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COMMENTARY

One Person's Drain Is another's Water Supply: Why Property Rights, Scope, Measurement and Hydrology Matter when it Comes to Integrated Water Resources Management

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A B S T R A C T

The expansion of Integrated Water Resource Management (IWRM) philosophies has given rise to some improvements in decision-making with greater attention being given to the relationship between upstream choices and downstream consequences. However, the limits of IWRM also need to be recognised, especially the demands on water planners seeking to balance multiple objectives across multiple sites. This paper scrutinises the need for superordinate integrated decisions when property rights are already well-defined and tradeable. By using simplified examples derived from the Australian milieu, we also consider cases where the property rights are less-well defined and trade is not an easy option. The examples demonstrate that efficient decisions can arise without a superordinate water utility making integrated plans but the scale of decisions does matter, as does the measurement of the attributes of water in question. The paper also shows the necessity for understanding and linking institutional scope, hydrological influences and ecological responses whenever IWRM is purportedly seeking to simultaneously bring about ecological gains. Vesting integrated decisions in water utilities on the basis of their revenue-raising capacity is also briefly scrutinised.

1. Introduction

Choices about water have often been dominated by engineering or supply-side considerations, but this is not necessarily controversial or a limitation. After all, urban communities in the developed world have benefited greatly from well-designed water infrastructure that has underpinned major improvements in human wellbeing.[1] More specifically, well-engineered water supply, sewage and drainage systems routinely deliver high-quality potable water and simultaneously transport hazardous waste. This is also done at relatively modest financial cost and in a manner that limits the impacts on human health and the environment. Modern water infrastructure can even induce environmental improvements, with adequate technology and resourcing (Shannon et al., 2008). But despite the long history of success for many urban water and wastewater supply systems (see, Angelakis et al., 2012), several stresses have emerged, giving rise to calls for different perspectives to decision-making.

First, greater variability in the availability of the resource, especially the increased incidence of drought, has meant that in many settings there has been a reconceptualization of the balance between supply and demand responses. Demand and the appropriate mechanisms for including it in water management options has generally been given more prominence in recent decades than was previously the case (see, for instance, Russell and Fielding, 2010): demand and supply are now generally considered simultaneously, or at least in an integrated fashion.

Second, there has been increased enthusiasm for rethinking the fugitive nature of water resources and an accompanying expansion of so-called integrated water resources management (IWRM) (e.g. Bowmer, 2014). Upstream choices about the use of water result in downstream consequences and IWRM is increasingly seen as doing a better job of resolving perceived 'head-of-system-tail-of-system' trade-offs, since it employs a more holistic view of resource management. This approach includes giving attention to the water that is returned to a system/drain after use, but it also incorporates interest in the possibilities of harvesting water in different locations to meet specific demands. Situated within this genre of approaches is consideration of different technologies that can facilitate harvesting water that would

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[1] This is not to say that significance challenges remain in the context of delivering reliable water and wastewater services in many parts of the world (e.g. Srinivasan et al., 2010).

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normally be considered as drainage. Sometimes this method is given a specific title, like water-sensitive urban design (see, for instance, Morison and Brown, 2011).

Third, the IWRM philosophy has been expanded in many settings to go beyond water management to include other resources. This extension to IWRM stems from recognition that water is only one of many input in most production system, including those related to environmental goods. For instance, the nexus between food, energy and water has become a common theme in debates (e.g. Romero-Lankao et al., 2017) and urban water managers are increasingly being asked to give greater attention to the link between water supply options and the energy requirements that attend each. This is particularly the case where power costs are rising along with concerns about the potential longer term nexus between some energy sources and climate change.

