Agriculture and Human Values
https://doi.org/10.1007/s10460-022-10355-w

"Half a flood's no good": flooding, viticulture, and hydrosocial terroir in a South Australian wine region

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Accepted: 18 August 2022

Abstract
Floods generate both risks and benefits. In Langhorne Creek, South Australia, a historically-embedded system of shared floodwater management exists among farmers, who rely on semi-regular flood inundations as part of the region's hydrosocial terroir – a dynamic conjunction of water, landscape, social relations and agricultural practice. Unruly floods coexist with a heavily regulated and precisely measured system of modern water management for viticultural irrigation across the region. Since the mid-twentieth century, groundwater extraction and new pipeline schemes have linked Langhorne Creek to the Murray Darling Basin water management system, which has displaced flooding as the primary source of irrigation water. The associated modernist shift towards the rationalization of water as a measurable resource has acted to sideline flood irrigation. Yet, floods maintain important viticultural, ecological and social roles in Langhorne Creek, adding to the flexibility and resilience of the region in response to water management challenges. The system involves technological and infrastructural components, such as flood gates and channels, but also relies upon the cooperation and coordination of community members. Local vignerons suggest that flood irrigation is environmentally as well as economically beneficial, rejuvenating riparian wetlands along watercourses. A more formal acknowledgement of the specific regional experiences of water management in a wine region like Langhorne Creek helps to fill a gap between emplaced and hydrosocial understandings of flood irrigation and broader assumptions about flooding as wasteful and inefficient.

Keywords Irrigation · Flooding · Langhorne Creek · Terroir · Viticulture · Wine regions

Introduction

Floods are frequently associated with destruction. As "natural disasters", floods can be unpredictable, damaging to agriculture and property, and dangerous to the lives of people and animals. Much of the literature focuses on floods as an "uncontrollable" and dynamic natural force, an effect that is magnified when flooding interacts with the static infrastructure of a human settlement. Yet flooding can also be beneficial, providing irrigation where rainfall or groundwater is scarce, and transporting silt-rich waters to regenerate agricultural soils and ecological systems that have throughout history supported a range of human societies (Macklin and Lewin 2015). To increase the management complexity, floods can be both regenerative and destructive for people dwelling on floodplains where flooding is regularly negotiated (Cunado and Ferreira 2014; Paul 1984; Rahman and Salehin 2013; Tockner et al. 2008; United Nations Economic Commission for Europe 2009). Yet, in a world where the pursuit of predictability and scientific measurability is cherished as part of a paradigmatic modernity, irregular and unpredictable events like floods are often positioned only as risks to be managed and mitigated, rather than potential resources. In this paper, we examine the historical and contemporary management of irregular flooding on the Rivers Bremer and Angas in the South Australian wine region of

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Published online: 08 November 2022

Langhorne Creek. The example illuminates the ways in which "unruly" floods can and do coexist with a heavily regulated and precisely measured system of modern water management for viticultural irrigation.

By examining water management in a South Australian floodplain, we call attention to the floods' productive unruliness, highlighting their workable variability within an ecological system that can be managed through flexibilities of practice and approach, particularly at a "local" scale.[1] To this end, we introduce the concept of "hydrosocial terroir" to describe the locationally specific relationships that people have with the water that is constitutive of place, products, and communities, which are vital to understand river social-ecosystems (Dunham et al. 2018; Verbrugge et al. 2019). Flooding in Langhorne Creek, we show, is generative in this sense, shaping not only the floodplain landscape itself but the social patterns of those who dwell and rely upon it. In drawing on insights from our case study, we contend that the dominant framing of floods as unmanaged or unmanageable limits understanding of floods as potentially beneficial. In other words, the failure to effectively distinguish between "good" or "bad" floods within the modern, rigid definitions of natural resource and hazard management may deflect from or undermine unique opportunities generated from more fluid understandings of the roles of floods as generating resources within local settings.

The work we present has added significance given the new and emerging challenges posed by the weather extremes and natural disasters associated with climate change – like prolonged periods of drought and water supply shortages followed by bouts of extreme, crop-damaging rainfall – which stress production systems (Connor et al. 2009). As climate change continues to mediate the relationship between people and their embedded ecologies, the ability to adapt water resource use in flexible ways will become more critical (Finlayson et al. 2021; Lereboullet et al. 2013). For many regions and communities there is a clear necessity to protect against damaging floods, but there is also a need to understand and deliberate upon the complexities of local flood events, to prepare for and mitigate against future inundations, and to maximize the potential benefits that floods might bring. Here, we examine how flooding might be occasionally recast as a mechanism of positive change in an increasingly water constrained world by analysing how Langhorne Creek's longstanding history of interaction with floods has been fundamental for developing flexible and resilient social responses to water risks and opportunities.

[1] We use this term reservedly, recognising the impossibility of severing the "local" from its broader context, and acknowledging the significant work undertaken in anthropology and other disciplines that problematizes the concept of the local (see e.g. Raffles 1999).

Conceptual background

Modern water, flooding and the hydrosocial

In "modern" water management systems, the freshwater supplies that are most valued are the ones that can be tamed and incorporated into technical and infrastructural regimes of control, treatment, and distribution. Jeremy Schmidt calls this kind of water "normal water", as it involves "bringing water's social and evolutionary possibilities into service of liberal forms of life" (2017, p. 5). This effort to conceptualize water as a "resource" to be harnessed for the good of human flourishing, and for the benefit of industry and commerce, is also what Jamie Linton refers to as "modern water" (2010 , 2014). Such perceptual approaches to understanding water's values, attributes, and duties are what guide large scale hydrological management regimes. Rivers have long been a prime target of these systems of hydraulic control as they are sizeable conduits of freshwater, whose propensity to overflow during and after times of high rainfall present short-term dangers and long-term risks. Although a range of past societies sought to harness and manipulate the rivers they lived alongside, the scope and ambition of riverine domination grew dramatically in the colonial and post-colonial periods. In Australia, India, and elsewhere, for instance, the construction and widespread use of modern weirs, canals, and dam technologies was equated with bringing technological and infrastructural "progress" to colonized nations, a logic that has continued to apply during the post-colonial era (Burdon et al. 2015; Drew 2017; Gilmartin 1994). These infrastructures are praised when they work well – which is to say, when they contain and distribute river waters as intended. However, when they "fail", such as when river waters breach banks or walls, the focus often shifts to how dam infrastructure might be better modified and managed to contain river surges and flooding events.

