# Urban Water Security - What does it mean?

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## Disclosure Statement

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# Urban Water Security - What does it mean?

This research is focussed on understanding what urban water security means - a surprisingly elusive concept given the global shift from rural to urban living. We first make the case for a distinct urban water security definition. We then identify 25 unique water security definitions, of which three relate to the urban context but all with scope for improvement. Applying novel indices, we assess the prevalence, complexity and evolution of themes and dimensions within all definitions and find a stable spectrum of themes; but note a shifting emphasis towards environmental and social dimensions, away from quality and quantity of supply. Overall the definitions are becoming more comprehensive by simply listing more outcomes to be achieved. Instead of this 'shopping-list' approach, we propose a simplified urban water security definition with a focus on agreement of needs with community stakeholders, while using the themes to guide what the objectives might be.

Keywords: water security, urban, definition

## Introduction

### *Background*

The OECD (2013) describes water security as one of the defining challenges of our time. In 2015, water was ranked as the global risk with the single greatest potential impact on economies over the next ten years (World Economic Forum 2015), and the World Health Organization (2018) predicts that by the year 2025, half of the world's population will be living in water-stressed areas. The United Nations Sustainable Development Goals (2015) focus on the elimination of poverty by stimulating action in 'areas of critical importance for humanity and the planet', including a dedicated water and sanitation goal (SDG6).

Achieving water security is both challenging and expensive - the UN reported that in 2015 alone, $US 8.2 billion was spent in official development assistance commitments for improved access to safe water and sanitation with 65% of this spent on drinking-water related activities and 73% of the program spent in urban communities (UN-Water and WHO 2017).

Not only is it difficult to achieve water security, it is difficult to maintain it. Changing climates around the world are affecting rainfall patterns, demand for water and the ability to capture, store and manage water resources. Many locations must also deal with the compounding impacts of more frequent and severe weather events (Climate Council of Australia 2017), population growth and increasing expectations for economic development.

Water security is not just a challenge for developing nations, rural or remote communities - severe environmental, social and economic impacts have been suffered during recent extreme droughts affecting all types of urban communities across the world including south eastern Australia from 1996-2010 (Turner et al. 2016), California from 2011 to 2017 (Brown Jr 2015, 2017) and South Africa's Western Cape province where storage levels dropped to less than 17% in 2018 (Western Cape Government 2018).

***Why more focus on words?***

A common understanding of language is a critical starting point to articulating objectives, establishing targets and focusing effort to achieve agreed outcomes. On first inspection, it is difficult to see clarity and consistency of language in the discussions on water security, let alone for urban water security - Garrick and Hall (2014) found both 'convergence and confusion about the concept', while Bogardi et al (2016) suggest that contradictory definitions and interpretations have prevented progress towards a common understanding. Hoekstra et al (2018) expect there should be different definitions according to the goal and Zeitoun et al (2013) go so far as to suggest that we should 'refrain from seeking a perfect singular definition of water security'. What is clear, is that the term 'water security' continues to increase in usage in the academic literature and is a growing area of interest but there is little interest in the urban context (Cook and Bakker 2013). Consequently, this paper systematically examines how water security definitions, themes and concepts have evolved with particular regard to the urban context; including how they have been applied by institutional and academic

communities. In short, is water security language going down the same path as sustainability, which some suggest evolved for over a decade but made no improvements in understanding compared to the earliest definition (Beck and Villarroel Walker 2013); or are we making progress in our thinking and moving towards an agreed understanding of what water security means including in the urban context?

Pivoting off a foundation of how water security is currently understood, we review urban water security definitions and try to understand why these are so lacking. We review urban water security research activity (as reflected in research publications) to provide insight into the specific urban context. Then we integrate the findings to construct a tailored definition for urban water security that can both guide the specification of detailed objectives to be achieved for an urban community, but remains broad enough to be useful in the domains of management and policy. All with the ultimate aim of understanding - what does urban water security mean? Since only with a common understanding of the language and goals, is the agreed target outcome likely to follow.

## Method

This investigation into the meaning of urban water security is focussed on consideration of both urban water security and broader water security definitions and language. While we note the important inter-relationship between urban water security and the web of water-energy-food securities (Zeitoun 2011), wider water management and sustainability-related concepts; this work does not attempt to place urban water security within any of these particular frameworks. The focus is on developing a clear and consistent understanding of language which could, in turn, support a future analysis of urban water security within such broader framings.

### *Finding water security definitions*

The first phase of the research was focussed on identifying unique definitions for urban water security. Given the small number of these, the search was then extended to include more generalised water security definitions that is, not specific to the urban context. For both groups of searches, this investigative phase commenced with a review and assessment of peer-reviewed, English-language, academic literature using the abstract and citation databases of Web of Science and Scopus, and non-academic literature using the World Wide Web (the Web) and Google search engine. Searches were focussed on locating documents with titles, abstracts or keywords matching 'urban water security' and titles matching 'water security'. The material identified included academic papers of research findings, technical books and book chapters, an extensive array of review articles, government and institutional reports, newspaper articles and web pages. These were reviewed and screened for definitions of urban water security and water security. A log of the definitions was tabulated to collate and manage the references, including the relationships between different definitions, authors and dates. Importantly, it was noted if the definition made specific reference to the urban context. The literature review was then expanded, guided by the material identified in the first tranche of searches, with particular attention paid to establishing primary sources for definitions. Where definitions were presented as new but appeared only to be rearrangements or para-phrasings of existing proposals, they were not considered unique and were discounted from further analysis.