Fourth, the necessity to develop integrated decisions about complex water management options has been taken by some to imply an expanded role for planners and government, since these agents are perceived to be better equipped to deal with these complexities (see, for instance, Varis et al., 2014). More specifically, a planner, blessed with an intimate understanding of hydrology is increasingly assigned the task of optimising water resource allocation across multiple users and at different scales. In Australia, for example, the much-publicised Murray-Darling Basin Plan requires a single planning agency (i.e. the Murray-Darling Basin Authority) to develop and implement a water resource sharing plan that simultaneously optimises economic, social and environmental outcomes. This is expected to occur across a basin comprising five separate state jurisdictions, urban and rural communities and covering more than 1 million square kilometres of agriculturally and ecologically significant land (Crase, 2012). In an urban water context, less ambitious planning processes have been assigned to water planners empowered to use an integrated approach in order to meet specific, but hard-to-measure ambitions, like 'improved liveability' (see, for example, Melbourne Water, 2017).

One area which has received only limited attention in this debate is the role of existing property rights and how this might impact on the need for integrated planning by a superordinate and well-meaning state authority. It can be argued that in the absence of that analysis, closer scrutiny of water planning agencies and the mechanisms by which they are presently seeking to make integrated decisions about urban water seems long overdue. This article adds to the literature that focusses on water planning and the analysis of IWRM by using specific cases drawn from Australia. Australia has an active history of water reform, especially in the three decades leading up to and during the drought years that characterised the first decade of this century. Accordingly, this offers useful insights to dealing with water scarcity, although the lessons are more generalizable. We seek to highlight the potential conflict between state-designed integrated water plans when there are already clearly assigned property rights and markets. We also highlight the role of the state when property rights are less-clearly defined and/or where measurement of precise benefits and costs is difficult. The paper focusses on specific elements of integration in urban water management and planning and in order to make the discussion manageable and accessible to a wide range of disciplines we deal with rudimentary questions, including: (1) what is being integrated; (2) who is doing the integration; (3) what measurement tools are being used to assist integrated decision-making. In answering these questions we highlight how property rights matter and why, in some cases, the need for plans to deal with IWRM is redundant. The remainder of the paper is structured around these key questions, before offering brief concluding remarks.

2. What to Integrate?

As the IWRM acronym would suggest, water is commonly the answer to the 'what is being integrated' question, but as will be noted later there are several dimensions to water. One of the obviously driving forces for integrated thinking with water has been the simple fact that water is fugitive and upstream choices have downstream impacts. In some urban domains this is less problematic than others, but to highlight the underlying source of complexity and why special planning efforts are required on the part of the state, attention here is given to how rights and responsibilities are defined. In that respect it is worth noting at the outset that Australian jurisdictions have invested significant efforts over the past three decades to define the rights to water[2] (Crase, 2008).

Property rights in this sense refers to the control over the stream of benefits that attend a resource. Property rights are also reciprocal, insomuch as the control of benefits can only come as a consequence of attenuating the control potentially exercised by others (Bromley, 1989). Even after being assigned, property rights are also generally attenuated in some form, implying there is a hierarchy of rights. Put differently, superordinate bodies seldom fully and absolutely cede control to subordinate bodies. For instance, an individual may hold a right to use a resource, but that right can be revoked and the state often retains the option of modifying rules of use. It is also important to note that property rights go beyond 'ownership' per se and include elements like transferability, divisibility, flexibility, duration, quality of title and exclusivity (Crase and Dollery, 2006).

An important part of the Australian water reforms was the efforts by affected jurisdictions to define the *quantity* of water available from different water sources and then set limits on abstraction, such that sustainable use for right holders was assured. In most cases this meant that rainfed water supplies were defined by setting an upper limit on long-term entitlements for abstraction. Ongoing access rights were also differentiated from annual abstraction rights, with the latter subject to change according to current resource availability; this allows them to reflect seasonal conditions. Accordingly, water users would need to hold an entitlement for water access, but could only abstract the quantum of water that matched availability in a given season. For example, a water user might hold an entitlement to take 100 Megalitres from a stream but if rainfall was half of the annual average, then the 'allocation' (i.e. annual right to abstract) to the individual for that year would be only 50 Megalitres.

Property rights in most cases were also further unbundled so that access rights were separated from use rights, with the latter including some constraints on harmful spillovers (e.g. the application of water to land that ultimately increased salt loads in streams could be prohibited). That said, most attention has been given to measuring and defining the quantity of water abstracted. The quality of water is usually managed through a system of state-imposed constraints supported by monitoring efforts and penalties for non-compliance.