The result is that the planet's rivers have, to a large degree, been brought into submission – save for the pesky and persistent problem of their capacity to occasionally flood. Put differently, managed rivers are no longer a threat, but floods are. Floods are seen as "disorderly flows" (Strang 2004, p. 123) that disturb an "assumed normalcy in socio-material relationships" (Krause 2016, p. 683). In other words, floods can turn "normal", "modern" water into unruly water, representing a disorderliness that challenges predominant hydraulic regimes. Although some scholars are starting to consider more seriously what it means to live with floods, this kind of work most often tries to understand how "lay" and "expert" knowledges can help in "flood risk management decision-making" (McEwen et al. 2016, p. 15; Whatmore 2009). What is given less scholarly attention are the diverse ways that people understand the positive attributes

of floods, and the ways that some communities create and maintain systems that accommodate, and even rely upon, beneficial flood events. These systems operate alongside modern water management regimes but are not overdetermined by them. They also involve considerable amounts of social organization and coordination – a hydrosocial relationship with floods.

The use of the term hydrosocial[2] has grown significantly in recent years due to its ability to explain how water flows and human sociality are deeply integrated (Krause 2016, p. 682). These "watery relationships", according to Krause and Strang (2016, p. 633), "challenge assumptions about nature and resources, questioning their conceptual and material boundedness and stability and furthering our understandings of the human and nonhuman aspects of their production". Flooding, then, is an issue of relationality: "… it is about how people negotiate the simultaneously social and hydrological fields of relationships in which they live their lives, inhabit their homes, and travel to work. Through these relationships, people are linked to (or separated from) not only each other, but also the river, the floodplain, and the drinking-water and wastewater infrastructures" (Krause 2016, p. 684). The explicit recognition of how the human and the non-human are intertwined in a co-evolution of sorts is important because it helps to rescue elements like water from (false) representation as a mere "resource" to be used objectively and dispassionately. Rather, human encounters with water are often driven by cultural interpretations, historical paths and emotions. It is for this reason that hydrosocial research does not shy away from looking at the "context-specific and non-scientific social and cultural meanings of water", especially as these diverse meanings result in unique relationships with water *and* distinct forms of water management (Wesselink et al. 2017, p. 6). The management of water can also be heavily influenced by the all too human relationships–including agreement or conflict–that people have with one another, which in turn shape the governance institutions that oversee water "resource management".

Within hydrosocial landscapes, human relationships with water become drawn into processes of spatial organization, administration, and governance, i.e. of territorialization. Scholars analysing these assemblages describe them as "hydrosocial territories" (Boelens et al. 2016; Götz and Middleton 2020; Hommes et al. 2019; Swyngedouw and Boelens 2018), which, though sometimes appearing "natural", are produced and (re)produced through social-natural-technological-representational interactions. As Rutgerd Boelens and his colleagues (2016) explain, hydrosocial territories are the "spatial configurations of people, institutions, water flows, hydraulic technology and the biophysical environment that revolve around the control of water" (Boelens et al. 2016, p. 1). Such work highlights the analytical significance of acknowledging the "web of relationships" within which the hydrosocial is situated – including the historical, cultural and political settings that impact human-water relationships over time (Boelens et al. 2016, pp. 1–3). By emphasising the complex web of inter-relationships, attention is drawn to "territorial claims", power contestations and disputed systems of control that additionally characterize hydrosocial territories (Götz and Middleton 2020, p. 2). In the Langhorne Creek case study that follows – as elsewhere in Australia or other settler nations – an understanding of the region's hydrosocial territory must therefore include the role of colonial cultural practices and institutions alongside the hybrid cultural practices and institutions that are part of the post-colonial present. Not only does Langhorne Creek offer a compelling case of the development of a unique "water culture" (Bijker 2012; Donahue et al. 1998; Strang 2015), it also demonstrates how the cultural appreciation for flood events has fostered agricultural and viticultural practices that are being challenged as the hydrology and the political-economy of the region undergo transformation. As we contend below, this work requires a recognition of the relationships between processes of territorialization in Langhorne Creek and the region's hydrosocial terroir.

Langhorne Creek as hydrosocial territory

The Langhorne Creek wine region lies some 60 km south-east of Adelaide, the state capital of South Australia, on the floodplain of the Angas and Bremer Rivers. These two streams originate in the Mount Lofty Ranges and flow down their eastern flanks, emptying into Lake Alexandrina, a large coastal freshwater lake fed primarily by the River Murray (Fig. 1). Lake Alexandrina connects with Lake Albert and the coastal lagoon of the Coorong to form an enormous shallow system of over 75,000 hectares, draining into the Southern Ocean near Goolwa (Sim and Muller 2004, p. 4). The Angas and Bremer are ephemeral creeks, running for several months of the year and most significantly in winter and spring following rainfall in their catchments in the Mount Lofty Ranges. A principal feature of these rivers is that they are subject to semi-regular flooding, during which time large areas of their flood plain is inundated, replenishing and watering the deep alluvial soils of the region.

The floodplain of the Angas and Bremer is part of the traditional country of the Ngarrindjeri people, which takes in the riparian, lake and coastal estuarine system of the lower Murray (Hemming and Rigney 2008). For Ngarrindjeri, a consubstantial relationship between people, land

[2] The lack of a hyphen in the word "hydrosocial" is intentional: the omission helps to visually indicate the "hybridity between water and humans" (Wesselink et al. 2017, p. 7).

