INTRODUCTION

Tracing Scales in Hydrosocial Relations

Veronica Strang and Franz Krause

Many societies, driven by globalized neo-liberal commitments to growth and development, have become dependent upon highly instrumental 'command and control' approaches to water. Relying on exploitative and unsustainable practices, they have prioritized the needs and interests of particular human groups and externalized the costs of their activities. The result includes widespread habitat loss, blatant suffering of marginalized humans and other beings, catastrophic rates of species extinction and an increasingly frightening environmental crisis.

This anthroparchy (Cudsworth 2005) has been criticized by researchers, and by activist movements concerned with social and ecological justice. International debates are also increasingly influenced by Indigenous communities who are seeking to protect their homelands from the choices made by colonial settlers, and trying to promote engagements with water that are more sustainable in accommodating variations in water flows and the multifarious needs of ecosystems.

Anthropology has an important role to play in articulating the culturally diverse ways in which people materialize and mediate their relations to water. One of the key challenges in addressing these issues is to make visible the connections between different scales of environmental engagement, and how choices made in engaging with local waterways and marine areas relate to the larger anthropogenic effects emerging in regional and global ecosystems, often with long-term consequences. Water readily illustrates how particular beliefs and values are applied at different spatial and temporal scales.

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Water, Scale and Materiality
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This edited volume therefore explores various communities' relationships with fresh and saltwater bodies, and considers how responses to environmental change are expressed in art, material culture and infrastructural arrangements. Asking how different cultural groups are meeting the challenges of environmental change, and what they can learn from each other in striving for more convivial more-than-human interactions, it suggests that efforts to shift values and practices in a more sustainable direction must also be multi-scalar in their form.

Methodologically, the volume relies primarily on anthropological and geographical approaches to research, and each ethnographic case study has been conducted in accordance with the ethical codes of practice provided by the contributors' professional associations.

Scale: Modes of Studying and Doing

Attention to scale is a key contribution to anthropological analyses exploring more sustainable relations with water. Hydrosocial relations (Linton and Budds 2014; Krause and Strang 2016) exist at different but interrelated spatial and temporal scales. Confronting global environmental crises and injustices is often seen as an articulation of scales: issues with large temporal and spatial horizons impact upon more constrained human times and spaces, and short-term or localized activities can have wider and cumulative consequences.

A focus on water usefully illustrates the fact that while ideas about specific scales are effective heuristic constructs, reality is more fluid – with different conceptual and material scales flowing into each other, and people applying particular (and sometimes multiple) visions of scale according to the context in which they are acting. For example, a research participant may explicate an immediate place-based scale of engagement with a water body while simultaneously locating this in a larger historical context of colonial appropriation, or in relation to the impacts of global environmental change on annual hydrological dynamics.

As this implies, defining scale requires us to recognize the multivalence of the term and the flexibility with which it is applied not only to spatial and temporal abstractions but also to social and material processes. This is also important for enabling a critique of hegemonic scaling practices – for example, those that identify indigenous communities as undifferentiated citizens of nation states, or which reduce places to generic types of habitat, waterway or geology in a larger-scale mapping of 'resources'.

Scale is therefore being discussed in many disciplines as well as in interdisciplinary settings. Political scientists have defined scale as 'the spatial,

temporal, quantitative, or analytical dimensions used to study any phenomenon' (Gibson, Ostrom and Ahn 2000: 219). Observing that the social sciences make use of ecological models, they suggest several questions to consider: (1) how scale, extent and resolution affect the identification of patterns; (2) how diverse levels on a scale affect the explanation of social phenomena; (3) how theoretical propositions derived about phenomena at one level on a spatial, temporal or quantitative scale may be generalized to another level.

In geography, scale has been defined as a phenomenon consisting of 'one or more levels of representation, experience and organization of geographical events and processes' (Johnson 2000: 725). Scale therefore refers to both spatial and temporal reach in multiple social and material dimensions (Eriksen 2016). While spatial scales are often considered in terms of local, regional and global levels, temporal scales may refer to geological 'deep time' (Irvine 2020), biological evolution, the historical *longue durée*, successive generations or the rhythms of project cycles and electoral periods. Just as the spatial scales of 'local' and 'global' sit in tension with each other, so may different temporal scales conflict with each other: for example, irrigating crops to boost economic development may result in soil salinization, thus jeopardizing the long-term health and productivity of the environment.

