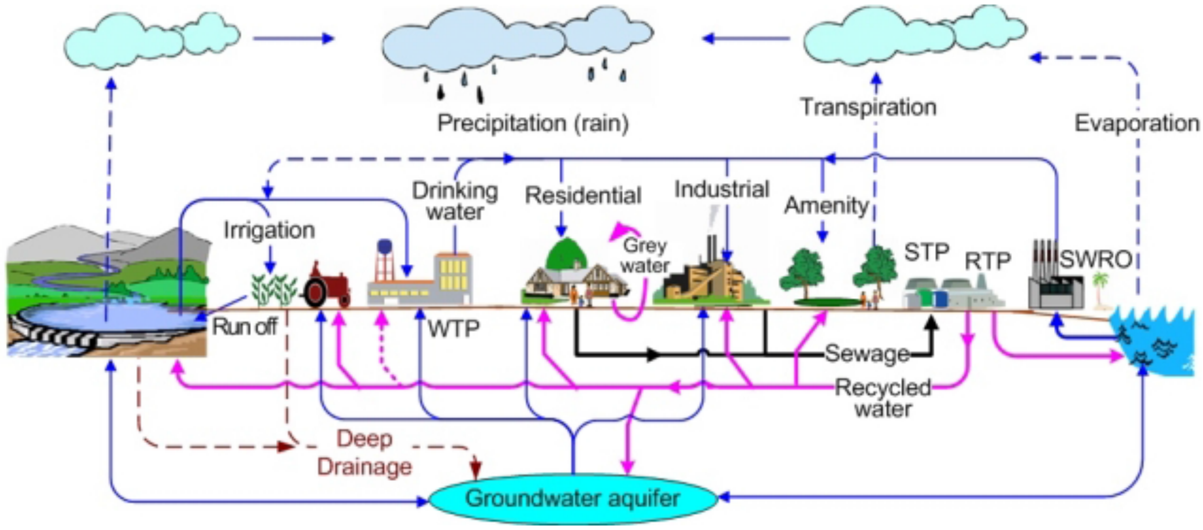

Figure 4. Recycled Water Hydro Cycle (Recycled Water in Australia 2015)

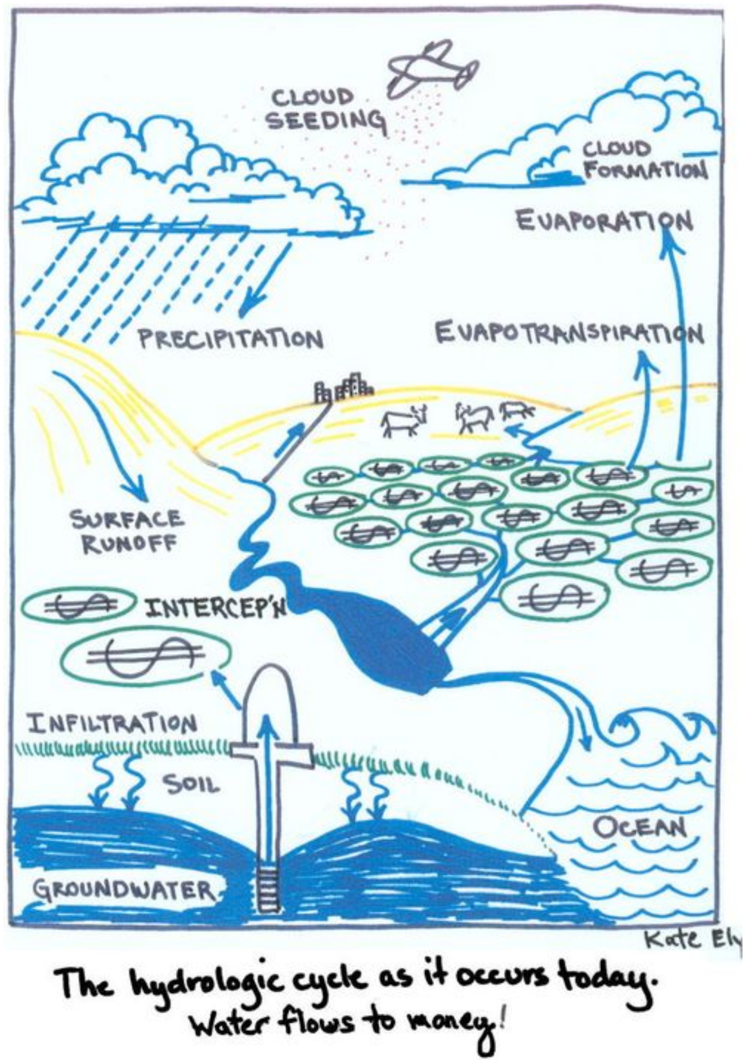

Figure 5. Water Flows Uphill to Money (Kate Ely 2008)

