Analysing the terminology of integration in the water management field

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Abstract

The idea that water management should take an integrated approach has become the global paradigm over the past two decades. This new paradigm has come to be known by many different names. This paper explores the use, history and meaning of these competing terms, and discusses the possible implications of this term-proliferation. The literature indicates that a minimum of 26 distinct terms have been used. The use of different terms appears to have underwritten a belief that each term identifies a distinctly different field of study. After analysing sample definitions and subject areas for the eight most frequently used terms, it has been determined that some terms do have fundamental differences and others are essentially the same. This unnecessary term-proliferation contributes to a ‘knowledge silo’ effect, impeding knowledge-sharing and research advancement within the water management field. It is recommended that both academia and industry start actively considering term-proliferation when searching and publishing literature.

Keywords: Integrated water management; Integrated water resource management; River basin management; Total water management; Urban water management; Water cycle management

Introduction

What does ‘integrated’ mean?

Beginning in the 19th century with the widespread construction of water reservoirs and sewered cities, the field of water management has traditionally operated within a relatively simple template: as a utility that provides services to customers. In this context water managers were responsible for meeting service standards for segregated services at the lowest cost possible. Having segregated services

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with their own service standards meant that separate water supply, sewage and drainage teams could monitor situations and wait until action was required. This ‘conventional’ approach was straightforward and aimed to avoid complexity by utilising large standard centralised solutions (Mitchell, 2006). Under this management style, in many locations the environment suffered from pollution and was largely neglected in decision making. Where environmental action was taken, it was usually targeted at well-defined, localised and independent problems (Vugteveen & Lenders, 2009).

Over the past two decades the field has gradually evolved to encapsulate a broader set of considerations, such as ecosystem protection, urban liveability and interactions with the economy. This shift in considerations was closely associated with the sustainable development agenda, which came to prominence over approximately the same period (Ioris, 2008).

To make informed decisions and pursue the goals of sustainability it became apparent that a change was required from the ‘conventional’ approach described earlier, towards an ‘integrated’ approach which considers multiple aspects and services in a coordinated way (Mitchell, 2006). The word integrated means desegregated and implies looking at the bigger picture, considering all relevant information or, in other words, viewing situations as a ‘whole’, made up of interconnected parts. In the field of water management the key difference between a ‘conventional’ and an ‘integrated’ approach is that the latter takes into consideration multiple competing objectives, contributing factors and the relationships between these variables.

This change from ‘conventional’ to ‘integrated’ is generally referred to as a ‘paradigm shift’. However, in the literature this new paradigm has been given many different names – including integrated water resource management (IWRM), integrated water management, integrated water cycle management, integrated urban water management, etc. In the literature these differing terms are usually accompanied by the authors’ opinions on what actually needs to be integrated, and some high level guidelines about how this should be done (Jaspers, 2003; Mitchell, 2006; O’Connor, 2010).

The opinions of experts appear to be, to a certain extent, based on local context and personal experience (Downs et al., 1991). Therefore this large variety of terms with differing definitions can be partially attributed to the fact that although the need for integrated approaches is universal, the exact factors that need to be integrated and the optimal process with which to consider them vary tremendously between situations. The context of a given situation has a large impact when selecting the appropriate concepts, such as: decision-making scale and boundary selection process, level of stakeholder input, institutional and legal arrangements, agricultural and economic considerations, technical and budgetary limitations, etc. (Vugteveen & Lenders, 2009). In some cases there is also contentious debate within a given context about the meaning and utility of terms. One notable example of this is the monocentric versus polycentric management debate common to river basins in developing countries (Lankford & Hepworth, 2010).

The history of integrated approaches

One way that the water policy field can be conceptually separated is into the three highly interrelated components of what, who and how. ‘What’ refers to objectives and standards such as sustainability and water security, ‘who’ refers to water governance and institutional arrangements, and ‘how’ refers to the processes through which water is managed. This paper deals primarily with the ‘how’ component, and seeks to develop a better understanding of what theories exist and in what ways they differ. Although some existing management styles differ substantially, the complex and interrelated nature of water issues in the modern age requires that all management styles include an integrated approach on some level (Biswas, 2004). In the interest of conveying the general history of the topic in the simplest possible way, the authors have at
various points in this paper used the term ‘integrated approaches’ to refer to all of the integration-related terms covered. The differences between these terms will be explored later in this paper.

The exact origins of integrated approaches in the field of water management appear to be contested in the literature; however, this is largely due to the fact that different aspects emerged at different times. For example, the idea of considering environmental impacts in decision making was realised decades ago, whereas social and liveability considerations within urban areas are relatively new and not widely practised (Mukhtarov, 2008).