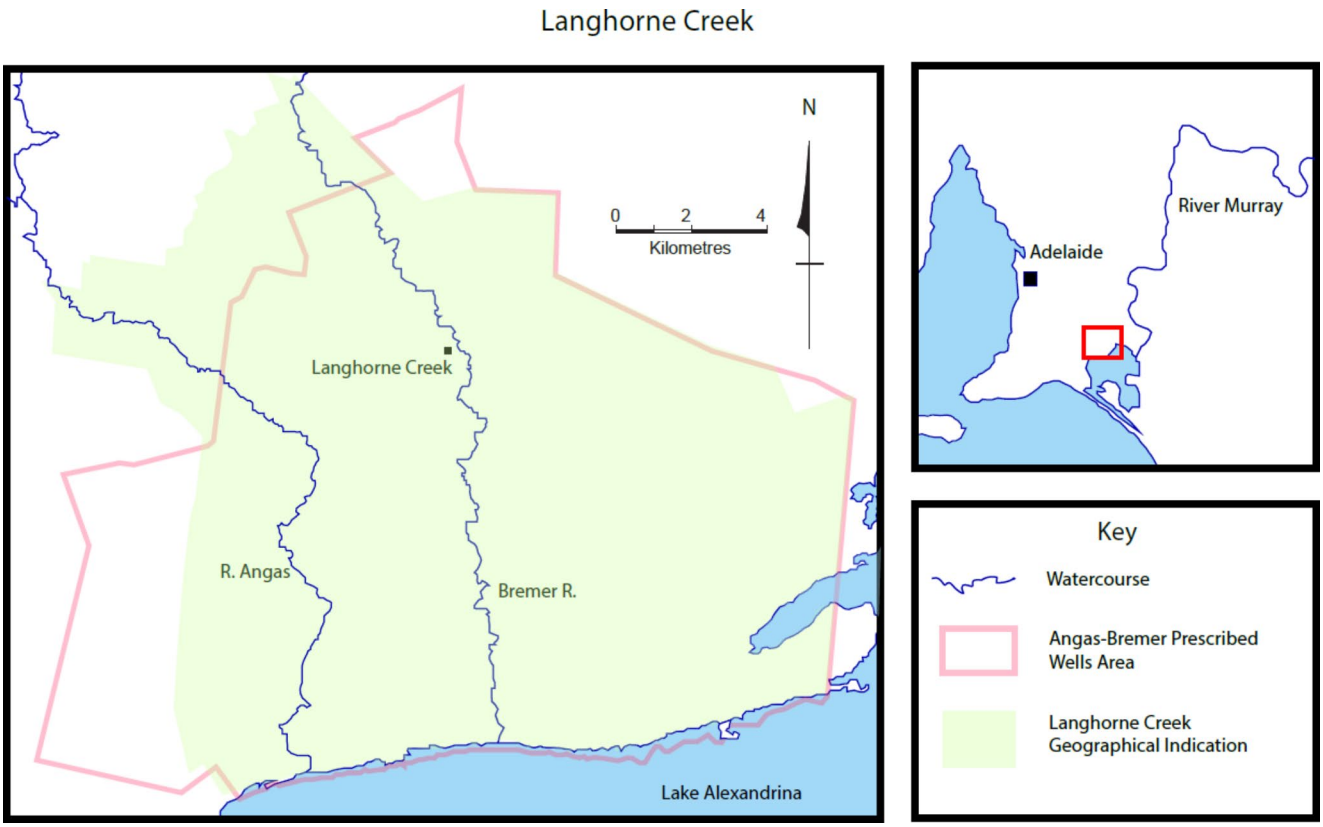

Fig. 1 Map of the Langhorne Creek region

and water is crucial. This is encapsulated in the concept of *Ruwe/Ruwar*, a philosophy of being that interweaves "lands, waters, body and spirit" in an ongoing sense (Hemming et al. 2010, 2017; Ngarrindjeri Nation 2019; Wilson 2016, 2017) – itself a "hydrosocial" understanding. From the 1850s onwards, the district was settled by British colonists attracted by its production potential linked to its rich alluvial soils and water supply. Water played a central part in a colonial history marked by inundations, droughts, infrastructure developments and political manoeuvrings over irrigation access and rights. With an agricultural settler community linked by common concerns over water and social relationships of water management of various kinds, Langhorne Creek offers an example of a "hydrosocial territory" *par excellence.* This territorialization is enacted most clearly through political-legal "inscription devices" (Li 2014) that work to formally define the space and its management, including the (largely overlapping) boundaries of the Angas-Bremer Prescribed Wells Area declared in 1980 to control water extraction and the Langhorne Creek Geographical Indication for the wine region (see Fig. 1).[3]

From territory to terroir

In this paper, we introduce a further conceptualization of hydrosocial space through the lens of *terroir* – a concept with French origins that has long influenced wine, gastronomy, and agricultural discourse, and which has been the subject of much recent critical analysis (Black and Ulin 2013; Demossier 2011; Dutton and Howland 2019; see also Patterson and Buechsenstein 2018). The notion of terroir usually refers to the specific relationships of "place" to the flavour and characteristics of wine, such that a wine can be said to "taste of" a particular place (*goût de terroir*). As Johnson puts it, "'terroir' is the almost mystical … word for the unchanging unity made up of the soil, the situation, and every facet of the vine's environment" (Johnson 1989, p. 268). While most frequently, contemporary terroir-talk invokes this "interpretive" relationship between wine and the physical-material conditions of the environment, it extends to encompass everything that influences wine production – including "tradition", history, political economy, and social networks amongst grape growers, winemakers, distributors, consumers, and a host of other actors (Bohmrich 1996). Terroir discourses in the "Old World" wine

[3] See http://www.angasbremerwater.org.au/documents/Angas_Bremer_Water_Allocation_Plan.pdf and https://www.wineaustralia.com/labelling/register-of-protected-gis-and-other-terms/geographical-indications/langhorne-creek for details of these territorial configurations.

regions of Europe link notions of productive quality/ies to a narrative of emplaced historical (or mytho-historical) "tradition" or "patrimony" (Demossier 2011; Gade 2004; Ulin 1995). In its most holistic interpretations, therefore, terroir is a relational assemblage emerging from links between wine, people, place, labour, technologies, vines, and the abundance of other life in the vineyard.

Terroir, referencing the "essence" of a particular place as manifested through the flavours and other sensorial characteristics of its produce, is very frequently linked to a political-strategic organization of space of some kind, i.e. to territorialization. Territorialization through the legal definition of winegrowing regions has a long history, from the delineation of Burgundy's terroirs in the fifteenth century, to Port, Chianti and Tokaji in the eighteenth century, to the increasingly detailed political-economic systems of appellations developed during the twentieth century and adopted in various forms in wine producing jurisdictions around the world (Meloni and Swinnen 2018). In Australia, Geographical Indications (GIs) were only formalized following a (1994) bilateral agreement with the European Community. This agreement restricted the way wine could be labelled, such that Australian wines could no longer be marketed using protected designations of origin under European law, e.g. "champagne", "burgundy", "port". Following this, Australia developed its own "Register of Protected Geographical Indications", providing legal definition for Australian wine regions.[4] Langhorne Creek was formally registered as a GI in 1998.