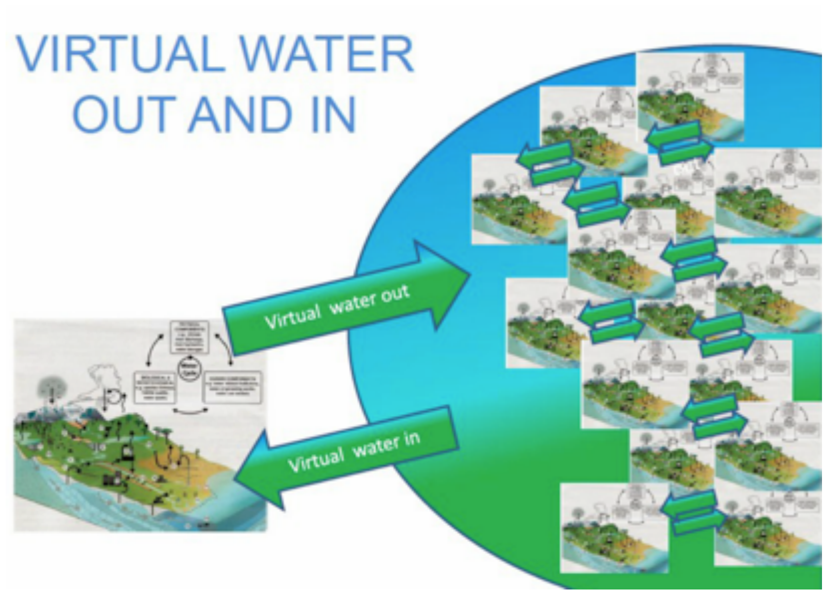

Figure 6. Virtual Water (Francesca Greco 2013)

The Hydro Cycle Working Group found two major concerns with these revised hydro cycles. One, the reworked images (of which **Figures 4-6** are only a few examples) tend to focus on a single gap, illustrating only a few of the more than one hundred twenty elements identified by scholars as missing from the classic hydro cycle. Two, the alternative conceptions are far less prevalent. They have not been nearly as integrated in education, research, and policy and feel less intuitive – though this is likely a testament to how well the classic cycle is taught, not a reflection of the new images themselves. Neither of these concerns denies the value of hydro cycle variations as teaching and demonstration tools, but they do suggest that the classic hydro cycle cannot simply be supplanted by one of these alternatives. The Group agreed that a major part of the classic hydro cycle's power lay in its simplicity. A single, two-dimensional, static image will never manage to clearly but thoroughly communicate all of these important processes.

This logic led the Hydro Cycle Working Group to conclude that our original vision of a replacement image nuancing the hydrosocial cycle was unrealistic and, given the complexity of human-water interactions, perhaps undesirable. But during the course of those conversations, another idea was born: the creation of a toolkit that would enable communities, policymakers, researchers, or other populations to identify the elements of hydrology and human-water interactions most relevant to their water security, governance, management, access, and/or relations. Taking this idea, the compiled list of factors, and a library of alternative hydro cycle images, the Hydro Cycle Working Group commissioned environmental artist Ruth Macdougall to begin working on the visual elements of the project. The resulting artwork is called the "hydrosocial spiral". While Ruth has developed a two-dimensional 'fixed' version of the hydrosocial spiral (**Figure 7**), the outcome is far more than a purely static image. Rather, the hydrosocial spiral is a participatory toolbox allowing for multi-dimensional representations of human-water processes and encouraging dialogue and reflection on water realities. In the next section, Ruth describes her iterative approach to creating and adding to the toolbox.