### *Analysing the definitions*

In the second phase of the project, the suite of unique definitions identified (n=25) was examined to determine common themes. These themes were then clustered into broad dimensions. The identification of the themes was not influenced by previously proposed elements or framings of water security, a summary of which is available from Dickson et al (2016). Rather, the themes identified (n=11) were determined based on what was observed in the

definitions. The themes were grouped into dimensions of technical, economic, environmental and social elements broadly aligned with the triple bottom line performance accounting framework (Slaper and Hall 2011). The review of definitions considered the context in which the definitions were proposed, particularly when attributing a purpose for the definition. However, the identification and analysis of themes and dimensions relied solely on the content of the definitions themselves, rather than the entire paper in which the definition was presented.

To analyse the thematic data gathered and determine if there were any patterns to the language evolution, two novel indices were developed - the Complexity Index and Theme Prevalence Index. Such indices provide a way of measuring a construct (such as complexity) using one or more data items and accumulating a score from a range of individual items (Crossman 2017).

To examine the complexity of definitions and determine if definitions were becoming more or less complex over time, the Complexity Index (CI) was developed. For this analysis, the complexity of a definition is considered a function of the number of themes it aligns with. The complexity index is determined for the group of definitions proposed in a particular period of years, independent of the number of definitions proposed within the time period, Equation (1).

$$CI_P = f(N_t) = \sum_{n=1}^{i} \frac{N_{t,i}}{N_{d,i}} . P^{-1} \qquad (1)$$

Where:

$CI_P$ = complexity index, for period P

$N_t$ = number of themes, $N_{t,i}$ = number of themes in all definitions in year *i*

$N_{d,i}$ = number of definitions in year *i*

P = time period in years

To understand the source of the complexity, the Theme Prevalence Index (TPI) was developed. The TPI is used to determine the contribution of each group or dimension of themes, to the complexity index for the period, Equation (2). The summation of TPIs for each dimension for a time period, equals the CI for the same period, Equation (3).

$$TPI_{dim,P} = \sum_{n=1}^{i} \frac{N_{tdim,i}}{N_{d,i}} . P^{-1} \qquad (2)$$

Where:

$TPI_{dim,P}$ = theme prevalence index for the dimension, for period P

$N_{tdim,i}$ = number of themes in the dimension in all definitions in year, *i*

$N_{d,i}$ = number of definitions in year, *i*

P = time period in years

$$CI_P = \sum TPI_{dim,P} \qquad (3)$$

Further review of the identified literature was undertaken to establish why the definitions had been developed and what was the intended application - was the purpose clear, had the definition been developed solely for communication purposes, was the definition intended to be used to assess water security, was the definition intended to support improved outcomes in any of the theme areas? It was also noted if the source of the definition was peer-reviewed academic literature. A citation count was taken from Web of Science Core Collection (as at October 2018) for all definition references sourced from peer-reviewed literature, except for one book (Clarke 1991) where the citation count was taken from Scopus (due to a lack of availability in the Web of Science).

***Focus on Urban Water Security***

Moving back to the focus of urban water security, a rationale is provided for developing a new definition. The next phase of investigation was then directed at understanding why there

are so few urban water security definitions identified (3 of 25). Peer-reviewed academic literature with 'urban water security' in the title or keywords was examined to understand the volume and scope of urban water security research undertaken and how the language of urban water security had been used and developed.

The final phase of the research project was focussed on construction of a definition for urban water security. This started with existing urban water security definitions, conventional definitions for the component words of 'urban', 'water' and 'security', and definitions for related water security. These meanings were then layered with the findings of the theme analysis. The resultant definition is presented and discussed.

## Results of review of water security definitions and themes

### *Finding water security definitions - Development of language*

In total, some 62 peer reviewed academic items were identified with matches to 'urban water security', 312 items were identified with matches to 'water security' and a further 18 items were identified from institutional sources located using Google searches of the Web.

There has been much written on water security including reviews of the history, language and definitions (Giordano 2017; Cook and Bakker 2012; Garrick and Hall 2014; Beck and Villarroel Walker 2013; Lankford et al. 2013; Pahl-Wostl, Bhaduri, and Gupta 2016; Gerlak et al. 2018; Zeitoun et al. 2016; Hoekstra, Buurman, and van Ginkel 2018). The concept and language of water security has been in use for many years, with references made at least as far back as 1933 to water-borne infections that 'came to threaten the water security of part of London' (British Medical Association 1933). According to Garrick and Hall (2014) the term gained increasing usage post World War II when political boundaries were redrawn. By the mid-1970s there was international discussion on the urgent 'water crisis' with the first international 'mega-conference' on water (Biswas 2004) held in 1977 (UN Water Conference Mar de Plata,

1977). But the language of water security was not yet in common use, as evidenced by the lack of reference in the Resolutions of the 1977 conference.

There is irregular use of water security language in academic literature before about 1990. Some reviews found the language was more widely used from the mid-1980s on (Cook and Bakker 2016). Some comment that common usage was only embraced after the *Ministerial Declaration of The Hague on Water Security in the 21st Century* at the 2nd World Water Forum in Netherlands in 2000 (Clement 2013; Bogardi, Spring, and Brauch 2016). Hoekstra et al (2018) discuss the transition from language around integrated and sustainable water management, into the new language of water security. While other reviews note the absence of any definitions or clarifications of language (Clement 2013; Cook and Bakker 2016), even when reporting on research into complex water security assessment and modelling (Nazif et al. 2013; Esmail and Geneletti 2017).

In terms of key definitions for water security (see Table 1), although earlier propositions can be found (Clarke 1991) the Global Water Partnership definition (2000) is considered foundational by some (Hall and Borgomeo 2013; Lundqvist 2001). Grey and Sadoff (2007) proposed a much-referenced definition (see citation count in Table 2) of water security drawing upon food and energy security definitions. Another widely referenced definition (Giordano 2017; Garrick and Hall 2014; Gerlak et al. 2018) was proposed by the United Nations (2013). Although there is significant commonality and overlap between the three definitions, none of these have prevailed or been universally adopted.