Territory and terroir are overlapping notions, reflecting different (but often complementary) perspectives of space that feed into one another. In Burgundy, as Demossier (2018) shows, historical understandings and practices of vineyard distinction have become legally codified through the rigorous *appellation d'origine contrôlée* (AOC) system, with its rich history further concretized in UNESCO World Heritage listing. Here, multiple layers of authoritative categorization over viticultural space give great weight to producers' claims to place-based value. Terroir narratives are, furthermore, often used to give credence to appeals to territoriality – that is, terroir is itself politically instrumental. In Israel/Palestine, Monterescu (2017) and Monterescu and Handel (2019, 2020) show how terroir claims to "authenticity" based upon biblical accounts of winegrowing in the region are frequently invoked to validate processes of Israeli territorial colonization. In so-called "New World" wine producing countries like Australia and New Zealand, terroir-talk is often weighted more heavily towards physical elements like soils, geology, topography, etc. than to claims of a naturalistic alignment with winemaking traditions, and producers and regional bodies regularly appeal to territorial representations of space, formalized through GIs, as a means of generating value (Banks et al. 2007; Banks and Sharpe 2006; Overton 2010; Overton and Murray 2016; Raftery 2017; Skinner 2020). Everywhere, however, terroir narratives move wine away from a status of undifferentiated commodity, marking it as singular in the same way that an appeal to hand-crafted artisanship distinguishes products subjectively from the mass-produced. This makes terroir valuable as a marketing tool: indeed, "toward the end of the twentieth century, it became a buzzword glossing place-based product authenticity" (Gade 2004; Monterescu 2017, p. 128). Nevertheless, as Ulin (2013) argues, by foregrounding the link between place and production, terroir discourse has the potential to obscure as much as it reveals, concealing very real socio-cultural or political-economic dimensions of wine production.

Terroir and territory offer important ways to approach questions of space and place in agriculture, both of which may help to illuminate the other. Thinking through a terroir lens permits us to approach water not only in terms of its "governance", "use", "management", "infrastructure", "social networks" etc., but as a more fundamental aspect of *place* itself. As well, terroir helps us to frame the ways watery relations influence the flavours and other sensory characteristics of wine grape production in landscapes with unique hydrosocial configurations.

Data and methods

This paper is drawn from fieldwork undertaken in the Langhorne Creek region during 2021 as part of the three-year project *Hydrosocial adaptations in Australian agriculture*, funded through the Australian Research Council. This research involved on-farm, semi-structured and "drive-and-talk" interviews (Drew et al. 2022) with 20 vignerons utilizing a range of irrigation sources: groundwater, Angas or Bremer flooding, Murray River water piped via a new pipeline (see below) or from Lake Alexandrina, or some combination of the above.[5] Our interlocutors represented a broad cross-section of wine business types in the district, including small-scale growers, family and independent wineries, and representatives of larger, cross-regional corporations. They ranged in age, with several being involved in farming in the district for many decades. As well, we interviewed representatives of regional industry bodies, government agencies, and water experts. Interviews were recorded and transcribed and analysed thematically.

[4] https://www.wineaustralia.com/labelling/register-of-protected-gis-and-other-terms/geographical-indications.

[5] Now, the greatest volume of irrigation water in the district is supplied via the "Creeks Pipeline Company" from the Murray River (Angas Bremer Water Management Committee 2020).

Case study: flood irrigation in Langhorne Creek

Perhaps no aspect of life in Langhorne Creek illustrates hydrosocial terroir more clearly than the seasonal floods along the Angas and Bremer. Flooding is, we contend, constitutive of the region in many ways. This is so materially, as the waters replenish floodplain soils and aquifers, and breathe life into the redgum swamps flanking the watercourses (Muller 2002; Sim and Muller 2004); but also socially and culturally, as farmers and residents have developed particular ways of living with the floods, and living with one another in relation to the floods. As discussed above, the fundamental unpredictability and liveliness of floods – their "unruly" nature (Jones and Macdonald 2007) – makes them dangerous, according to the disciplinary logic of modernism. They become seen, primarily, in terms of risk: a potentially disruptive force that must be approached through techniques and processes of management, mitigation, measurement and regulation. In Langhorne Creek, however, floods have been a valuable source of irrigation for over a century and a half; it is the ongoing challenge of living and working with this watery unpredictability on the Angas and Bremer floodplains that has "fertilized the soil" of a resilient hydrosocial landscape. Although images of flood-inundated vineyards tend to make modern vignerons shudder, as over-irrigation is usually considered anathema to controlling grape and wine quality, in Langhorne Creek this is not the case. The reasons why have to do with the specific conjunction of soils, vines, and social adaptations to irrigation practice, as we will discuss below. In what follows, we provide geographical and social context for the Langhorne Creek region while exploring the various ways floods are understood and valued by farmers.

In the early colonial period, the fertile and relatively well-watered Angas-Bremer floodplain proved very attractive to European settlers, who saw in this country enormous potential as pasturage and cropping land (Linn 1986).[6] By the early 1850s several families had settled on the banks of the Bremer, forming the small village that was to be known as Langhorne Creek (referencing a cattle drover, Alfred Langhorne, who traversed this river a decade earlier) (Linn 1986).[7] In 1850, Frank Potts settled on a hundred acres of land at "Bleasdale", adjacent to this township, and by 1858, "to take profitable advantage of the rich flood plains around the town", he had planted thirty acres of Shiraz and Verdelho vines and established a winery (Linn 1986, p. 58; Smith and Ragless 1986). Grape vines soon became a key component of the floodplain agro-ecosystem around the township. According to the 1909 *Cyclopedia of South Australia*,

> [The Bremer] flows sluggishly in this part … as it approaches its outlet into Lake Alexandrina, but in times of flood, (it) spreads widely over its banks depositing richly fertilizing soil. On the flats thus favoured, there are fine meadow lands, fruit plantations and vineyards where a considerable quantity of wine is made. (Cyclopedia of South Australia, vol. 2, 1909, quoted in Verrier 1977, p. 3)

For early settlers, the floods along the Angas and Bremer rivers were highly valued, as they provided vital irrigation and regularly replenished soils in a region where natural rainfall is low thanks to a "Mediterranean" climate pattern, in association with the rain shadow effect of the Mount Lofty Ranges to the west. In the absence of floods, farmers began to experiment with damming the rivers to harness water for their own purposes, often to the chagrin of those downstream (Angas Bremer Water Management Committee; Sim 2004). Soon, however, an innovative solution was reached, beginning with Potts at Bleasdale, in the form of diversion weirs: wooden gates in the riverbanks that could be opened and closed, permitting river water to be directed through diversion channels and onto vineyards at times of high flow (International Commission on Irrigation & Drainage 2021). Similar infrastructure of sluice gates, channels, and earth embankments were subsequently developed by settlers along the Bremer and, to a lesser extent, the Angas (Angas Bremer Water Management Committee; Sim 2004; Smith and Ragless 1986; Verrier 1977) (Fig. 2). Much of this infrastructure along the watercourses remains in use today, maintained by vignerons who continue to divert winter flows onto their vineyards.