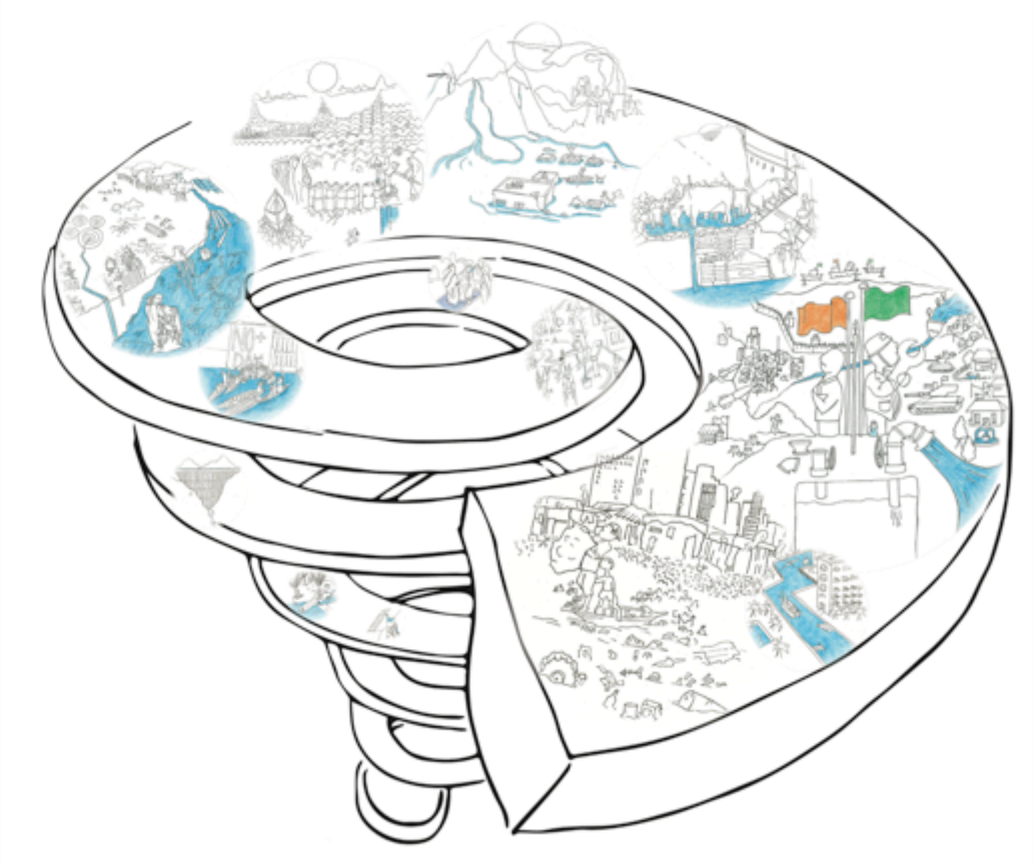

Figure 7. The Hydrosocial Spiral

DEVELOPING THE HYDROSOCIAL SPIRAL: REFLECTIONS AND INTRODUCTIONS FROM THE ARTIST

As with so many creative projects, the process that allows one concept to surface over many others may only be articulated upon reflection and with the help of more able wordsmiths than I. Through my research, I was introduced to Charles Minahen's *Vortex/t, the Poetics of Turbulence*, and at once recognised the key features of our spiral in his writing. In the appendix of his book, Minahen seeks to identify the features that make vortices, helices, spirals and gyres distinct from each other whilst noting that these forms exist at all levels of the known universe, widely dispersed through the whole range of phenomena from macro to the macro cosmic, and inhering in both organic and inorganic systems and states.