Agriculture, as the primary extractor of water, was at the forefront of most of the property right reforms, although urban users were also touched by these changes. For instance, urban water utilities accessing water from a stream must hold an entitlement that defines the quantity of water that can be extracted and the annual allocation would vary, just as would occur with other extractive users, like irrigation.

To illustrate some basic principles on the role of property rights, a single stream is assumed to connect two urban communities; one upstream and another downstream. In this example, extracting water from the headwaters for household consumption can be offset, to some degree, and not reduced water access for the downstream community. This could be done by returning treated wastewater at a nearby location to the upstream abstraction point. The returned water can constitute a significant portion of the initial abstraction, especially in densely settled urban environments where garden use is limited; in this instance a

[2] The Productivity Commission (2017) notes that some work still remains to be done on this front and Crase (2012) and others have noted that, even where jurisdictions have complied with national reforms, greater attention to hydrological detail would have helped.

large portion of the 'used' water would be returned as sewage water, such that the quantity available to the downstream community is not as limited, were water not returned to the stream. Moreover, if the treating technology is adequate, returning any sewage can actually give rise to higher quality water being returned to the stream than was initially the case (e.g. Dogan et al., 2016), an argument we take up later.

The point of invoking an integrated solution across the urban domain at least is to optimise the quantum of water available as well as the water quality across the two communities. Put simply, this involves contemplating both the abstraction activities and the returning processes simultaneously (i.e. integrating the choices about abstraction, treatment of wastewater and return flows to the system for further abstraction downstream). There is, of course, nothing particularly controversial about this approach, but there are several key institutional considerations which might be easily overlooked.

For example, if the upstream and downstream communities are serviced by the same entity (i.e. a single water utility responsible for providing both potable and wastewater services to both communities), then the integration can occur internally (i.e. within the one utility). Regional water utilities in Victoria (Australia) that access a common stream for multiple communities are a case in point. North East Water, for instance, accesses water from the River Murray for several communities along the stream. Interestingly, current arrangements around water rights mean that North East Water is also able to claim credit for the quantity of treated wastewater discharged back to the stream against the volumes abstracted to satisfy consumption demands. These arrangements have been in place since 2008 (i.e. the height of the millennium drought) (North East Water, 2012).[3]

There are strong financial incentives embedded within these arrangements for the urban water utility to consider problems relating to withdrawals and return flows as an integration problem, at least from a volumetric perspective. First, additional water might be needed to service any growth in urban communities and the most common solution in this case would be the purchase of extractive water rights from others using the river, usually irrigators. The monetary impost on the water utility from buying entitlements would be exacerbated were the return flows not measured and credited back to the utility - this effectively encourages the water utility to make the most of existing entitlements and to report abstraction and return flows to those responsible for managing the stream. Second, the utility has at least some incentive to improve wastewater disposal upstream since downstream treatment costs would rise for the receiving community if returned water, released in the upstream environment, was of poor quality. Of course, the extent to which the utility opts to carry additional treatment costs for returned sewage water will be impacted by the relative costs of downstream treatment for potable extractions, along with the costs of buying additional entitlements.

Whilst a simplified example, there are some key lessons here about how any rational integrated choice might be made. More specifically, it is critical to be able to measure the different dimensions of water that are being integrated (volume and quality in this case) or else it is not possible to adjudge winners and losers and establish trade-offs, even if they occur within a single organisation. Without metering the volumes of water abstracted and returned it is not possible to assign values to the water used and returned for use by others. In addition and critically, in the case of water volumes, there are existing and clear property rights and these are readily tradable in a market. This means that the volumes so measured also have an observable monetary value and this automatically encourages integrated thinking.

We now consider the case where the downstream community was supplied by a separate utility to that operating at the upstream community. Would the incentives for integrated thinking about volumes be weakened?