Prior to the development of technologies permitting easy access to other sources of irrigation (groundwater and water from Lake Alexandrina and the Murray), such manipulation and redirection of "natural" flows was essential in ensuring vines received sufficient water throughout the growing season. A good winter sets the vines up well to deal with a hot, dry summer. Kirsty,[8] a viticulturist, pointed out to us how the flow could be manipulated to ensure even coverage of her vineyards:

> The water comes down – the entry points are down near the Frank Potts Reserve, where they've got a

[6] Although the farmers of British and European descent with whom we spoke recognized Ngarrindjeri traditional ownership of the area, they did not elaborate on the details of Indigenous history or invoke Ngarrindjeri concepts into their narratives of water use and management.

[7] Several of our interlocutors are descendants of these colonial settler families.

[8] Names used are pseudonyms.

Fig. 2 Flood gates on a distributary offshoot of the Bremer

> floodgate there, and we've got a floodgate just up here, just a small one. So, what we do is we back the water up in [this block] until it's full. And then we start opening up boards. And that comes down through here, down through that section, and down the back of the winery. And then it all sort of just fills up.

Just as important as the physical infrastructure described above to the success of flood irrigation were the socio-technological arrangements developed by early colonists, involving agreement and participation between neighbouring property owners (Verrier 1977; Angas Bremer Water Management Committee; Sim 2004; Wine Australia 2021; Shalsi et al. 2022) – a system that persists into the present day. A farmer using sluice gates to divert floodwaters from the river might hold the water in a vineyard for a time (usually a day or two), then open their gates to release the water for neighbouring, downstream vineyards. The water can be used to irrigate several properties in this way, before flowing back in the river or into one of the region's redgum swamps, thus providing benefits for important riparian ecosystems (International Commission on Irrigation & Drainage 2021; Danenberg 2019).[9] This necessitates a high degree of trust and coordination between neighbours. Flood events are unpredictable in their timing, volume, flow rates, quality, and dynamics, so the ability of each landholder to achieve equitable benefits from irrigation hinges on the upstream neighbour's willingness to release water from their own property in an appropriate manner. This is an arrangement that is not formalized, but instead exists as a "gentlemen's agreement" between farmers whose families may have lived next to one another for a century and a half. As one farmer, Ken, told us,

> That's just the way the water flows. If I decide to flood, I can't just water my place. Because you can't do the job properly. You need sufficient water to do your own place and send it on to the next person. Because after the neighbour has it, it goes on to the swamp.

While some regular floods are beneficial, regional agricultural history is tied intimately to the variable flows of water – marked by wet years and large inundations like

[9] These seasonal wetlands are cradles of biodiversity, valued by many of the farmers we interviewed.

the great flood of 1941, when Langhorne Creek township "became isolated in the centre of a sea of water six miles wide" (Verrier 1977, p. 28) and in 1992, when again the Angas and Bremer "joined up". As well as the floods, the health of the groundwater aquifer underlying the region has been critical to hydrosocial relations. With the advent of mains electricity in the district in the 1950s, irrigation bores became widespread and the cropping area expanded enormously. Subsequent over-extraction led to a spike in salinity levels that rendered some groundwater nearly unusable for agriculture (Waterhouse et al. 1978). To overcome this crisis, an advisory committee of irrigators was formed in 1979 to seek solutions and provide advice to government decision-makers. This group, which has been known since 1997 as the Angas Bremer Water Management Committee (ABWMC),[10] pushed for the adoption in the late 1980s of a licencing scheme whereby groundwater extraction licences could be traded for Lake Alexandrina water (Harris 1993; Howles 1994; Cuadrado-Quesada and Gupta 2019). The establishment and history of the Committee represents a formalization of the cooperative social infrastructure that has long been in evidence in the region.

With the turn of the 21st Century came the decade-long dry spell known as the "Millennium Drought", during which time very low River Murray flows into the Lake resulted in high salinity levels. This prompted the development of a new private-public pipeline scheme, the Creeks Pipeline Company (CPC), drawing water directly from the Murray above the Lake and thus securing – at least for the time being – the irrigation future of the district.[11] Such developments have been praised as examples of collective community action overcoming the "tragedy of the commons" (Shalsi et al. 2019, 2022). However, as irrigation to the district is now supplied largely by the CPC (Angas Bremer Water Management Committee 2020), with groundwater primarily a "backup" to the higher quality Murray water, the significance of the localized hydrological system, and flooding as a valuable component of that system, is being challenged.[12] Flooding remains immediately important for most farmers adjacent to the Angas and Bremer, as we will discuss in the following section, but developments in irrigation infrastructure, water policy and economic incentives from the early 1990s have permitted much broader vineyard planting, beyond the limits of the floodplain.

[10] https://www.angasbremerwater.org.au/.

[11] http://www.creekspipelineco.com.au/.

[12] The Murray Darling Basin extends across South Australia, Victoria, New South Wales, the Australian Capital Territory and Queensland. The Australian government's *Water Act 2007* established the Murray-Darling Basin Authority as an independent statutory agency responsible for planning and governmental advice across the Basin (https://www.mdba.gov.au/).

Valuing floods

For much of Langhorne Creek's history, floods were regarded as critical. Now, despite the effective widening of the geographical horizons of the district as it is integrated into the geo-political dynamics of the Murray Darling Basin, and even though floods have become a less significant irrigation source for most grape growers, flooding remains an important element of hydrosocial relations in Langhorne Creek. According to one local history, published in 1977, "Langhorne Creek is a very unique town, in that it actually welcomes floods … they are the grape-growers' best friend – provided of course that they are not too big, or that they do not arrive at the wrong time of year" (Verrier 1977, p. 23). Floods, when they arrive, are a focal point of the community: flowing over roads, turning paddocks into lakes, lapping at doors. Most houses are built on raised land; low-lying dwellings are fenced with small stone garden walls, the gaps of which must be filled in by flood boards or sandbags. The pub, built at the highest point in the town, remains open – "you can get there by boat!" – and this is where residents meet to share stories and discuss the situation, comparing the flood to other deluges in the past and predicting its future movements. In past decades, technologies of flood prediction and communication were not as precise as they are nowadays: older farmers told us that they might rely on a friend living upstream to call them if rains in the Hills were generating flood conditions that would subsequently reach Langhorne Creek. Now, flows on the Angas and Bremer are monitored at various points and reported on the Bureau of Meteorology website, along with flood warnings.[13]