When the GWP and OECD joint Task Force on Water Security and Sustainable Growth issued their report (Sadoff et al. 2015) they chose not to provide an explicit definition for water security but rather to note the balance required between addressing social and environmental demand for water against water-related opportunities and the need to manage water-related risks. Likewise, the Asian Development Bank took a very similar approach when it issued its outlook

in 2016 (Asian Development Bank 2016) – choosing not to provide an explicit definition for water security, but rather to note that it includes sufficiency of supply, healthy ecosystems and protection from water-related disasters. Other respected players in the field continue to develop new definitions (Australian Water Association 2016).

Table 1 Widely referenced water security definitions

| **Definition** | **Reference** |
|---|---|
| Water security, at any level from the household to the global, means that every person has access to enough safe water at affordable cost to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced. | (Global Water Partnership 2000) |
| Water security is the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies. | (Grey and Sadoff 2007) |
| Water security is the capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability. | (UN-Water 2013) |

### *Originality of Definitions*

As part of this research review, a strong focus was put on clearly identifying original water security definitions and their primary sources. This proved somewhat difficult. Over time, referencing and cross-referencing of definitions that are reproduced either verbatim or paraphrased has created something of a mire. There were multiple occasions when definitions presented in peer-reviewed technical papers have been attributed inaccurately. Recent examples include the work of Gerlak et al (2018) who attribute a definition to Norman et al (2010) that was originally proposed by Dunn and Bakker (2009); and a second definition attributed to Bakker (2012) that is a rearrangement of the often quoted Grey and Sadoff definition from 2007. Other examples include work by Zeitoun et al (2016) who attribute a definition to the group Grey et al (2013) that was originally proposed by Grey alone, according to Hope et al (2012).

Primary references were identified for all definitions analysed in this project with the exception of one, whose primary source was a Chinese language reference that could not be

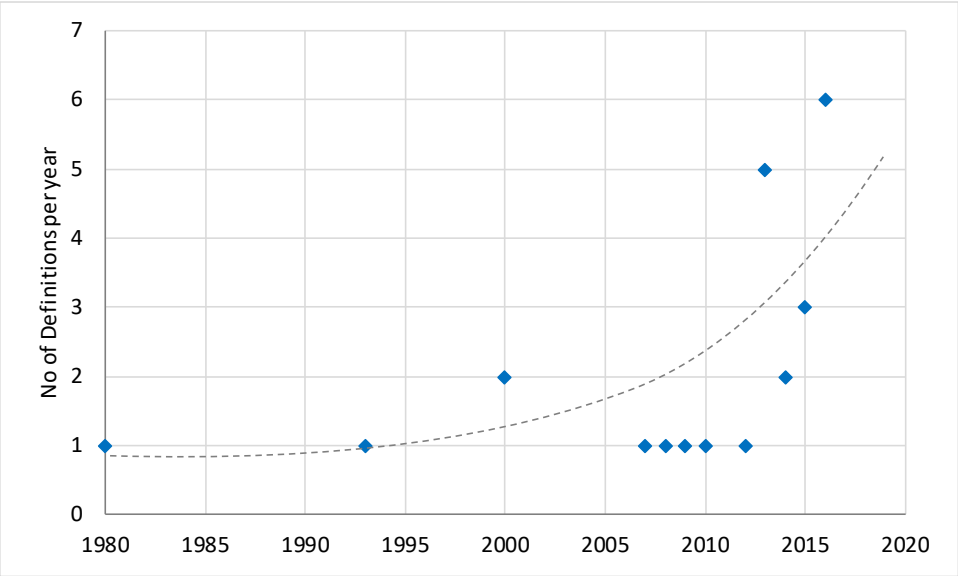
verified but has been included in our review for completeness. Hao, Du and Gao (2012) attribute their definition to Zeng, Li and Fu (2004).

***Unique water security definitions***

Of all the definitions identified in the literature review as unique, one was excluded on the basis that it was nonsensical (Lu, Bao, and Pan 2016). The WaterAid definition (2012) referenced by others (Zeitoun et al. 2016) was not separately included in the analysis because it paraphrases an earlier proposal (Grey and Sadoff 2007), hence failing the test for uniqueness. In 2015, Bichai et al presented the aims of water security strategies in water-stressed metropolitan areas in a manner similar to a working definition. While not a specific definition for water security or urban water security, it was deemed worthy of consideration within the context of this review and included in the theme analysis, but was not considered further in the analysis of specific urban water security definitions.

In total, 25 unique definitions for water security were identified for analysis (see Table 2). Thirteen of these were found in peer-reviewed academic literature, with the remaining twelve developed by major international institutions and agencies. All definitions were qualitative in nature, with several using subjective language such as ‘sufficient’ or ‘adequate’. Very few definitions were proposed prior to about 2007, but there has been a significant increase in the number of new definitions proposed particularly since 2013 (see Figure 1).

Figure 1 Number of new water security definitions proposed each year.




***Analysing the themes of water security definitions***

There were 11 common themes identified in the suite of definitions, and these were grouped into four dimensions (see Table 2). The earliest definition (Bromley, Taylor, and Parker 1980) is focused on the themes of quantity, reliability and resilience of water supply, which can include the entire supply chain from bulk raw water supply, through treatment to distribution. These themes are expanded by Clarke (1991) to include water quality and the impacts of water quality (including sanitation) on human health and physical welfare, and the economic productivity of water including its financial value and its contribution to a healthy economy. In 2000, definitions were proposed by the Global Water Partnership and the World Water Council. Between them they introduced themes of affordability, the relationship between water and the environment including the cyclic relationship with ecosystem health (ie water impacts on the health of ecosystems and ecosystem health impacts on water security), sustainability of water resources including integrated water resource management, water related hazards such as floods, and the cluster of policy, stability and capacity which includes relationships with policy frameworks, political and institutional stability and also institutional, technical and financial capacity to achieve water security. The last themes to appear were risk and certainty (applied to

all aspects of water security) and the impact of water on liveability and wellbeing including community resilience, equity and the social value of water. These last two themes appeared in definitions in 2007 (Grey and Sadoff 2007) and 2008 (Wutich and Ragsdale 2008) respectively.