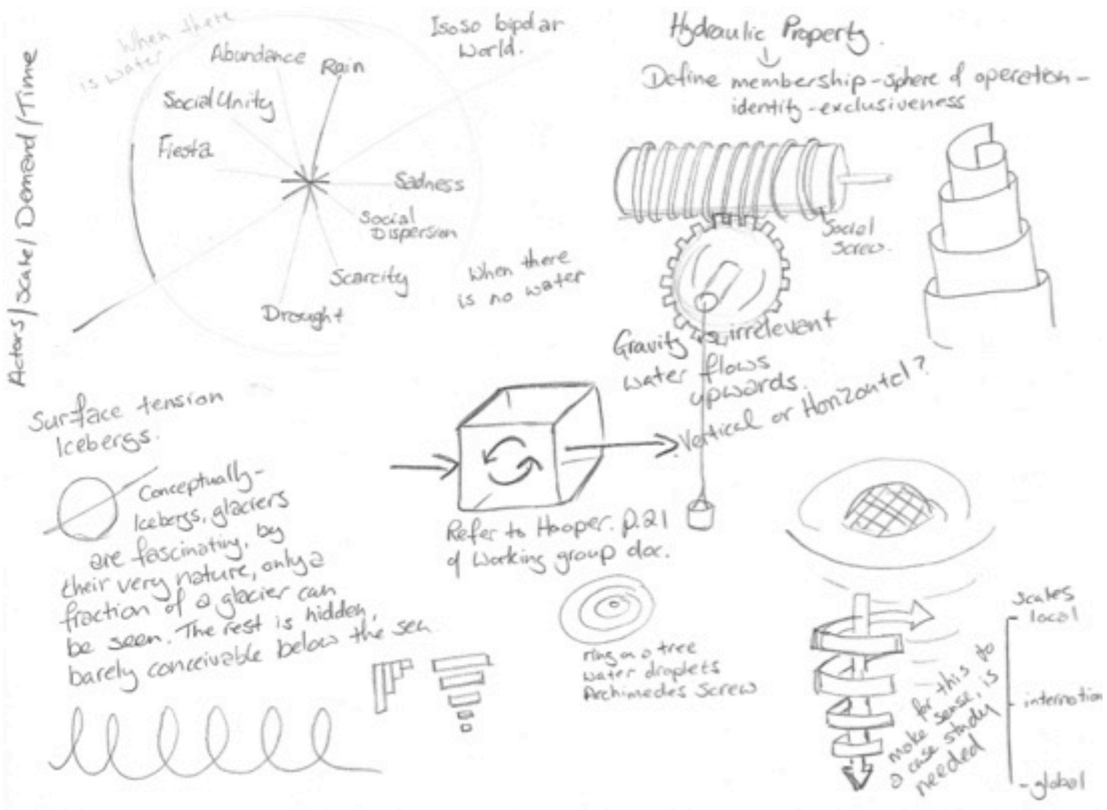

Figure 8. Development drawings. Key factors to consider are: scale, time, demand and multiple actors.

The body we propose now is a 'spiral helix', a hybrid of the spiral and the helix, also known as a 'vegetal helix'. It exhibits circular movement with alternately increasing or decreasing circles evolving from a central point, towards new growth and around an invisible cone of energy. Importantly, the spiral helix shape allows us to move away from the closed loop of the hydro cycle and the use of arrows, which dominate almost all diagrammes associated with water. It is my opinion that these arrows disempower the viewer, exerting the limited meaning intended by the diagramme's authors, rather than allowing individual interpretations to be drawn by viewers living in vastly different environments. Instead, this structure allows multiple narratives to evolve.

The spiral helix is closely associated with power, an essential component of this new visualisation that not only references the kinetic power of water and whirl pools as depicted in the art of many cultures and creation myths, but also of the modern concept of water flowing upwards towards money and political power. As such, as the spiral winds round, time moves on, the environment changes. Population increases and so too does extraction. But there is one constant on the spiral: the outer edge represents those individuals and communities with political and economic power, and the inner edge represents those who suffer from a lack of political and economic power. It is proposed that a channel of blue water traveling along the spiral illustrates this power. In the earlier stage of the spiral (e.g., the bottom), the channel should travel almost centrally along the path of the spiral. Towards the top, as political power and inequity grow, the water channel dramatically veers to the outer rim.

In order to engage with the different scenarios taking place on the spiral helix, scale was the first obstacle to negotiate. As a result, a number of tableau were created in the form of movable discs, intended to be close up vignettes of what may be occurring at various places on the spiral. Topics were chosen from the issues list identified by the Hydro Cycle Working Group (see **Figure 3**). Unlike the classic cycle, these scenes place human activities firmly at the centre, depicting such themes as water engineering through aqueducts and dams, spiritual uses of water through purification rituals, and price tariffs through markets. Deforestation, climate change, agriculture, and recreation are also included. (See **Figures 8-21**.) Numerous other vignettes could be included (e.g., desalination, cloud seeding, and hydro-diplomacy). The relative ease in adding topics through these movable discs is one way the hydrosocial spiral has proven useful for teaching. The next sections discuss some of our collective experiences in applying my work in water research and education.