The vines in Langhorne Creek speak to the longevity of the region's multi-pronged water regime [Fig. 3]. Some have attained a venerable age, as at Metala vineyards, where some of the oldest documented Cabernet Sauvignon vines in the world – planted on the floodplain in 1891 – remain in production. Vines adapt to the specific conditions of sporadic inundation surprisingly well, we were told: mature vines can moderate water and nutrients taken up through the vascular system even under flood conditions, and are therefore less susceptible to over-watering than vines with shallow root systems used to surface drip irrigation. Soils are also a crucial factor in the ability to grow high-quality grapes on the floodplain:

> The Mines Department drilled a well [on my property] back in the '80s, they went down six metres with an auger. And they were bringing vine roots out – when they took the last sample of soil out at six metres, it had vine roots in it. It's just beautiful alluvial soils.

[13] http://www.bom.gov.au/cgi-bin/wrap_fwo.pl?IDS60164.html.

Fig. 3 A flooded vineyard

> So there's thousands of years of topsoil from Mount Barker and the Hills, which comes down and just lays over it – tens of thousands of years, millions of years, and you get a layer of silt every time it comes and that's just built up … rich soil full of the nutrients. You don't have to add anything to it. (Greg)
>
> The soil profile is quite unique because it doesn't give the water up quickly. So, it's not like the vines can just suck it all up and over-vigour themselves. It's quite a self-regulating [system] that it's actually quite hard work for them to get that water out of the soil, so they don't go too crazy, but they've got access to water. (Fiona)

Regularly, flood-irrigated vineyards in the region produce premium wines, garnering awards and glowing critic reviews. Growers point out that some of the most well-regarded wines of the region are grown using "traditional" flooding; indeed, the main issue most have with flood irrigation is not quality as such, but consistency and control.

> If you're a viticulturist, [flood irrigation] can be a no-no: they say they've had too much water, they have too much vigour, they're out of balance and they don't make good grapes. But, well, I don't know whether you've tried [redacted winery's] wines or not? They come off the floodplain. And they're very good. (Ken)

While some winemakers (more often, large corporate wine companies and their suppliers) prefer the consistency that can be achieved through closely regulated irrigation regimes, others accept variation between vintages to be a natural and acceptable part of winemaking. It is part of the terroir, the "art" of winemaking to work in concert with the vagaries of the growing season, whether hotter or cooler, wetter or drier. Furthermore, for most growers along the Bremer and Angas watercourses, floodwaters represent only one mode of irrigation among several. As Wendy, a viticulturist, explained,

> We've got three ways of being able to water the vineyard here. One is when there's a natural flood and you couldn't keep it out if you tried. That's just Mother Nature, where the flood breaks the bank and comes through. Then we also have – if we get three quarters of a creek [referring to water height in the Bremer] or higher, we can put the flood boards in the creek and bring it under the road through the tunnel. We've got floodgates on the other side of the vineyard here, we can hold it for, you know, 12–24 hours, depending on how long we think the old girls [vines] need it, and then we let it go on to the neighbours' and basically ends up in those redgum swamps out the back. And then there's drip irrigation, which is now from the River Murray … We probably try to use less flooding now. Because you can't do as precise viticulture as

> what you would like. But then the old girls out here, the ones right here were planted in '66. They've got roots deep down, you know, so the drip irrigation is not that effective for them.

Flood irrigation systems are often associated with inefficient use of water. An example of this is in Mendoza, Argentina, where large channel systems extend from rivers fed by meltwater from the eastern slopes of the Andes. This has turned an otherwise arid desert landscape in the rain shadow of the Andes into an "oasis" of productive agriculture, especially wine grape production (Castex et al. 2015; Johnson-Bell 2017; Morris 1969). As in Langhorne Creek, water in Mendoza is "rationed between vineyards and farmers through the opening and closing of miniature flood-control gates" (Johnson-Bell 2017, p. 57), though on a much larger scale. But unlike Langhorne Creek, Mendoza receives *all* of its irrigation water from flooding. Now, a combination of inefficient water management practices and climate change means the region must reckon with long-term water scarcity risks, threatening agricultural viability (Castex et al. 2015, p. 2). With Mendoza as an example case study, Johnson-Bell makes the claim that flood irrigation is "the worst form of irrigation in terms of both water conservation and fruit quality, as it soaks the vine's root system. Flood irrigation is only suitable for bulk wine production" (Johnson-Bell 2017, p. 57). A distaste for flood irrigation on the grounds of quality is widespread within the viticultural world, but does not align with the experiences of most of our interlocutors along the Angas and Bremer, who use floods judiciously (alongside other techniques) to grow quality fruit to make distinctive wines. Such water is not "wasted" either, with flood irrigation occurring only when there is excess water in the rivers, which then goes on to replenish swamp and creek ecosystems as well as the underground aquifer.

A tension exists, therefore, between emplaced understandings of overbank floods in Langhorne Creek as broadly positive events, and wider expectations that position flood irrigation as (usually) linked to higher yields, poorer quality, and environmental degradation. Fiona, a winemaker, told us that it was easy for people to get the wrong impression of the effects of flooding on grape growing and winemaking in Langhorne Creek:

> I'd read an email from our American distributor, and I got on their website … I thought "I'll look at the description of Langhorne Creek". And basically, it was all about flooding and fertile soils. And I just thought to myself, for someone that doesn't understand the region, they think flood irrigation means large volume, fertile soils mean large production. It makes it feel very commercial. (Fiona)

In Langhorne Creek, as respondents made clear, flooding is generally regarded as prudent management of a natural weather event in a way that makes sense locally and that, importantly, reduces pressures and reliance on other fragile water resources including Murray River water and aquifers, into which excess water is pumped via recharge bores – a process known as "managed aquifer recharge" (Gonzalez et al. 2020). But, as Dennis pointed out, the traditional management of overbank flooding does not align easily with the bureaucratic needs of modern water management, with its emphasis on measurement, monitoring and accounting for every litre:

> You get a flood, the flood water's gonna rise up, some places it's going over about this deep [gestures], sometimes is going to go that deep, and it's going to go down, and run through one of your vineyards, and into the next guy's. And that's how the system works. Runs through the top vineyard into the next guy, out through all those redgum swamps, back out of them into the next guy, down through there. How are we going to meter that? And then they think they can say, "Well, you've had so many megs [megalitres] on your property. So, it's got to be licensed." But it's the same water! How do you measure what went into my ground, and what didn't, and flowed off to him? How many megs was that? And that sort of system only works because it's an agreement that's been in place for decades and decades between families and people that all know each other. And it works. The river redgums all get watered, the environment's OK. The water all ends up back in the river and going in the lake… what hasn't soaked in. The only loss is what sucked into the ground.