Anthropologists have often distinguished between micro and macro units of study (Berreman 1978), using notions of scale to link individual experiences with those of local and wider communities, and with biographical and longer historical timelines. However, they have also warned against viewing scale as a simple measure of magnitude, where large scale encompasses more and small scale less. Marilyn Strathern (2004) has pointed out that, in comparison with highly focused studies, more inclusive perspectives reveal *different* rather than *more* insights, and Kirsten Hastrup (2013) notes that fieldwork practices scale their subjects in specific ways – all of which are both partial and total. Dominique Desjeux (1996) suggests that the focal point of observation varies from study to study, and observation between the 'macro' and the 'micro' is discontinuous. As this implies, scholarly approaches utilize concepts of scale for heuristic purposes (Neveling and Wergin 2009). It can be challenging to parse the extent to which academic and public discourses have reified concepts of scale and the 'reality' that different scales are entities constructed through social practices, institutional arrangements and material artefacts.

Nevertheless, people often do consider scale in their practices and imaginations, and the notion is deeply engrained in many institutional processes. Thomas Hylland Eriksen (2016; 2018; 2023a) suggests that

'clashing scales' are implicated in a wide array of current social, economic and ecological crises. The different logics at which large-scale and small-scale economic or political processes operate lead to systematic dilemmas for decision-makers and engender conflicting goals and priorities. Eriksen observes that wherever scales clash, larger scales dominate, such that national political interests trump those at a local level and transnational capital outcompetes local businesses (2018). At the same time, he suggests that anthropological research can traverse differences in scale by providing insights about large issues through conducting fieldwork in small places (Eriksen 2023b).

Anna Tsing has proposed a processual approach (2000; 2012), arguing that, rather than being predefined phenomena, scales are the products of scaling practices. Things do not simply happen at one scale or another; people actively 'scale' their projects to link or delink them with other processes and projects, intermingling 'local', 'global' and other scales. In these terms, scale is a social construct: a processual project of 'scale-making' forged through communications, actions and institutions. Scale is made through discursive practices and labour (Carr and Lempert 2016). It is performed (Kaiser and Nikiforova 2008), and it is therefore always in flux (Brenner 2001).

A focus on relationality and process reminds us that scale can also be viewed through the lens of Actor-Network-Theory, in which heterogeneous more-than-human actors, ideas and material things interact dynamically, and – as noted above – shift between scales. John Law's concept of 'punctualisation' (1992) underlines the precarity of isolating objects, or for that matter scalar constructs themselves, from the larger relationalities in which they are immersed.

Scale is also central to imagining the future and its social and material relations (Harvey 2018, Hetherington 2016). The development of water infrastructures that have major impacts on more-than-human lives are driven by governments' ambitious visions of economic prosperity achieved through the development of transformational megaprojects costing billions and taking many years to construct (Harvey and Knox 2012). Simultaneously local, national and international in their scope, such megaprojects reflect historical patterns and future imaginaries. As Susann Baez Ullberg observes, in describing the long delays and ongoing promises of schemes to bring water from the Andes to the coastal plains in Peru, temporality is a key property of infrastructures, which are 'situated in socio-material relations of past experiences, present needs and future expectations from private and public stakeholders, political opposition and the citizenry alike' (2025: 229). Such large-scale ambitions are not new – there are many historical examples of societies creating transformational water infrastructures – but

the normalization of such massive developments around the world, the level of material coercion that they impose and the intensified impacts on ecosystems everywhere have created unprecedented social and environmental changes, with potentially global consequences.