Figure 9 and **10**. The Archimedes Screw used for Irrigation

Figure 11. The Roman Aqueducts

Figure 12. Water used in Chhath purfication

Figure 13. Water Markets

Figure 14. Dam Disputes

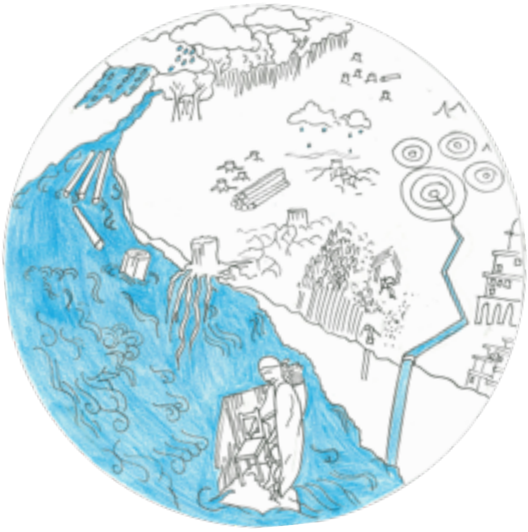

Figure 15. Flooding caused by Deforestation and Over-extraction

Figure 16. Emergency Boreholding

Figure 17. Climate Change and Sea Level Rise

Figure 18. Virtual Water

Figure 19. Water Conflicts

Figure 20. Constructed Rivers for the Rich's Leisure

Figure 21. Water Inequities and Power Imbalances

TEACHING THE HYDROSOCIAL SPIRAL: A PARTICIPATORY TOOLBOX FOR CO-LEARNING

In **Figure 7**, the hydrosocial spiral is shown as a two-dimensional fixed image. Certainly these kind of static visualisations have their place in teaching, research and policy. However, the greatest potential of the hydrosocial spiral lay in using it not as a diagram, but rather as a participatory tool. Using the basic structure of the spiral, groups – of students, community members, and policymakers – can be facilitated through a process of identifying the ways in which water moves and changes in their particular setting. This visual tool opens spaces for dialogue that purely verbal conversation may not; it also provides a shared medium for individuals with different vantage points to reflect upon. The authors suggest that the hydrosocial spiral can be of use as a tool for research and policy, employed in focus groups to spark conversations.

When employing the hydrosocial spiral as a participatory tool, the suggested process involves introducing the history of the hydro cycle and graphical modeling along with the basic logic of the spiral, breaking participants up into groups, and providing each group with a blank spiral (**Figure 22**) along with cut out vignette and blank discs. Groups then develop their own version of the hydrosocial spiral, giving them the chance to highlight the processes they see as most impactful on issues of water availability and access. Depending on participants' local ecosystems, political situations, professions and livelihoods, and the like, vastly different discussions ensue.

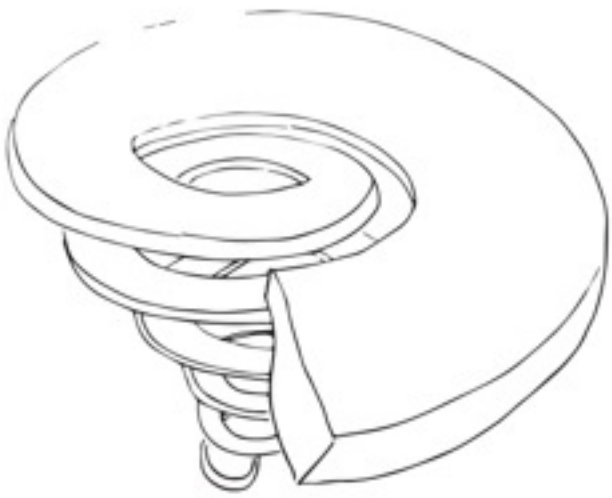

Figure 22. A Blank Hydrosocial Spiral is used for Participatory Dialogue

Testing the participatory toolkit in classrooms at the University of East Anglia with postgraduate taught students, the biggest takeaway has been the incredible flexibility of the shape and discs. For the past four years, groups of water security students have been participating in three-hour seminars exploring these concepts and developing their own artistic representations of issues of interest. Year on year, the students have given serious thought to the spiral's construction and thoughtfully engaged with its strengths and limitations. The task invites the students to step outside their comfort zone, using their own hand-drawn images to investigate the cycle academically, artistically, and politically. Each time, the exercise brings conflicts of interest to the surface, with students pushing for varying foci dependent on their own background and preoccupations (conversations mirroring the original Working Group's!).

During the construction of the hydrosocial spiral, it was of importance that the new visualisation be able to stand on its own and be easily understandable without further interpretation. Given that seminars have given student groups roughly sixty minutes to debate, decide, and create their artwork, the resulting visual responses are not always so easily legible, but they do represent a student-proclaimed helpful and reflective process.

Some students have instinctively seen the spiral in the same way its artist originally conceived of it, primarily as a representation of time and increasing technological intervention. Others have seen the spiral as a river leading toward a single human at the very bottom, and have drawn and placed various interruptions and interventions to that person's access to water along the spiral. Yet others have taken *two* spirals and woven them together to resemble the DNA double helix, using one to represent political processes and the other, ecological.