While floods continue to provide an important source of irrigation, they are not equally valued by all. Attitudes to flooding in Langhorne Creek are evolving with the new technologies and practices permitting irrigation from other sources, along with the changing dynamics of the floods themselves. Nowadays, we were told, floods are much less frequent than they once were: decades ago floods were annual events, and often there were multiple floods per year. Now, long stretches of time may pass with no "natural" floods. The last "proper" flood was in 2016, five years prior to our research. According to our interlocutors, the reasons for this are twofold. Firstly, a changing climate has made rainfall less predictable. Generally, this means slightly lower winter rainfall, but also an increased number of larger rain events during the summer months, associated with monsoonal weather systems moving into South Australia from the north west of the continent. Future climatic

modelling for the region predicts a continuation of trends towards higher temperatures and lower rainfall (Remenyi et al. 2019). Secondly, there has been great change in the way water flows into the rivers from catchment areas in the Mount Lofty Ranges. In the opinion of Langhorne Creek farmers, this stems from a large number of hobby farm dams collecting and holding rainfall, as well as rapid urban development, particularly around the town of Mount Barker at the top of the Bremer catchment. These changes to hydrological flow do not just affect the number of floods that might be experienced along the Bremer but their intensity and dynamics: the floods seen nowadays are said to be swifter as Hills dams overflow during large rainfall events and greater volumes of rainwater run off hardened urban landscapes, rapidly funnelling a turbid "slug" of water into river courses (Danenberg 2019).[14] According to locals, the waterways are being gouged out by higher flows, with vegetation loss in channels leading to quicker water movement and riverbeds now sitting many metres below the banks. As an interlocutor commented when asked about the changes in the rivers near their properties:

> It's definitely running faster … I believe the town is under a lot of pressure in a big event now, because of the volumes of water we could get in a big flow. And if it's running faster, it's probably more damaging, [because it] can't get out the river system. You know, if it's a flood over 24 to 48 hours, it's got a chance to get over the bank further up, but if it all rushes down in one hit … (Greg)

Discussion

As floods become less dependable or predictable, their role as an irrigation source and as a source of ecological regeneration is being brought into question. While this is a source for concern for those who see floods as central to the identity of the district, the re-framing of the floods could reflect a broader shift towards "modern" understandings of water and its management, which are recasting hydrosocial relationships at different scales.

Even among floodplain viticulturalists in the "historical core" of the district, around Langhorne Creek township and along the banks of the Bremer, flooding is now not uniformly valued. Some told us that the unconstrained, "unruly" floodwaters make the blunt instrument of flood irrigation increasingly risky. Certainly, flooding is difficult to manage precisely, conflicting with the needs of most modern scientific viticultural practices. It is difficult to plan for floods, and there may be several years in a row when a "natural" flood is not forthcoming. When floods *do* come, their specific dynamics vary enormously: in volume, flood rate, and the location at which river banks are breached. One grower, who contracts most of his grapes to a large multi-regional wine company, told us that this winery prefers to purchase grapes grown using drip irrigation to avoid perceived inconsistency of quality. The unpredictability ensures that some growers, rather than seeing floods as an integral, essential and valuable part of the region, now perceive them as an irritation or impediment to "best practice" viticulture:

> (Floods are) an annoyance to us now in the vineyard. We can't control it. Wet spots get too wet, dry spots don't get enough. The wine industry's changed too, the big heavy crops from the flooded areas that've got too wet. Wineries don't like that sort of fruit as much as back in the 60s, 70s, 80s - the industry's fussier on the quality they get. (Dennis)[15]

Viticulturists stressed that a "full" flood is almost always preferable to a "partial" flood. While a full flood will inundate an entire vineyard, a flood that causes a vineyard to be partially submerged challenges viticulturists who need to "balance" flood water with supplementary irrigation in the parts of the vineyard that remained dry, in an effort to avoid uneven ripening of the crop.

> Well, if you got a half a flood, that's not very useful. So, we would top it up [by pumping more water from the main river flow], make it a full flood. (Steve)

Kirsty, too, told us that she welcomed floods on her vineyards, but only if there was enough water to flood a full block. Without adequate flow volume in the Bremer, she would not force the issue. Standing on the raised bank of the river, she pointed out over a vineyard which, to us, looked very flat, but which actually sloped slightly from one side to the other: "This end down here will be a metre underwater, (but) the other end up there might just get a bit of water over it. If you get a half a flood through this area, then we only get half of this block with water underneath." Such partial flooding makes things difficult. Uneven flooding means uneven ripening, and at times this block had to be harvested in three different sections: "that's time and effort, money and resources, headache for the viticulturist."

Another risk is associated with floods arriving at the *wrong* time, such as during grape ripening and close to

[14] Such fast-moving torrents are often front-loaded with salt and agricultural runoff: the first of the floodwaters may thus be inadequate for irrigation.

[15] See Anderson and Aryal (2015) on historical patterns of change in the Australian wine industry.

vintage. This might result in plump and flavourless grapes or berry split, or add to the moist microclimatic conditions that permit vine diseases to flourish. Over-irrigation in the service of higher yields per hectare is almost always to be avoided when trying to achieve grape quality, as Steve explained:

> We have a limit on the amount of crops that we will grow, which is ten tonnes per hectare, four tonnes to the acre. And if we grow more than that, we find that fruit quality suffers, flavour suffers, and the fruit's not as tough … If you go over that, then you start pushing flavour, and more importantly, the acid-tannin balance down.

Several respondents stressed that any simple assumption that flood-irrigated grapes are always of lower quality is not accurate. In fact, larger but sporadic inundations can promote deeper root growth than the shallow systems fostered by driplines – meaning that vines are likely to be more resilient, and less susceptible to fluctuations of temperature and surface water application as they send roots deeper in search of moisture and nutrients.[16] As a result, the wines themselves are often reflective of the flooding – indicating that the hydrosocial terroir can itself be tasted and reflected upon by consumers, representing a potential area for the generation of economic value.