Mental and Material Scales

Thomas Widlok has suggested that 'scale is a dimension of the mind', and that there is considerable diversity in how people imagine scale (2022: 15). He draws on the work of Douglas Bird and colleagues (2019), who argued that scaling is culturally specific, and researchers and researched may employ different 'modes of scaling'. Ostensibly 'small-scale' societies, such as those of hunter-gatherers, often inhabit and know quite 'large-scale' territories and maintain 'large-scale' social networks. Moreover, the work of David Graeber and David Wengrow (2021) suggests that – contra Hobbes and Rousseau – growing population densities have not led inevitably to increases in social and economic hierarchies, but that throughout human history people have applied both large and small scales in creating their polities.

As a 'dimension of the mind', scale is intrinsic to cognitive processes. Across cultural boundaries, but shaped by social and historical contexts, people make 'scheme transfers' that enable them to carry ideas between spatial and temporal scales (Bourdieu 1990). Pierre Bourdieu's earlier work focused on scheme transfers between house design, social and cosmological arrangements (1970; see also Cunningham 1964). Durkheim classically noted how cosmological schemes reflect social and political arrangements (1965 [1915]), and Bruce Lincoln (1975) points to scheme transfers between cosmological concepts of cosmogony (creation of cosmos), mesocosms of sociogony (creation of society) and a microcosm of anthropogony (creation of humankind). In relation to water, bodily homologues about circulation are readily transposed to imagine flows within ecosystems and larger global systems, and concepts of pollution and purity traverse social and ecological phenomena at all scales (Strang 2004). A key issue in this volume is that water is particularly useful for 'thinking with'[1] across different scales, and provides an invaluable fluid metaphor for multi-scalar scheme transfers. And, as George Lakoff and Mark Johnson's work implies (2003), metaphors themselves are critical cognitive mechanisms for thinking up and down scales.

Andrew Herod (2011) argues that metaphors of scale reinforce hierarchies, and the concept should be abandoned in favour of 'flat ontologies' in which scales are not presumed to have any materiality. But rejecting the

materiality of scale is problematic: as mentioned above, people do experience scale phenomenologically and imaginatively, and they concretize their ideas practically and materially.

Stefan Helmreich (2023) has worked with wave scientists and engineers to learn how they relate physical, small-scale models of waves and infrastructure, or virtual computer-based models of waves and floods, to the waves in the real world. He finds that US science and engineering have come a long way in modelling and understanding waves, from their original Cold War anxieties to their more recent climate change research, but the temporal and spatial scale shifts inherent in modelling exercises routinely break down. For example, scaled-down 'model' waves hitting a scaled-down coastal town move much faster, or at a higher-scale speed, than life-sized waves on the shores of real towns. Scale transfers may work very well in some respects, but may fail in others. This tension is another central theme that runs through this collection.

Nurit Bird-David (2018) has emphasized that scale is not only about temporal, spatial or population quantity but also fundamentally qualitative. Social relations and cultural understandings among a group of people who habitually live in a small-scale context are likely to be qualitatively different from those of people accustomed to inhabiting larger-scale contexts. Scale is also materially qualitative. For an insect, the water that humans experience as fluid is so viscous that it provides a solid platform or a sticky trap. Based on a parable by Gregory Bateson, Eriksen (2023a: 14) offers us an imaginary 'polyploid horse' that was engineered to be twice as high, long and wide as an ordinary horse, but instead of being twice as strong it struggled to survive, in part because its legs – though doubled in strength – were unable to support an eight-fold increase in body weight.

Research on hydrosocial worlds across times, places and scales shows that the materiality of water plays a key role in the scales at which people relate to it as well as in the similarities of these relations across scales. Thinking with water moves us away from notions of putatively differentiated scales of experience towards recognizing that ideas, materials and practices also flow between scales. Water assumes consistent forms and behaviours at different scales (Schwenk 1965) and interactions with water at different scales may be reminiscent of fractals, with similar patterns recurring across scales (Krause and Harris 2021). The challenge lies in tracing the movements of hydrosocial ideas, practices and materials between social and material scales, and in this sense a multi-scalar analysis of water-related material culture can be revealing.