No new themes have appeared since 2008, and all themes have appeared in definitions as recently as 2016. This would indicate that the spectrum of themes has been stable for some 10 years.

The most common themes identified in the definitions are related to quantity of supply (20 of 25), water quality and human health (19 of 25), and environment and ecosystem health (17 of 25); followed by sustainability (12 of 25), economic productivity (10 of 25) and liveability and wellbeing (10 of 25). All remaining themes appeared five to seven times each across all definitions. There were no definitions that made direct reference to the aspect of water security that deals with physical protection from intentional harm (such as terrorism), noting that there were several generic references to risk management. While the spectrum of themes in each definition varies from one to eight, no two definitions contained the same combination of themes.

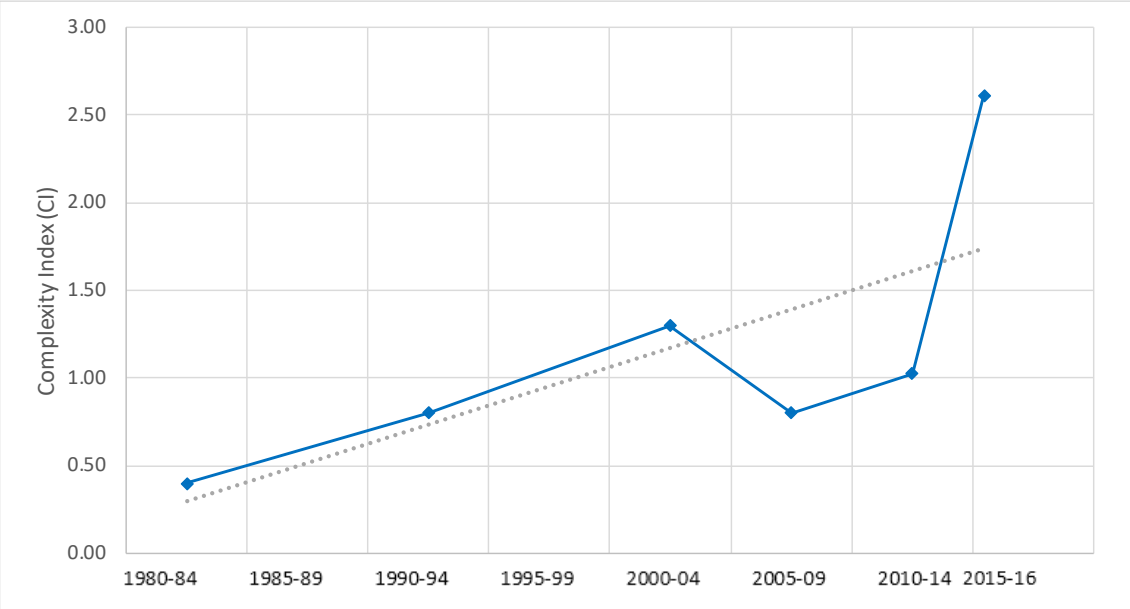
Table 2 Summary of water security definitions and applications by theme

| Reference | Notes on Definitions | | | | | Technical | | | Economic | | Environment | | | Social | | | Spectrum of Definitions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Citation count for Peer reviewed | Specific Urban Reference | Purpose of definition clear | Definition used for communications | Definition coupled to assessment | Quality & Human Health | Quantity of supply | Resilience & Reliability | Affordability | Economic Productivity | Environment & Ecosystem health | Sustainability | Water related hazards | Policy, Stability & Capacity | Liveability & Wellbeing | Risk & Certainty | |
| (Bromley, Taylor, and Parker 1980) | 27 | | ✓ | | | | D | D | | A | | | | A | | | 2 |
| (Clarke 1991) | 49 | | ✓ | | | D | D | D | | D | | | | | A | A | 4 |
| (Global Water Partnership 2000) | | | ✓ | | | D | D | | D | D, A | D | A | | | | | 5 |
| (World Water Council 2000) | | | | | | D | D | | D | D | D | D | D | D | | | 8 |
| (Grey and Sadoff 2007) | 228 | | ✓ | | | D | D | | A | D, A | D | | | | | D | 5 |
| (Wutich and Ragsdale 2008) | 72 | A | ✓ | | | D | D, A | | | | | | | | D, A | | 3 |
| (Dunn and Bakker 2009) | | | ✓ | | ✓ | D | D | | | | D | D | | | | | 4 |
| (Houdret, Kramer, and Carius 2010) | | | ✓ | ✓ | | D | D | | | | | | | A | | A | 2 |
| (Hao, Du, and Gao 2012) | 2 | A | ✓ | | ✓ | D, A | D | | | | D | D, A | | | | | 4 |
| (Asian Development Bank 2013) | | | ✓ | | ✓ | D | D | | | D | D | | | A | D | | 5 |
| (Grey et al. 2013) | 41 | | ✓ | | | | | | | | | | | A | | D | 1 |
| (OECD. 2013) | | | ✓ | | | D | D | D | | A | D, A | | D | A | A | D, A | 5 |
| (Scott et al. 2013) | 30 | | ✓ | | | D | D | D | | | D, A | D, A | | | D, A | | 6 |
| (UN-Water 2013) | | | ✓ | ✓ | ✓ | D | D | | | D | D | D | D | D | | | 7 |
| (Garrick and Hall 2014) | 27 | | | | | D | | | | | D | | | D | D | | 3 |
| (Norton 2014) | 6 | | | ✓ | | D | D | | D | D | D | D | | | | | 6 |
| (Bichai et al. 2015) | 8 | A | ✓ | | | D | D, A | D | | | | A | | | | | 3 |
| (Huang, Xu, and Yin 2015) | 7 | D | ✓ | | ✓ | D | D | | D | D | D | | | | D, A | A | 6 |
| (Sadoff et al. 2015) | | | ✓ | | | | D | | A | A | D | | D | A | A | D, A | 4 |
| (Australian Water Association 2016) | | | ✓ | | ✓ | D | D | | D | D | D | D | | A | D | D | 8 |
| (Chen and Shi 2016) | 1 | D | ✓ | | ✓ | | | | | D | D | D, A | | D | D | | 5 |
| (Dickson, Schuster-Wallace, and Newton 2016) | 12 | | ✓ | | ✓ | D | D | | D | D | | D | | | D | | 6 |
| (Global Institute for Water Security 2016) | | | | ✓ | | | | | | | D | D | D | | | | 3 |
| (Romero-Lankao and Gnatz 2016) | 3 | D | ✓ | | ✓ | D | D | D | | | D | D | | D | D | D | 8 |
| (UNESCO 2016) | | | | ✓ | | | | D | | | | D | D | | D | | 4 |
| **Definition Theme Count** | | | | | | D=19 | D=20 | D=7 | D=6 | D=11 | D=17 | D=12 | D=6 | D=5 | D=10 | D=6 | |
| **Application Count (to improve outcomes in theme)** | | | | | | A=1 | A=2 | A=0 | A=2 | A=5 | A=2 | A=5 | A=0 | A=7 | A=6 | A=5 | |