The literature suggests that there is a commonly held belief that concepts of integration in the water management field did not exist before they were discussed in a series of global summits in 1977, 1992 and 2002. However, a brief scan of the literature quickly reveals that some aspects have been around much longer (Mukhtarov, 2008). Two authors make the case that some integrated concepts such as downstream water re-use, diverting excess water to groundwater recharge, participatory water tribunals and organising water management on the basis of river basins can be identified in Spain as far back as the Middle Ages (Rahaman & Varis, 2005; Vivas et al., 2009).

In modern history the first records of the use of integrated approaches in water management occurred in the United States in the early 1900s. Some of the first terms that were used to describe these concepts were ‘rational comprehensive planning’ and ‘multiple-purpose water construction’ (Mukhtarov, 2008). These terms were involved in the broader idea of ‘river basin management’ which was based on the idea that river basins were the ‘natural’ unit for water management (Warner et al., 2008). Some authors argue that the exact origins of integrated approaches to water management can be traced back to the USA Flood Controls Act of 1917 or the establishment of the Tennessee Valley Authority in 1933 (Gallego-Ayala, 2013). These ‘river basin management’ concepts were very much centred on the construction of dams on a river for multiple purposes (Warner et al., 2008).

In the 1950s, the term IWRM was first used by the United Nations (UN) (Mukhtarov, 2008). This was part of the broader concept of ‘integrated resource management’ which can be described as ‘the sharing and coordination of the values and inputs of a broad range of agencies, public and other interests when conceiving, designing and implementing policies, programs or projects’ (Mitchell, 1990).

In the 1970s and 1980s, the water management field started to shift towards having more of an emphasis on environmental considerations (Warner et al., 2008). In this period many terms were created around the concepts of ‘ecosystem based approaches’ such as ‘holistic river basin management’ (Downs et al., 1991).

At the 1977 UN Conference on Water, held in Plata Del Mar, for the first time a large proportion of the international community began to discuss the need for integrated approaches to water (Biswas, 2004). The idea did not become widespread until it began to gain momentum after the two UN Conferences held in 1992, where ideas were formalised into Chapter 18 of Agenda 21, recommending the adoption of integrated approaches for water management. In 2002, at the World Summit on Sustainable Development, recommendations were made that IWRM plans be made for all river basins around the world by 2005 and, in the years following, IWRM was largely adopted around the world as the way to achieve sustainability in the water sector.

Consolidating this process, the Global Water Partnership (GWP) suggested that the following definition for IWRM be adopted:

‘A process, which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems’ (Global Water Partnership, 2000).
The term IWRM and the interpretation above have become the most widely used terminology for integrated approaches within the water management field (Rahaman & Varis, 2005; Mukhtarov, 2008). However, despite this apparent international consensus, in the period following this process many other terms with similar definitions have appeared in the literature.

Even though the term IWRM and the concepts and practices behind it were accepted by a large proportion of the international community following the World Summit on Sustainable Development, there are a substantial number of experts who hold the view that IWRM is too rigid and that a one-size-fits-all top-down management approach is not suitable for every situation (Lankford, 2008). Some authors hold the view that IWRM often fails to incorporate significant issues, such as irrigation, by not adapting to local contexts through the role of polycentric governance and citizen participation (Lankford et al., 2007).

It was from this viewpoint that the ideology of adaptive water management (AWM) was spawned. Although there are some differing opinions on what form AWM should take, the literature is consistent on the point that management processes should be continually revised and updated in order to continually improve and tailor them to particular situations (Pahl-Wostl et al., 2007; Bruch, 2009; Lankford & Hepworth, 2010).

Unlike the AWM ideology which emerged as a conscious challenge to the generally accepted IWRM paradigm, some other terms do not explicitly challenge the IWRM paradigm and in many cases do not refer to IWRM at all. As no emphasis is placed on the difference between the IWRM concept and the concepts of these terms, it is not always clear to what extent terms differ from IWRM and from each other. As the distinctions between the majority of terms are not immediately obvious, it is logical that conceptual analysis should be employed to provide further insight into what differences exist between terms.

Before attempting to determine the potential impact of terminological issues on the water management field it is prudent to take a moment to consider the current state of the field itself. There are numerous problems that exist within global water management. One problem is a lack of knowledge-sharing or, as Biswas (2004) phrased it, ‘sitting in water-tight cages and preaching holistic approaches’. Another problem commonly discussed is the ‘absence of strong and legitimate institutions to promote water governance’ (Gupta et al., 2013). Some consider it a problem that politics intrudes on the ability of specialists to manage water-related problems (Blomquist & Schlager, 2006). Lankford (2008) argues that the typical water management approaches are often theory-facing rather than problem-facing and this leads to strategic level planning being insufficiently context aware. In summary, as Gupta et al. (2013) state, societies on all scales are struggling to deal with global water governance and its implications.