For example, local water bodies and human engagements with them are frequently subject to social and material pressures from larger

infrastructures, modes of governance and wider global market forces (Eriksen 2023b). Conversely, local interactions with water bodies may inform attempts to expand these forms of engagement into larger infrastructural arrangements. The systematic approach to traditional Balinese *subak* irrigation with nested institutional, material and religious arrangements (Lansing 1991) is a case in point. Eric Swyngedouw's notion of 'glocalization' (1997) highlights the simultaneous scaling up and scaling down of particular phenomena, while Nikhil Anand's work on hydraulic citizenship (2017) demonstrates how relations with water mirror and perpetuate societal arrangements on multiple scales.

Multi-Scalar Modes of Hydrosocial Tools

Both small- and large-scale forms of material culture seek to impose order on water flows by containing and directing water (Strang 2021). There is considerable morphic resonance between the containers, pipes and valves that store and direct water within domestic contexts and those that distribute it throughout urban areas. A domestic water storage tank or rainwater cistern captures and contains water for distribution to household activities just as a dam and reservoir holds supplies for surrounding farms and settlements. Both seek to avoid leaks and to regulate water flows so that these are sufficient and timely, but not excessive. Manifesting a form of biomimicry across scales, these technical arrangements also echo the homologies between ideas about flow and circulation in bodies and ecosystems noted earlier.

The notion of biomimicry deserves closer attention. Typically, it has been used to consider how design and engineering have drawn upon 'nature' for inspiration, such as in the patterns of camouflage clothing or the use of overlaying (literal) scales/tiles to create waterproof buildings (Benyus 1997). But it is also useful to consider how the properties of materials are scaled up or down into art and material culture. For example, recent research on the Venetian lagoon (Strang, in progress) suggests that the centrality of water in the city is linked with its particular focus on glass, which is mimetic of water and seeks to capture and hold its glittering physical properties and translucent colours in a fragile but stable form (Figure 0.1). Such uses of material, in ways that mirror the properties of elements or things, provide useful insights into how materialities enable imaginative transfers between scales.

At all spatial and temporal scales, there is a continual 'wrestle' with the materiality of water (Edgeworth 2011: 158). How this wrestle is conducted is revealing of core beliefs and values in relation to water. Examples

Figure 0.1. A glass 'wave', Venice. Photo: Veronica Strang.

of this can be found in work on dams and diversions (Strang 2013) and in juxtapositions of hydroelectric dams and salmon fishing weirs (Krause 2011). It is therefore useful to consider the resonances between, on the one hand, water-related art and material-culture objects and, on the other hand, infrastructural and societal expressions of relations with water.

This volume focuses on the role of materiality in scaling, and how ideas, beliefs and values in relation to water are manifested in (and recursively maintained by) visual arts, material culture and infrastructures. A key aim is to foster a conversation between scholars in these areas. However, in exploring the resonances and divergences of hydrosocial relations, there is no simple segue between scales; neither is there a ready equivalence between 'infrastructures' and 'large-scale' or national debates on the one hand and 'material culture', and 'small-scale', local studies on the other. Infrastructures and material culture exist at all scales (Cross 2017).

It is similarly important to resist a widespread tendency to associate smaller-scale activities with more benign inter-human or human-environmental relations and larger-scale arrangements with oppression and ecological exploitation (Ojani 2023). Arts and material-culture research and infrastructure studies are perhaps better considered as different perspectives on similar phenomena. The hydrosociality of water mills, for

example, could be investigated in both scholarly areas, each yielding particular insights. In this book, we want to bring these perspectives together to explore different ways of engaging with water: at times controlling it, at times going with its flow and sometimes materializing a combination of these two extremes.

The contributions to this book, investigating relations with water at various scales and in dialogue with various other disciplinary canons, develop a fruitful conversation about engagements with water that contributes to cross-disciplinary understandings of a multifaceted – and multi-scalar – environmental crisis. In doing so, they employ various understandings of scale and scaling – for example, in terms of perspective, in relation to scope and in contrast to zooming in and out – which they elaborate in their individual contributions. What they have in common is a critical attention to the ways scales emerge, transform and affect the world in connection with water, and how hydrosocial relations flow between scales or are warped by them.