Table Notes: D= theme of definition, A= application or purpose for which the definition was developed, including to improve outcomes in theme areas.

The complexity of definitions was examined using the Complexity Index calculated for each time period using the data summarised in Table 2 (see Figure 2). The complexity of definitions varies significantly between time steps, but overall shows a positive trend, which has continued beyond 2008 when the spectrum of themes stabilised.

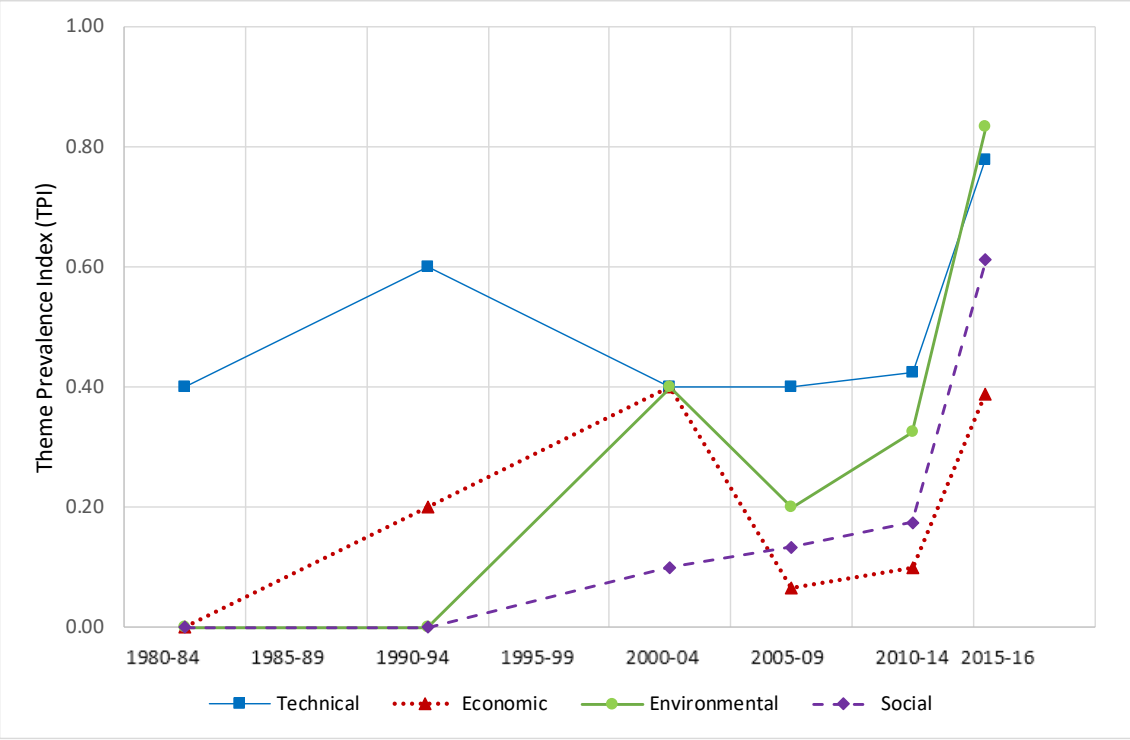
Figure 2 Complexity of water security definitions.




The Theme Prevalence Index (TPI) assists in understanding the nature of the increasing complexity of definitions. The TPI was calculated using the data summarised in Table 2, at each time step, for each of the four dimensions of themes - technical, economic, environmental and social (see Figure 3). There are several observations to be made when inspecting the TPIs. All the themes have increased in prevalence over the analysis period. The social theme is the only one that did not fall in prevalence at some time, continuing to rise in prevalence across the entire time period. By the end of the analysis period, the environment dimension surpasses technical which was consistently the most prevalent dimension up until 2015-16. The calculated TPI values would also

suggest that the definitions for water security have become more comprehensive over time. Prior to about 2000 there was no specific reference to environmental or social themes in the definitions proposed, now these themes commonly appear, with environmental themes the most prevalent dimension in the 2015-16 cohort.

Figure 3 Variability of theme prevalence within water security definitions, (by dimension, over time).