Still others have completely discarded the spiral. The challenge of developing an image or diagram that can speak to all environments is perhaps the greatest of all for building a global understanding of water. In dealing with this challenge, one team used a globe as the base visual. Another emphasised ecosystem variety by shifting from a global perspective to a comparative localised analysis. Their images were far simpler and more intuitive than the spiral, showing the way water is diversely used at the household level in Australia and Kenya with pictograms stylised as one might find in a children's book. Not only does their representation consider the ways in which two geographically different countries use and value water, it also brought into relief how political and economic differences impact everyday domestic life. In feedback, this group emphasised that whilst they had not overtly used the spiral, their interpretation was inspired by it and the introduction of its development.

A particularly exciting divergent image created by students is shown in **Figure 23**. The group chose to focus on Dubai, a hydrological masterpiece created in the desert where skyscrapers and water parks abound. Their image moves away from the spiral, instead using the world's tallest skyscraper as the basis for an infographic. That symbol is far more relevant to the location – and speaks to the economic and political power held over (and by) water in that part of the world. Using the floors of the building to plot increasing and decreasing water issues over time, the format is an interesting one that leads to ideas of how water use in multiple cities could be explored using context-specific architecture. A 'hydrosocial city' could be created where water use in vastly different locations can be considered from across the street.

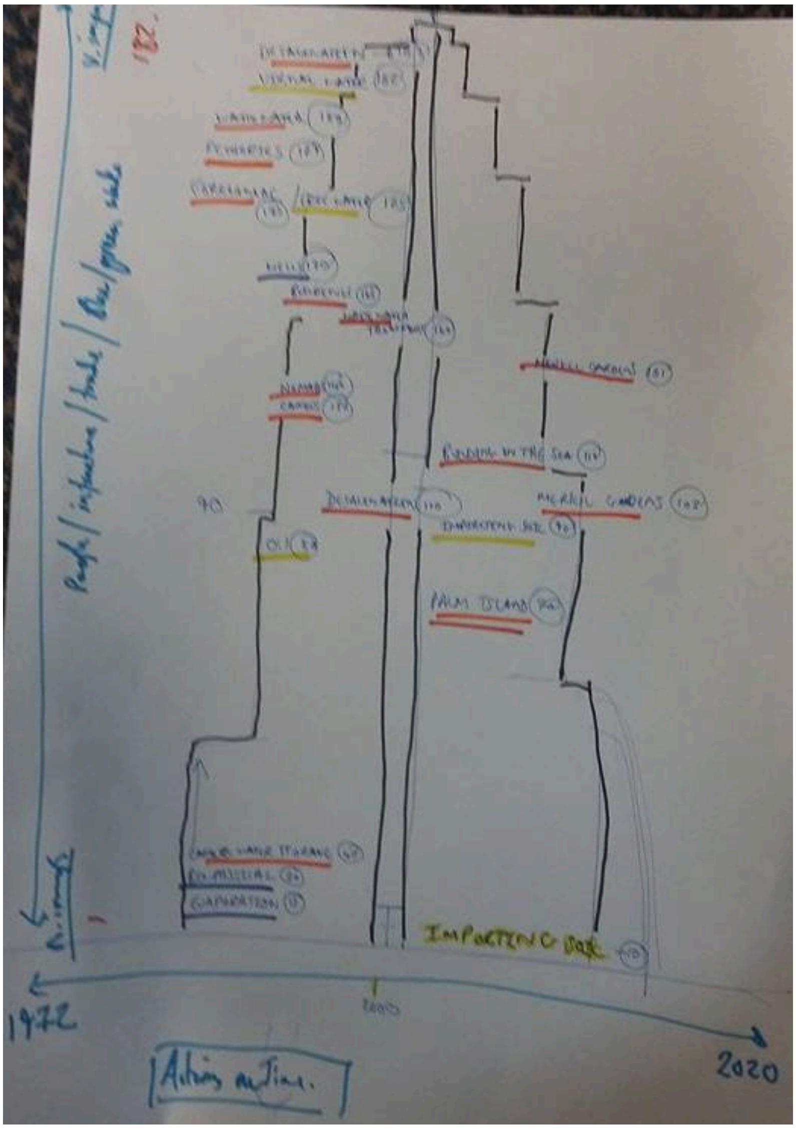

Figure 23. Sample artwork produced during a hydrosocial spiral seminar at UEA

Even for those students who rejected the specific spiral, the general toolkit was a useful instrument. Groups made use of various vignettes and the idea of visual representation to inspire their own ideas and presentations. Overheard comments from students such as, "It's very therapeutic to draw like this" and "your brain is thinking in a different way," as well as solicited feedback praising the ease of critique via art suggests that visual media is a particularly effective tool in exploring complex ideas.