Since entitlements upstream are tradeable in this case, any credited return flows to the stream can be readily related to a cash equivalent – i.e. the same volume that would need to be purchased from another user via the water market. Similarly, for the downstream community to grow it must still access additional new water resources, one of which is the entitlement market. Thus, in this case the incentives for separate upstream and downstream utilities to integrate activities around the quantity of return flows to service growing demand elsewhere are broadly equivalent, regardless of the scale of the entity doing the integration. The market for entitlements underpins the integration of these functions and the scale of the decision-making entity (i.e. the water utility) is less important when it comes to volumes of water used across the two communities. The point is that having measurement of the resource, clearly specified property rights and a market for those rights makes the scope of the decision entity less important.

In contrast, consider the arrangements for water quality where the upstream and downstream water-supplying entities operate separately. An important distinction here is that water quality is measurable but currently not specified as a tradeable right[4] (at least in most cases) and is generally managed by a system of regulations and constraints. For the upstream utility to go beyond the minimum requirements for treating the returned wastewater, it would necessarily be required to carry additional costs. In order to integrate such a choice with the preferences of the downstream utility for better water quality, there would need to be some bilateral negotiations between the two entities. Put differently, in the absence of clearly defined and tradeable rights around water quality an alternative is required to bring the entities to a common and mutually beneficial arrangement.

Scale matters. If the winners and losers are within the same entity/utility, then there is at least some chance that the transaction costs of reaching agreement are kept in check. For example, when the entities are separate the likelihood of rent-seeking is probably higher and there are clear incentives to misrepresent the benefits and costs to the other party. This is more difficult (although certainly not impossible) where the information is shared within a single entity, at least when the utility has good management practices and systems. The point is that superordinate planning has a more important role to play in achieving integrated outcomes for water quality considerations when property rights and trade are not a default option.

In practice, the notional benefits of integrated decision-making are being used as the rationale for expanding well beyond the spheres of water. As noted earlier, the so-called nexus between water and energy is being used as a rationale for developing holistic plans that relate to both energy and water (e.g. Department of Environment, Land, Water and Planning, 2017) and such plans should be viewed against a backdrop where markets already exist for energy supply and quantities of water at least. In sum, there is no clear need for an integrated decision making process when a property right already exists and a market exchange can occur. Moreover, the scope of the agency assigned the role of designing and integrated choices is not particularly critical in these cases. Integrated decision-making by a superordinate body might be justified if the interest is in water quality, which is less marketable, or some other dimension of energy that is not presently captured in market prices. Here the scope of the decision making entity will matter.

Climate change and its uncertain relationship to water availability have played at least some part in the enthusiasm for planners invoking the notion of integrated decisions. Harvesting localised water resources in preference to transferring low-cost water using extant infrastructure and/or using energy to transport the resource is sometimes presented as

[3] It is worth noting that for most agricultural uses, return flows are not well measured in Australia. This creates a separate set of complexities, especially when governments seek to rein in extractions by this sector (see, House of Representatives Standing Committee on Agriculture and Water Resources, 2017). A detailed analysis of this topic is beyond the scope of this article.

[4] This is not to say that such rights could not be formulated. For instance, some tradable rights in salinity are available within the Murray-Darling Basin (see, OECD, 2000).

a vehicle for building resilience or capacity to deal with the vagaries of a future climate (e.g. Wong and Brown, 2009). What is not at all clear, however, is the extent to which the planner has additional foresight versus those who are presently building uncertainty and risk into market choices where property rights already exist.

3. Who is Doing the Integrating?

To date this example has been used to focus on integrating only two dimensions of water – its quantity and quality. In contrast to water quantities, water quality could logically be integrated by a superordinate body and give rise to more efficient outcomes. What is clear from the earlier example is that the "who" question matters to the extent that rights might not be already well-defined and tradeable. This is of course a simplified version of the Coasian argument – if rights are defined reasonably well and transaction costs are kept in check, then by-and-large an efficient outcome will emerge, regardless of who is making the choices – there is no compelling case for high-level integration where rights are defined and tradeable. But 'who' does matter when the rights are either poorly defined or difficult to trade, because of high transaction costs.