In specifically examining the themes in the bundle of 2016 definitions (n=6), compared to the entire suite (n=25), the following is observed (from Table 2). The most common theme in the 2016 definitions was sustainability, which appeared in all six, compared to a ranking of fourth across all definitions from all years. The liveability and wellbeing theme also shows an increase in popularity in the 2016 definitions (appearing in 5 of 6) and moving to second position compared to its overall ranking for all definitions (sixth of eleven themes). Finally it is observed that only three of six (50%) of the 2016 definitions proposed quantity of supply as a theme, which is substantially

lower than its prevalence across all definitions (72%) where it was the most-common theme overall.

The trends exhibited (in Figure 3) suggest that the definitions for water security have potential to converge at some time in the future with a theme prevalence index of one and including reference to all themes. However, this is clearly not yet the case, and relies on the ongoing stability of the themes.

### *Application of Definitions*

In reviewing the evolution of water security language through the proposed definitions, consideration has also been given to why the definitions were developed and how they were intended to be applied (as noted in Table 2). In almost one third of cases (8 of 25) the definition was used to support development of water security assessment tools, with 62% of these coming from non-peer reviewed sources. In two cases (both non-peer reviewed) the definition's sole purpose was as a communication tool. But in almost one quarter of all definitions (6 of 25) it was not clear why the definition had been developed, equally divided between peer reviewed academic sources and non-peer reviewed sources.

Where it could be determined why a definition had been developed (n=20), there was limited alignment between the spectrum of themes presented in a definition and the nature of its proposed purpose; and in general, the purpose of a definition is aligned with fewer themes than the definitions itself (for example the 2016 definition by the Australian Water Association covers some eight themes but its stated purpose is focussed on policy development only). Overall, the most common reasons why definitions were developed are to support policy, stability and capacity to enable water security outcomes and to improve liveability and wellbeing social outcomes.

### *Summary of thematic analysis*

The theme analysis shows that the spectrum of themes within the water security definitions has stabilised, but the significance (prevalence) of the themes is continuing to evolve. Over time, water security definitions have shifted towards more environmental and social themes reducing the emphasis on quantity and quality of supply. This is resulting in more comprehensive, and also more complex definitions.

Overall, the number of definitions for water security is continuing to increase every year, producing definitions with different combinations of thematic emphasis. However, the analysis conducted here suggests that water security definitions could converge in scope into a coherent integrated definition referencing all themes, but only if the spectrum of themes remains stable.

## Discussion - Proposing a new definition for Urban Water Security

### *Do we need another definition?*

The language of urban water security first appears in the academic literature at the turn of the millennium (Lundqvist, Appasamy, and Nelliyat 2003; Falkenmark 2000; Lundqvist 2001) around the same time as the first comprehensive definitions for general water security (World Water Council 2000; Global Water Partnership 2000). However, there were no early attempts to try and define urban water security. Lundqvist (2001) noted that there was no specific and widely endorsed definition and rather than propose one, chose to take a generalised definition for water security (Global Water Partnership 2000) and apply it to the urban context. However, he argued that the GWP definition omitted reference to the productive use of water which is a necessary urban water security consideration and the GWP definition also required clarification of subjective language (such as enough, affordable, safe) to fit the ‘considerable variations of socio-economic circumstance’ in urban areas.

No specific definition for urban water security was proposed in either academic or non-academic literature until 2015. Two earlier water security definitions (Wutich and Ragsdale 2008; Hao, Du, and Gao 2012) had been applied in the urban context, but the definitions proposed were general. Only three definitions specific to urban water security have been identified as part of this study (see Table 3), all in the academic literature, with two focussed on 'capacity' and 'sustainability' (Chen and Shi 2016; Romero-Lankao and Gnatz 2016) and a third focused on 'access, safety, and affordability' and 'psychological' security (Huang, Xu, and Yin 2015).

The Romero-Lankao and Gnatz definition was the most clearly presented, with the other two clumsy in their use of English language and difficult to interpret. However, even the Romero-Lankao and Gnatz definition, which is well-aligned with the Grey and Sadoff definition of 2007, could be improved. The Romero-Lankao and Gnatz definition for urban water security is based on the 'capacity of urban water actors'. Capacity can be described as the ability to do something or the amount of something that is able to be done (Collins 2018). So in effect the Romero-Lankao and Gnatz definition suggests that urban water security is achieved if there is potential for urban water security to be achieved – which does not seem entirely reasonable. Chen and Shi take a similar approach in their definition with a similar focuses on 'capacity'. In contrast, the Huang et al definition, although poorly constructed, focusses on ecosystems to deliver outcomes and aligns with the liveability and wellbeing theme (Table 2) to include consideration of 'feelings of psychological security' – a specific social outcome to be achieved.