Using art allows the creativity of students, informants, and even researchers and policymakers to come forward. The ability to change, edit and engage with the visuals gives participants a voice they may not otherwise have and allows them to identify what the original piece misses.

These lessons have also been applied in a Water School for primary school children in Southwest Morocco run by Dar Si Hmad, a local non-profit organisation harvesting fog to supply rural communities with potable water. In addition to learning the hydrologic science of the classic cycle, students use art to explore the different ways water moves in their villages. The approach allows them to understand the science behind fog-harvesting while valuing local knowledges and traditional approaches.

Taken together, these diverse classroom experiences indicate the strong potential of the hydrosocial spiral participatory toolkit as a method for engaging varied communities in discussions over water. The next section details a second application of the spiral: as a framework for analysing water issues.

Applying the Hydrosocial Spiral in Research: A Historic Case Study

As a tool to study hydrosocial interactions, the spiral may be more effective when applied to individual case studies rather than trying to address *everything* historically and globally. In October 2015, a project on 'Reimagining water futures: exploring culture and the communication of water stewardship science' led by Dr Naho Mirumachi at King's College London allowed Ruth to experiment with such an application. As part of the project, Ruth joined a workshop initiating networks between academics, science communicators, and cultural sectors. Mirumachi's approach reflected many of the aims of the new hydrosocial interactions scholarship discussions earlier, rejecting simplistic messages of 'water wars' or 'global water crisis' in favour of nuanced considerations of how local water problems are bound in issues of regional geopolitics, modern-day consumption, global food and energy trade, and power politics between (and within) the Global North and South. Working on the assumption that art has the power to affect ideational change and spur on those who have the catalytic ability to invoke that change (including businessmen and -women, consumers, politicians and policymakers), Ruth introduced the hydrosocial spiral and discussed its development and applications with attendees.

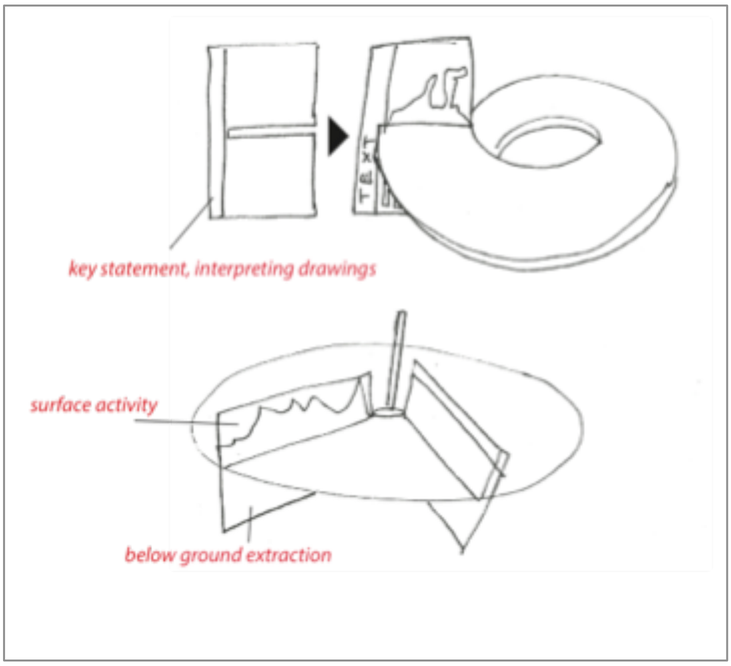

Figure 24. Advancing the Hydrosocial Spiral through Movable Slides

As a consequence of the workshop, Ruth was able to advance her original conception and take a first step toward a three-dimensional incarnation of the spiral. Instead of discs, this 3D version utilises slides inserted onto the spiral. Just as groups are given blank discs to use with the 2D spiral, teams can be given empty slats for placement on a 3D model. These slats make visible the groundwater consequences of human extraction, pollution, politics, and the like, allowing the simultaneous consideration of both surface and subsurface activity over a period of time.