To expand this notion and in an effort to understand where decisions should optimally reside within a hierarchy of rights, we extend the earlier simplified example of two communities where water supply and sewage was managed within a single utility with both upstream and downstream customers. In the earlier analysis the upstream city opted to return highly-treated wastewater and claim credit for volumetric return flows against extractions. The driver for this was that rights on the quantity of water were well defined and there was a market to ascribe value. Simultaneously, the incentives to opt for high-quality wastewater treatment upstream was that gains could then be internalised by reducing treatment costs at the downstream receiving site – rights were not tradable but any gains from additional upstream treatment could be appropriated, if the scale of the decision-maker was set appropriately.

We now suppose that there is an additional asset located on the connecting stream between these two centres, such as an ecological site that supports the habitat of an important native fish species.

The property rights around ecological changes (i.e. understanding who gains from the benefits of the resource and by how much) are assumed to be somewhat clear in this case although far from as well-developed as the extractive rights around volumes of water. The rationale for this assumption is that many Australian jurisdictions have made progress on legislating the benefits of ecological improvements in freshwater streams and how they accrue to the community at large (see, Productivity Commission, 2017, p. 130). In addition, efforts have been made to relate ecological health with changes to other users' rights; such as by imposing minimum stream flow requirements to maintain specific ecological assets or setting aside volumetric entitlements of water that are then used by environmental managers to actively bring about favourable ecological responses. In this way the benefits from the resource have been defined in a general sense, even though the ecological science is somewhat incomplete. Moreover, the individual beneficiaries are not separately distinguishable from the community at large, as compared to volumetric rights which are held separately by specific water users.

In contrast to water quality, the ecological gains are also not as clearly measurable; there is a general understanding that ecological improvements can accrue through a watering regime and add value, but there are no shadow prices to form a comparison (e.g. additional treatment costs for downstream users) and no market exists, other than the prices governments are willing to pay to secure politically-acceptable changes in environmental conditions. An additional complicating factor in this case is that the timing of stream flows can have a markedly different impact on ecological assets. In the case of the River Murray, in particular, most native species respond positively to higher stream flows at the end of the winter months; this better mimics natural events and helps builds resilience as well as increasing the size of native populations (Crase et al., 2012).

If we follow the logic developed earlier that integrated decision making is better-suited when rights are not completely defined and tradeable, then the ecological benefits for fish species can be efficiently integrated by a single party, but only if the scale of the decision-making entity is appropriately set. The capacity to manage efficiently will also be greater if measurement of any benefits improve, since the trade-offs will then be clear.

In this context, the water utility we described earlier has some scope to influence ecological outcomes. Because the riverine ecology on the River Murray is in large part influenced by the seasonality of flows, the water utility could feasibly store the treated wastewater at the upstream site and release it at a time that maximises the ecological benefits, whilst simultaneously achieving its ambitions around the integrated management of water quantity and quality between the two urban communities. However, the difficulty of applying these constructs in totality to this example is that the ecological outcomes along this particular stream are not produced by a single action or even a series of actions controllable by the water utility. Rather, ecological outcomes are co-produced by a range of purposeful and incidental choices by decision makers at different scales along the stream. A farmer located between the two centres could easily offset any potential ecological benefits by discharging farm pollutants to the stream, thereby harming fish. Likewise, the state or national government could opt to release large environmental flows from upstream dams that dwarf the efforts of the urban water utility to achieve any ecological improvement.

In this instance scale really does matter but so does hydrology and ecology and the utility can only make a material contribution to ecological outcomes by coordinating with entities that control much larger flows through the system (and pollution by farmers). In essence, there is little to be gained by integrating ecological aspirations into the choices of this urban water utility; at least it is not efficient to do so because the impact on the ecological asset from the choices of the utility is immaterial.

The point is that a planner that operates at a scale larger than the water utilities is required to deliver efficiency in this case because the benefits of ecological management in this instance are only controllable at that scale. The more generalizable message is that the efficiency of IWRM is contingent on hydrology and the influence that exerts over the environmental attribute of concern. Simply claiming an integrated decision delivers superior outcomes is not sufficient – the decision needs to have a material impact on the component of the environment over which influence is sought. Clearly, that choice will improve once the gains from alternative collective actions are better understood (as noted by the Productivity Commission (2017) and others). Another important additional lesson is that measurement remains important to securing an efficient outcome even if an integrated decision is taken at an appropriate scale with accord given to hydrological/ecological impacts.