Scaling Hydrosocial Relations in Seven Parts

In Chapter 1, Stefan Helmreich discusses the temporal scales across which digital wave modelling operates. Focusing on work practices and a training course at the US National Oceanographic and Atmospheric Administration (NOAA)'s Center for Weather and Climate Prediction, Helmreich finds that time is compressed, extrapolated and purified as data on ocean movements is fed into wave models that are then used to predict future events and replicate past situations, such as the waves of Hurricane Katrina that hit the USA's southeast coast in 2005. Producing and applying these models means scaling in and out of the past and the present ('hindcasting' and 'forecasting'), bringing together the speeds of modelling and of actual waves, the biographies of wave modellers, as well as bodily experiences of material waves and the formalized waves of the computer program. Helmreich juxtaposes the computer memory on which the digital model operates to the 'ocean memory' held by people and the seas themselves. Wave models are a product of their combination, which also means that they require temporal framings at various scales.

In Chapter 2, Frances Morphy analyses how temporal scales that seem far removed from each other in Western historiography and geology emerge as directly entangled in Yolngu worlds in northern Australia. Bringing together the deep history of Yolngu settlement around today's Gulf of Carpentaria, which followed the sea-level rise after the last ice age, with today's stories, dialects and place names, she contrasts the 'scalar

thinking' of Western time with the Yolngu 'eternal present' of connectivity beyond temporal distinctions. A key indicator of this is Yolngu knowledge about Wangarr, which refers both to ancestral creator beings and to the spatiotemporal dimension of their existence. Through their movements, Wangarr have created and continue to create a world of spatial relationships that is as ancient as it is current, and as shaped through events as it is eternal. Thus, historical shifts in water levels are as much part of Wangarr as are current watercourses and seasonal cycles of wet and dry. Frances Morphy concludes that Yolngu people today are articulating their 'anti-scalar' world with the political and climatic scales that affect them, finding new ways of inhabiting both a linear and an eternal temporality.

In Chapter 3, Veronica Strang shows how water beings around the world – snakes, dragons, mermaids and other serpentine deities – are multi-scalar beings, existing at different sizes simultaneously. Water beings thereby mirror the scalar properties of the hydrosocial relations they inhabit and embody. Strang contrasts these multi-scalar phenomena with the large-scale industrial and agricultural water uses that fundamentally transform land and waterscapes, often to the detriment of non-human beings and ecologies. The chapter focuses on water beings among Chewa people in Malawi – for example, Mwali and Thunga, who bring rain and fertility; M'Bona, who creates orderly water flows; or Napolo, who embodies and brings floods in response to controversial economic developments and ecological degradation. What unites these powerful water beings is their fluid scalability and their ability to manifest themselves in multiple forms, from individual serpentine bodies to hydrological phenomena like rains, rivers and floods. Strang shows how indigenous movements, in their efforts to resist extractivist projects and promote more benign social and ecological developments, are further upscaling these fluid beings by enrolling them in national and international campaigns.

In Chapter 4, Franz Krause investigates relationships with freezing and thawing water in the Gwich'in and Inuvialuit Settlement Regions in what is today northwest Canada. He juxtaposes the material culture surrounding an annual bet on the exact moment the river ice will break open in front of a settlement in the Mackenzie Delta with the machinery around the annual construction and maintenance of an ice road that seasonally connects the settlement to the national highway network. Despite their differences in temporal and spatial scales – one local, momentary and recreational; the other over 100 km long, requiring many months of work and providing critical infrastructure – both sets of hydrosocial relations point to a world of uncertain phase changes between solid and fluid water. Krause contrasts these relations with global discourses about a melting

cryosphere that sideline the uncertain experiences and practices of inhabiting cold-but-warming places in favour of a narrative of linear decline. He argues that while many patterns are similar across different hydrosocial scales, it matters significantly which spatial and temporal scales we employ to approach life in a disintegrating cryosphere.