Table 3 Urban water security definitions

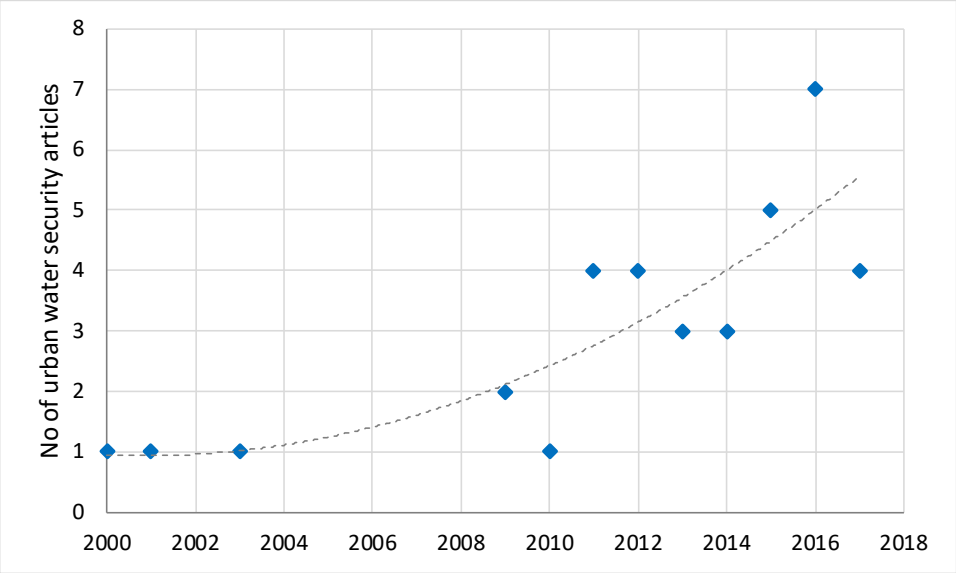
| Definition | Reference |
|---|---|
| Urban water security is defined as a persistent condition in a limited urban region under which water ecosystems can ensure the adequate access, safety, and affordability of water to meet minimum livelihood standards and human feelings of psychological security. | (Huang, Xu, and Yin 2015) |
| Urban water security is regarded as the capacity for sustainable development of the city under the influence of water resources, which could ensure the development of society, economy, ecological environment, citizens and humanistic environment. | (Chen and Shi 2016) |
| Urban water security is the capacity of urban water actors to maintain a sustainable availability of adequate quantities and quality of water, to foster resilient urban communities and ecosystems in the face of uncertain global change. | (Romero-Lankao and Gnatz 2016) |

Compared to the complete suite of 25 definitions, the three urban water security definitions show a stronger emphasis on liveability and wellbeing, (see Table 2). In other aspects, the predominance of quantity, quality and human health themes in the urban water security definitions reflects the patterns seen in the broader water security definitions.

Based on the relatively low citation counts (Table 2) for the papers in which the urban water security definitions appeared, there is little evidence that any of the three definitions have been widely adopted by others. This may be due to their relatively recent development or it may be due to the scale, scope and nature of urban water security research activity. A review of literature shows that there was little research activity of any kind specifically into urban water security concepts prior to 2009, with an increase in momentum occurring around 2011 (see Figure 4). Even then, overall research activity in this area is not high (peaking at seven peer reviewed publications in 2016) when compared with the broader topic of water security which had more than 30 papers published a year from 2010 to 2013 (Cook and Bakker 2016). This limited interest in urban water security research has also been noted by several other authors (Romero-Lankao and Gnatz 2016; Garfin et al. 2016), which is surprising given the

increasing global emphasis on sustainable city living and the recent experience of water crises in many urban communities around the world.

Figure 4 Number of urban water security research papers.




There are multiple examples in the literature of research conducted specifically on urban water security but with no clear definition (Chang et al. 2015; Lu, Bao, and Pan 2016; Yang et al. 2012; Esmail and Geneletti 2017). There are even technical papers where ‘urban water security’ forms part of the title or key words and yet appears nowhere else directly in the paper (Sahin et al. 2017; Muller 2016). The Urban Water Security Research Alliance (UWSRA) formed in Australia in 2007 during the Millennium Drought, brought an ‘unparalleled intensity of focus’ (Urban Water Security Research Alliance 2012) to urban water research in South East Queensland. Yet with a $50 million budget and portfolio of 23 research projects, the UWSRA did not present any definition for urban water security in its on-line communications with stakeholders or the community, instead focusing initial research efforts into water supply and recycling options, shifting later into demand management, water quality and integrated urban water management (Urban Water Security Research Alliance 2012).

UWSRA researchers are not alone in forging forward into research with limited clarification of language and strategic context. Brears' book titled *Urban Water Security* (2017) dedicated a chapter to 'What is urban water security?' consciously choosing not to provide a specific definition. As with Lundqvist some 14 years earlier, Brears starts with a general definition for water security (UN-Water 2013), then moves on to examine the challenges to achieving urban water security.

Given the reticence of other researchers to propose a definition, should urban water security simply be treated as a sub-set of water security generally, as suggested by Lundqvist (2001), or should it be elevated to a specialised area of study? Reviewers Cook and Bakker suggest that narrowing the framing is necessary to operationalise water security at a management level (2012), yet their more recent (2016) comprehensive study of water security language they did not identify 'urban' as a key water-security-related concept in academic research. With more than half of the world's population now living in urban areas and the shift from rural to urban communities continuing (United Nations 2014), it is essential that the transition to sustainable city living is well-managed, including ongoing access to water. The requirement for common understanding of urban water security language and concepts continues to be a pillar for progress that is only partially constructed.

Applying an existing water security definition to the urban context is a potential option but issues arise in the selection of which definition to use. This approach is further complicated by the seemingly 'incomplete' listing of themes presented in all the definitions (as listed in Table 2). So, there is an opportunity to take an alternate approach - to tailor a definition specifically for the urban context. Cook and Bakker (2012) recommend using either a broad, integrative framing on a policy and management level, or a narrow framing for operationalisation. We would suggest it

might be possible to provide a definition that both guides the specification of detailed objectives to be achieved for an urban community, but remains broad enough to be useful in the management and policy domains.

### *What makes a good definition?*

A definition is a statement that gives the meaning of a word, expression or phrase. Definitions can serve a range of purposes and their general character varies according to that purpose (Gupta 2015) for example a descriptive definition provides a meaning by making observations. Good definitions are clear and use simple language, they avoid self-referencing and they should rely on the same part of speech (for example nouns should be described using nouns). Definitions can comprise three key elements – a formal definition of the term or phrase in the form of a sentence; an example or description of how the term is used; and an equitable expression or synonyms for the term or phrase (O'Neill 2005; Private Writing 2013).