4. Measurement Tools and Who Should Pay?

In addition to the ecological habitat between these two urban communities we now turn attention to another site between the two cities and in this case we posit the existence of an amenity asset. The value of such assets are even more poorly measured than the ecological sites, partly because there is no established metric for amenity. For instance, some residents in the region may favour visiting a site with exotic trees and well-developed infrastructure, whilst others prefer native trees and less-intrusive infrastructure, yet both arguable yield amenity (see, for instance, Cooper et al., 2016). Of course, if multiples sites exist along the stream then these could be shaped to cater for all forms of amenity and in this case a water utility interested in maximising welfare through integrated decision making might seek to include these into any global choice. A complicating factor, however, is that amenity can also accrue at many additional sites outside the area managed by the utility and these are potential substitutes for amenity that accrues between the two urban centres. Thus, the water utility could seek to integrate the benefits of amenity into the way it manages water flowing between the two communities, as described earlier in the case of the ecological benefits, but the impact is unlikely to be efficient without coordinating with managers of other amenity sites outside the jurisdiction of the water utility.

In contrast to integrating the ecological benefits, it is important to stress that we have suggested that amenity is also so peculiar in its makeup that even if coordination did occur the measurement dilemmas would make it particularly difficult to robustly adjudge any trade-offs or improvements. Thus, whilst the case for considering amenity at a higher scale than the water utility is relatively clear, efficient management (integration) at the superordinate level can only be achieved if measurement is enhanced. This raises broader questions about the measurement tools that are currently being employed to facilitate integrated decisions that lead to so-called improvements in amenity and liveability in urban areas and the streams and drains within those precincts (see, Department of Environment, Land, Water and Planning, 2017).

It might not be that surprising to know that economists often express disquiet about measurement tools that are incongruous but are nonetheless used to rationalise choices (Dobes and Bennett, 2009). It is for this reason that many in the profession prefer to use dollars as a standard metric to consider the benefits and costs of alternatives. Whilst acknowledging that dollars are not everything and a dollar has a different value for individuals in different circumstances, the numeraire of cash remains a useful hallmark for economic analysis. The development and enhancement of techniques to assign dollars to non-marketed goods has assisted in this regard, even if such approaches attracted earlier criticism on ethical and technical grounds (e.g. Booth, 1994; Hanley, 1989).

In our previous example we presented several integrated choices for a water utility. We noted that the coordination of water quantities was assisted by well-measured water entitlements and these were then tradable, and thus the volumetric measurement tools were readily convertible to dollars. Similarly, the water quality related activities described in our example were convertible to cash – the extra expense of treating wastewater upstream versus the costs of additional treatment of potable water downstream. To date we have said little of the dollar values of the other two elements to be integrated in our example; namely, the ecological and amenity sites described above.

One way to establish values and to integrate choices around unmarketed sites with the 'dollar' components of water is to deploy a form of non-market technique. Non-market techniques are of two forms: one uses a related market to ascribe dollar values and the other ostensibly 'creates' a hypothetical market and then use carefully constructed questionnaires to generate price data. In this case non-market techniques could be used to estimate the dollar value of a change in either the ecological or amenity standing of riverine assets and this could possibly help inform a decision maker seeking to integrate all these values.

Precisely such an exercise was undertaken by Cooper et al. (2016) recently. More specifically, Cooper et al. (2016) considered both the ecological and amenity value of freshwater streams in Melbourne, one of Australia's largest and fastest growing cities. A choice experiment was developed that considered Melburnians' willingness to pay for an improvement in the ecological status of streams passing through the city and the amenity that could be gained from those waterways. A stated preference approach (choice experiment) was deployed such that respondents could opt to pay for (a) an improvement in the ecological status of streams, as measured by a change in a formal index of stream condition, (b) an enhancement in the amenity of streams, as illustrated by a shift in the number of sites meeting a preferred condition, and (c) a change in both ecological and amenity aspects that realised an improvement. Importantly, the entity making this integrated choice was to have been the water utility that provides bulk water and sewage services to the region. The payment vehicle for those participating in the experiment was an increase in annual water bills paid by households.