Figures 25, **26**, and **27** are the first application of this altered approach to the hydrosocial spiral, inspired by Battesti's "The Power of Disappearance: Water in the Jerid Region of Tunisia" (2012). Water usability and human interactions remain key elements to analysis. The slides explore the interactions and impacts of French colonisation, the Tunisian state, and local knowledge with oases in North Africa.

Figure 25. Slide created for placement onto the hydrosocial spiral representing French colonisation in Tunisia.

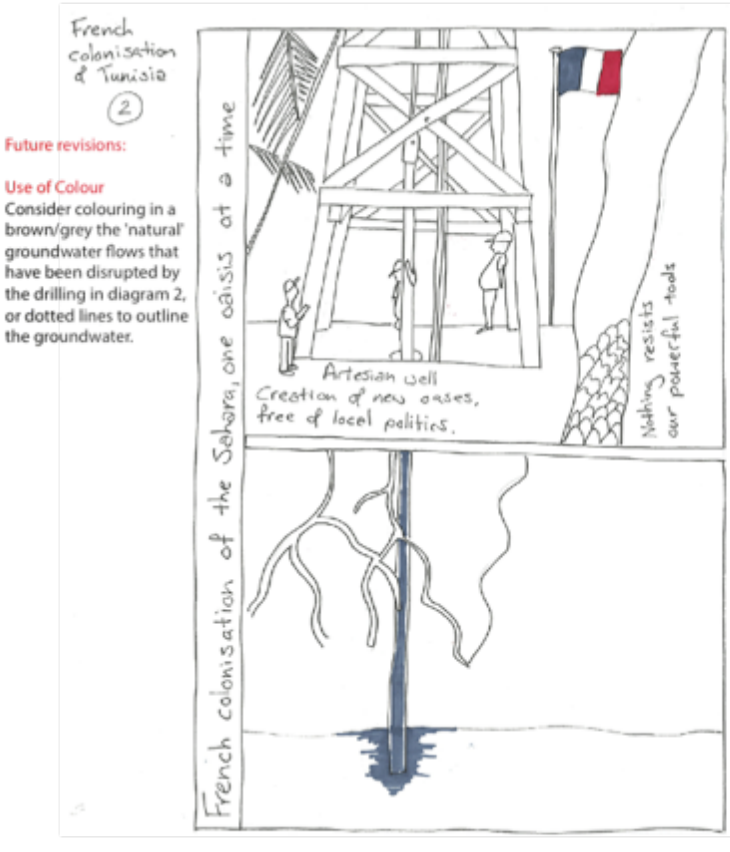

Figure 26. Slide created for placement onto the hydrosocial spiral representing artesan wells.

Figure 27. Slide created for placement onto the hydrosocial spiral exploring the politics of water in Tunisia.

Conclusions

Through hydrosocial relations approaches, water scholarship has progressed considerably since the classic hydro cycle was created in the 1930s. Unfortunately, the diagram has not evolved as fully as our thinking. This resulting gap provides a clear action step for further work. It is time to re-envision the hydro cycle. The hydrosocial spiral is an attempt to do just that in a dynamic, participatory way allowing for insight into the complexities of water and society.

From our experience, the spiral prompts more questions than it answers, underlining its efficacy as a catalyst for ideas rather than offering a defining visual solution. It is clear that continued and enhanced collaboration around water and hydro flows is necessary. This collaboration needs to be done in interdisciplinary settings and move beyond academia to include a wide range of stakeholders. Beyond the complexities of bridging academic disciplines, further study should also be done among people who view water in fundamentally different ways. Exploration should happen not only across the well-known *private versus public* and *human right versus economic resource* debates, but also between those who view water as a fundamental element and those who see it as a social construction. The human element of hydrosocial relations must be brought to bear even as the powerful non-human realities of nature recognised. Multiple perspectives on water, some of which seem to be mutually exclusive, must be considered simultaneously and in conversation if we are to arrive at a more nuanced understanding of the hydro cycle and water itself.

As a hydrological diagram, the static hydrosocial spiral image is flawed. It is far more complex and non-intuitive than the classic hydro cycle and still fails to a number of key issues. But as a participatory toolkit, the approach has great potential. We continue to test that potential and ways to expand it. Water in our world is not static. Nor should the visualisations we use to understand and explore it be. A number of research and teaching tools on the hydrosocial spiral are available online at uea.ac.uk/watersecurity. The world's water is precious – but our diagram is not, so feel free to make use, undo it and challenge it, and be sure to let us know what you find.

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