Common approaches to developing a definition include – reviewing existing definitions and reviewing definitions for similar terms or phrases; breaking a phrase into its constituent parts and examining the definitions of the separate parts; describing a term or phrase in terms of its functions, structure, nature or what it is not; and using facts, examples and anecdotes to assist the reader with understanding.

### *Building a definition*

To build a definition for urban water security, we have already examined existing definitions and found them to have merit but also be in need of improvement. Next we examine the common understanding of each component word.

There is no common global definition of what constitutes an urban settlement (United Nations 2014), it varies based on characteristics such as population density or

thresholds, the presence of infrastructure and the provision of services. However, at its most basic, urban is generally accepted to mean relating to or characteristic of a town or city, being a population centre that houses and supports a community. 'Water' in the context of urban water security could reasonably be considered to be accessible, fresh water (ie not saline or locked in glaciers) that is fit-for-purpose in terms of quality. Finally, 'security' is the state of being free from danger or threat. So the starting point for our definition is to pivot off these common meanings.

Consideration is next given to related water security definitions and how these have evolved. The growing complexity of definitions and the shifting thematic emphasis show the risks of using itemised lists within a definition – past efforts that focussed on quality and quantity of supply are now noticeably deficient in their reference to the environmental and social wellbeing dimensions more recently being sought. So a relevant, yet flexible definition is desirable rather than one that is hard-wired to the latest trends and at risk of failing to accommodate future advances in thinking.

The final considerations in building a definition were focussed on the rising social dimensions of urban water security, paired with a need to transition to more outcomes focussed research – both challenges previously identified (Wheater and Gober 2015; Ainuson 2010; Norman et al. 2013; Grey and Sadoff 2007). As far back as 1992, one of the key principles to achieving sustainable water development and management was a participatory approach involving all levels of stakeholders to identify agreed levels of service and security goals (Gorre-Dale 1992; Council of Australian Governments 2008; UN-Water 2013; Global Water Partnership 2000). Importantly, these goals should not be uniformly set or applied but should be determined considering the characteristics of particular water supply systems and relevant situational knowledge

provided by communities (Council of Australian Governments 2008; Mason 2013; van Beek and Arriens 2014; Ainuson 2010). We would argue that any definition for water security in the urban context must articulate an overt requirement for agreement of objectives with stakeholders. This is an extension of the definition proposed by Grey and Sadoff (see Table 1) where outcomes aim to be 'acceptable', but we propose providing greater clarity on the players to be engaged.

If the considerations discussed above are combined and integrated then urban water security could be defined as sustainably meeting the agreed water needs of a community, where:

- The community's water needs must be agreed between the water service provider and the community, and should be described in terms of technical, economic, environmental and social dimensions.
- To be sustainable, the needs must be met now and there must also be confidence (aligned with the community's risk appetite) that the needs can be met in the future.
- In establishing the agreed water needs, consideration should be given to:
    - the balance between competing demands for limited water resources (including maintaining healthy water catchments and waterways) and demands for the community's limited financial resources;
    - providing water volumes sufficient to support both physical and psychological well-being (including basic health and hygiene as well as liveability and employment opportunities) with fit-for-purpose water quality (for both health and aesthetic targets) that is affordable and accessible;

- the community's risk appetite including for safety (including flooding and dam safety), reliability (likelihood of failure) and resilience (time to restoration after failure), and consistent with the community's view of equity (including between community groups, between people and the environment, and between current and future generations).

The proposed definition makes several significant contributions and improvements to the urban water security definitions proposed to date and the water security definitions that might be applied to the urban context. Firstly the definition makes sense – both grammatically and contextually. Most importantly we have put the focus onto the community, cooperation between stakeholders and the need for sustainable approaches to achieving water security outcomes. Our definition does not itemise or pre-empt the water system characteristics that will be important to every community, nor does it aim to achieve some unquantified minimum standards, but rather it allows for objectives and accompanying targets to be tailored to a particular community within the broad framings of technical, economic, environmental and social themes. Critically, the proposed definition infers the requirement for objectives to be agreed with a community. Such an approach of cooperative goal setting is in contrast to conventional arrangements where communities have little or no input into the determination of the water security objectives (Allan 2018).

Further noteworthy characteristics of the proposed definition include minimising the use of subjective language such as 'sufficient' or 'adequate' but allowing for what is acceptable to be determined by each community; the definition of a community is left flexible to accommodate different local definitions, geographical bases (such as local government boundaries versus water basin boundaries) or types of water users (such as residential/non-residential, permanent/transient, paying/non-paying); and the need for

on-going evolution and refinement of needs and the strategies to deliver security is inferred through the lack of a time-step and the drive for sustainability.

## Conclusions

We have discussed the need for a specific definition for urban water security that can be operationalised to provide a foundation for achieving targeted urban water security outcomes. We have built a definition for urban water security that embraces common language and the well-established participatory approach to sustainable water management practice, it is concise, yet flexible and focusses on a cooperative goal setting approach between water service providers and the community underpinned by the themes of water security identified in the broader water security literature.

The proposed urban water security definition provides a systematic improvement to existing urban water security definitions. However, there may be scope for further development. We suggest that the definition should be tested through case studies and other approaches to: reveal its value, identify challenges to its application and inform any refinements or enhancements.

Additional work is also required to better understand how urban water security sits within broader urban water management frameworks such as sustainable water management, integrated water resource management, the water-energy-food nexus, the web of securities, risk management, resilient water management approaches and water sensitive cities. An enhanced understanding of the relationships between these frameworks will provide even further clarity on what urban water security means and help with systematically operationalising urban (and general) water security.

Ongoing challenges to achieving desired urban water security outcomes will also be in determining how best to access an informed, water-aware community and

clarifying roles and responsibilities to achieve the water security objectives and outcomes sought.

Urban water security is an emerging field of study, of growing significance. We hope we have added to the understanding of the language and provided a focus for further advancement towards positive, real-world outcomes.

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