An interesting aspect of this work was that, on average, participants expressed a positive and significant willingness to pay for an improvement in the ecological status of streams passing through the city. A similar positive and significant willingness to pay was evident when there were simultaneous gains in ecological and amenity aspect of streams. Importantly, there was no significant willingness to pay at the mean for amenity gains in their own right, at least not in the context of the experiment used for this exercise.

One interpretation of these results is that respondents are willing to pay for improvements in the ecology of streams via their water bill but not for changes in amenity on its own. Put differently, water customers are seemingly willing to have ecological values integrated into decisions that relate to access to potable water and wastewater treatment but less inclined to accept that actions on amenity should be similarly integrated by a water utility. Of course there are a range of other interpretations that could be considered, like a view that the amenity of Melbourne's streams is already adequate and requires no additional improvement. Nonetheless, there are at least some grounds for considering these results in the context of what customers might regard as a sensible scale of integration.

More specifically, it seems quite plausible that the people of Melbourne have a positive preference for improved amenity but are reluctant to have those changes facilitated by heftier water bills. The extent to which the water utility and others have taken this information on board is unclear with the state continuing to advocate that its water utilities should opt for integration plans that specifically deal with liveability (Department of Environment, Land, Water and Planning, 2017).

In the context of the general framework we have sought to develop around integrated water decisions several lessons are worth noting. First, the ecological gains in this case were measurable and clearly influenced by the actions of the bulk water supplier (unlike in the earlier case of the River Murray where the stream was too vast to be influenced by the utility). There are clear, tradeable property rights in these catchments and taking these values into account at the level of the water utility is potentially efficient (i.e. Melbourne Water can make choices that materially alter the ecology of streams in some locations and it can make trading choices that can influence ecology). Second, amenity, whilst defined in the choice experiment, remains problematic with ample substitution possibilities in a city like Melbourne. Moreover, the management of alternative amenity sites resides with other levels of government (e.g. local governments) so Melbourne Water would either need to expend significant resources to coordinate with other tiers to achieve an efficient outcome or cede control of stream-located amenity sites. The penchant for wrapping numerous technical elements into a single metric termed 'liveability' is unlikely to assist in generating an efficient outcome.

5. Concluding remarks

In this brief paper we have sought to highlight some of the lessons about IWRM, especially in an urban context. We have also identified specific pitfalls and constraints that need to be considered and raised questions about the efficiency of making integrated decision at superordinate levels under different property right scenarios. Whilst some of the examples used are relatively simple we argue that the principles exposed also hold for complex situations.

First, it is important to be able to measure the components of the resource that the decision maker seeks to integrate. It is also preferable that the measurement take place in a comparable metric, like dollars, else the trade-offs between options cannot be seriously scrutinised. If the elements can be valued in dollars then there is some prospect that rights will be tradeable and attentions should shift to the possibility of markets helping achieve integration. Where trade is occurring the entity undertaking the integration is potentially less relevant, at least to the extent that trade provides an automatic incentive for all parties to efficiently integrate resource decisions. If trade is not an option but the value of choices is known, then the scope of the entity making the choices does matter. Ideally, those making integrated choices will have equivalent scope to the impact of decisions since this improves incentive compatibility. In this context, hydrology can be very important because the control of some elements of water may not be sufficient to bring influence over the component of the environment being integrated. Even when the hydrology links to the multiple changes sought, the access of a water utility to customers and revenue should not automatically imply that this is the appropriate decision making entity. Moreover, using water charges to deliver a multitude of services under the guise of IWRM can potentially misplace the legitimate role for other tiers of government.

Second, if the resource element of interest cannot be measured then the scope and behaviour of the decision entity needs to be viewed cautiously. Claims that integrated decisions are welfare improving by default cannot be verified when the resources that are purported being integrated cannot be enumerated. Simply claiming that an integrated decision is more amenable to unknown future conditions does not rationalise its superiority.

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