In Chapter 5, Jeanne Féaux de la Croix analyses multiple scalings of the Naryn–Syr Darya River as it flows through, Kyrgyzstan, Tajikistan, Uzbekistan and Kazakhstan. Focusing on findings and materials that her research group had developed for an exhibition designed to travel along the river, Féaux de la Croix investigates the scaling of what matters politically through the question of at which temporal and spatial scales hydrosocial issues are considered relevant and important along the Naryn and the Syr Darya. Understanding scaling as a calibration of attention, Féaux de la Croix sketches the common narrative of the decline of Central Asian rivers due to the scalar mismatch of river basins and national boundaries, and portrays a number of artistic practices as alternative scalings of the river – with alternative potentials for understanding riverine issues and possible futures. Collages of historical riverside photographs problematize gender norms, a children's book tells the love story of a river and a riverside tree, and a sculpture made from deltaic reeds questions priorities in national narratives. Féaux de la Croix illustrates the fact that art practices and anthropological analysis share the ability to rescale hydrosocial relations, showing how the river is not only the object of water conflicts and politics in Central Asia but also a site for gendered inequalities; ecologies of care; and regionally significant, if nationally marginalized, economies.

In Chapter 6, Manuel Méndez traces the history of water industrialization in the Chilean Atacama Desert in the context of nitrate mining during the nineteenth and early twentieth centuries. Surface water is extremely scarce in the desert, but a fossil aquifer has long provided water to travellers at particular wells and meeting points. With the increasing demand for nitrates in European and North American agriculture and chemical industries, small-scale mines spread across the desert using groundwater to extract the nitrate. Méndez explains the history of this method and describes the transformation of scale in mining and water use with the introduction of a new technology in the late nineteenth century. He analyses the political, legal, technical and economic factors that facilitated this transformation, as well as the social and ecological effects it has had in the Atacama Desert. For example, with the much higher water requirements of the new mining technology, water for drinking and hygiene became less available to the growing population and was commodified despite ever-larger quantities of groundwater being extracted from the aquifer. Méndez understands the scalar shifts of water use and nitrate production

through 'virtual water' accounting, whereby water from the Atacama Desert – one of the driest places in the world – has been used to extract a substance to facilitate agricultural productivity and economic growth thousands of kilometres away.

In his Afterword, Howard Morphy uses the discussions of scale to reflect on the successes and failures of Yolngu art among national and international audiences. On the one hand, he documents how Yolngu artists have used their work as a medium of engagement across scales – for example, in a territorial court case to defend their land rights. On the other hand, he cautions that scale transfers often break down as the rich messages encoded in Yolngu art are lost to non-Yolngu viewers without an understanding of how artworks embody intricate multi-scalar contexts. Howard Morphy concludes that allowing and enabling shifts between scales is also a matter of political power, which is reflected in the Australian state's willingness or reluctance to pay attention to references reflecting Yolngu scales at the national level. By focusing on the articulation of Yolngu art between local, national and global scales, Howard Morphy emphasizes the power of hydrosocial relations and imaginaries to express specific concerns in more generalized contexts.

As a collection, the contributions to this volume focus usefully on the materialities of water in all of its forms, and the art, material culture and infrastructure through which humans engage with these. In doing so, the case studies demonstrate the capacities of anthropology to connect spatial and temporal scales. 'Thinking with' water, and how it flows both literally and metaphorically between scales, expands our understanding that scale is processual and qualitative, and that more-than-human lives are lived, simultaneously, on multiple scales. In addressing the environmental crisis, watery scale-making helps to make local concerns tangible globally, and vice versa, underlining the reality that multi-scalar changes in ideas, policies and practices are required to secure a sustainable and equitable future.

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Franz Krause is Professor of Environmental Anthropology and Co-Director of the MESH (Multidisciplinary Environmental Studies in the Humanities) hub at the University of Cologne (Germany), interested in the role of water in society and culture. He is also a member of the university's Global South Studies Center. Before his studies with Ehdiitat Gwich'in and Inuvialuit in the Canadian Mackenzie Delta, he conducted research in Finland, England and Estonia. He is the author of *Thinking like a River* (2023), co-author of *Environmental Anthropology* (2023) and co-editor of *Amphibious Anthropologies* (2025).

Note

1. Following Claude Lévi-Strauss' observation that people 'think with' other species and aspects of the non-human domain (1963).

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