Changes to hydrological flows mean that floods on the Bremer and Angas are now, in our interlocutors' experience, less frequent, less predictable, and perhaps unrulier in their behaviour – characteristics which are exacerbated by ongoing climate change. Changes to flood dynamics alter the physical limitations of the ways floods *can* be used for irrigation in the district. Alongside this, regional receptivity to flooding has changed over time based on social and economic changes. Technological advances like electric bores and pipeline projects have enabled an expansion of irrigation and viticultural plantings well beyond the floodplain's historical core, especially during the export-driven wine boom of the 1990s and 2000s (Muller 2002; Anderson and Aryal 2015). The late 20th Century in particular was, for Australian wine, highly technocratic: viticulturists sought, above all, economic and technical efficiencies to gain an edge in extracting value. Precision in vineyard management became of crucial importance, not least in irrigation application.

[16] It is a common viticultural maxim that unirrigated vines and those that are forced to "work" for water are usually hardier, and produce superior fruit (though with lower yield): "Unirrigated vines are forced to dig down deep to find moisture and they pick up nutrients through the soil formations as they do this. Irrigated vines often miss out on vital nutrients because their root systems remain on the surface, where the moisture is" (Johnson-Bell 2017, p. 55).

Hydrosocial terroir and cooperative adaptation

Despite the changes, multiple values remain for flood irrigation in Langhorne Creek: the unique physical infrastructure and grape growing techniques it has generated; for its role in producing wines with regional characteristics; and also the cooperative mutuality of the regional social infrastructure (Shalsi et al. 2019, 2022; Cuadrado-Quesada and Gupta 2019). These are, of course, values that have been identified among winegrowing communities elsewhere, as Ulin (1996, 2002) describes in the case of wine cooperatives in Southwest France. Even in the South Australian context, where the history of the industry in general is one of individualistic capitalist entrepreneurship, wine co-operatives have existed at various times, including the McLaren Vale-based Southern Vales Co-operative, to which some Langhorne Creek growers contributed (Steinberner 1994; Haughton and Browett 1995). As geographical appellation plays a greater role in marketing and promotion of wines and wineries (Blakeney 2012; Van Caenegem et al. 2014), an awareness of the importance of regional cohesion for mutual benefit is widespread. In Langhorne Creek, as in other Australian regions, most growers are members of the regional grape growers' and winemakers' association, a coordinated body responsible for regional representation and promotion, to which they pay a levy.[17]

Community-mindedness extends beyond formal arrangements in viticultural regions (Raftery 2017; Bardsley et al. 2018; Skinner 2018). Terroir reinforces these relationships as it emphasizes land and system over producer, highlighting that any single producer does not have a "monopolistic privilege over *the ability to* fashion such particularity from land" (Raftery 2017, p. 362, emphasis in original). The hydrosocial terroir of Langhorne Creek is a vital example of this informal process of cooperative adaptation, which we have illustrated using the example of flood management as a collective endeavour that has helped to shape the regional character. As viticulturalists become less immediately dependent upon their neighbours, however, the hydrosocial terroir is threatened. While agreements between neighbouring farmers can still take place with a handshake, based on a history of goodwill and recognition of mutuality of cause to arrange the diversion and sharing of floodwaters, the demands of modern water management, and the associated financial, political and technological infrastructure involved, is necessitating a formalization of governance arrangements that extend well beyond the region. As uniqueness and quality are increasingly prized in the consumption of wine, those irrigators who maintain a flexibility, vigilance, and openness

[17] https://www.langhornecreek.com/.

to the unpredictability manifest in unruly floods may be key to retaining and regenerating the distinctive regional terroir.

Conclusion: floods and hydrosocial terroir

Water is a crucial aspect of viticulture, and the provision of irrigation is necessary in most regions to grow wine grapes. In a water resource-constrained world, where changing climate and population growth is placing increased strain on agricultural systems, extractive regulation is necessary, and viticulturists and other water users have experienced an increasing rationalization and modernization of water management involving measurement, metering and accounting regimes, governed through regulatory oversight, and responsive to market dynamics. Yet such regulation often exists alongside and in relation to much more emplaced practices of irrigation, embedded in specific cultural and social histories of water management and understandings of hydrological landscapes. This is what we term "hydrosocial terroir", in a nod to the concept of terroir common in wine and other agricultural discourse. In this article, we have emphasized flood management in Langhorne Creek as emblematic of emplaced water practices, which persist alongside and in conjunction with modern understandings of water as a key aspect of the regional hydrosocial terroir. The hydrosocial is critical to understanding territorial and terroir configurations of space-and-place in Langhorne Creek: the relationships between farmers, other key social and political actors, the rhizomic connections to the city and to other farming and irrigation districts. The grape vines upon which the region is dependent were planted here because of a confluence of interconnected hydrosocial elements, including the deep, well-drained soils of the Angas Bremer floodplain, the resources of an underlying aquifer, proximity to the shallow Lake Alexandrina, and now also including the pipeline linking the district to the Murray River.

Floods, by and large, confound attempts to ration and rationalize water. It is difficult to measure flows rushing through large flood gates or over a riverbank. Paradigmatic as they are of unruly and ungoverned water, floods run almost by definition counter to modern understandings of water as a simple measured and monitored "resource" (Linton 2014). Yet despite these unruly tendencies, floods have been successfully managed as a resource in Langhorne Creek for a hundred and seventy years. Beyond their material importance in watering the land and replenishing its rich soils, the floods are socially and symbolically important as the historical wellspring of the district, the reason for its colonial settlement and economic success. In many ways, the floods tie the region together. Farmers maintain patterns and practices of shared access to floodwaters, seen as a common good that is materially important for agriculture and environmentally beneficial. This remains possible so long as the floods are valued, and so long as these understandings of value and mutual benefit are maintained through relationships of cooperation among irrigators. Water policies must often be broad-reaching but, as the example of flood management in the region shows, they need not, and perhaps should not, be simply universalising. We contend that greater attention to, and engagement with, established hydrosocial practices fosters efficiencies and flexibilities within complex hydrosocial systems. By developing understanding of unique local relationships with water, the hydrosocial terroir can form the basis of a resilient and cooperative water regime.

Acknowledgements The authors would like to thank the community, vignerons, and irrigators of Langhorne Creek. Special gratitude is due to Lian Jaensch and Langhorne Creek Grape and Wine for their support and assistance. This research forms part of the project *"Hydrosocial Adaptations to Water Risk in Australian Agriculture"*, funded through the Australian Research Council's "Discovery" program, grant number DP210101849.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions

Declarations

The authors do not hold any competing interest relating to this work.

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