**Analysing the terminology of integration**

As mentioned in the previous section, there are many problems that exist in the water management field. There are a number of factors that contribute to and exacerbate these issues. It is the opinion of the authors of this study that the large variety of terms is a factor that slows progress within the field by aiding the creation of knowledge silos. One piece of evidence that points to this conclusion is the way literature reviews are conducted. An example of this can be seen in the literature review conducted by Gallego-Ayala (2013) in which the researcher searched for the terms IWRM and Integrated Water Management but not Integrated Urban Water Management, Total Water Management or other
terms. In the paper’s analysis section, concepts are discussed which are highly relevant to the urban sector such as water supply augmentation, the economic value of water, and climate change. The literature review in question therefore has not included a large proportion of the literature, and thus has reduced value for water policy makers.

In the light of this, the authors propose that the terminology used is a matter of some importance in the consideration of water policy. The authors Downs et al. (1991), Medema & Jeffrey (2005) and Vugteveen & Lenders (2009) agree that the terminological issues are of importance and their work will be discussed in this section.

Several preliminary reviews of different terms have previously been attempted. A study conducted in 1991, before IWRM became widely adopted, determined that there were at that time already between 21 and 36 different terms being used to describe ‘the paradigm of a unified approach to basin management’ and suggested ‘that there are advantages to be gained by using terms in a standard way’ (Downs et al., 1991); in its conclusion, the study discussed the perceived difference between two popular terms, ‘comprehensive basin management’ and ‘integrated basin management’, before ‘provisionally recommend [ing]’ that ‘holistic river basin management’ be used in certain circumstances.

A study in 2005 sought to answer the question ‘IWRM and Adaptive Water Management: synergy or conflict?’ and concluded that both terms had similar drivers, that theoretically they complemented each other, and not enough was known about the practical application of either to answer the question (Medema & Jeffrey, 2005).

Another study in 2009 discussed the meanings of 10 competing terms and found that they could be grouped into two categories; holo-centric terms which are conceptually rooted in human issues, focusing on factors such as social considerations and stakeholder consultation, and eco-centric terms where ecosystems are considered the major structural and functional units (Vugteveen & Lenders, 2009).

The authors have not discovered a clear and up-to-date record in the literature on what terms exist, their relative popularity, and to what extent their meanings and associated concepts and practices differ. Also there has not been any serious discussion of potential impacts that the existence of these numerous terms may have had on knowledge sharing.

This paper sets out a preliminary review of a large set of integration-related terms. The objectives of this study are to identify the most popular integration-related terms, compare the popularity of terms, investigate their respective meanings and associated concepts, and to make an initial assessment of what potential impact term proliferation may be having on knowledge sharing.

Method

Identification of terms

The first stage involved surveying a sample of the available literature in order to identify and catalogue the various terms that include the aspect of integrated approaches in water management.

This process began with a reading programme that set out to select papers that involved a general connection to the use of integrated approaches in relation to water management. This collection of 80 papers was deliberately undertaken in a sporadic fashion, as the main aim was to achieve diversity and breadth within the field. The diversity that was sought included a variety of institutional types, including state, academic and industry sources, a broad representation of countries of origin and of a diverse range of disciplines such
as ecology, economics, water management, public and environmental policy, etc. The papers were drawn from a range of sources including online databases such as Scopus, and the online libraries of Elsevier and the American Society of Civil Engineering. The papers that were collected are predominantly academic but this set also included a variety of reports from public and private organisations.

The process for this involved the researchers screening the literature for repeated terms and assessing from stated definitions, and/or context, whether terms were being used to identify integrated approaches. In the majority of cases the terms appeared in the title, abstract or key terms, making identification easier. The most obvious inclusion criteria was the presence of the words ‘integrated’ and ‘management’ in phrases that were repeated throughout. In other cases where the trigger term ‘integrated’ was not present, a closer reading sometimes identified related themes, such as concepts related to ‘total’, ‘adaptive’ or ‘sustainable’ water management. In such cases further analysis was required to determine if the term did in fact include an integrated approach. The output of this process was a list of distinct terms.

Data collection

The second stage of the study involved collecting historical data on the use of terms from an online literature database. The use of terms was recorded against time and between subject areas.

Following the identification of distinct terms, the researchers were then able to use database search functions to quantify the frequency of use over time for individual terms. There are currently two online literature databases which are able to facilitate this process: Scopus and Web of Science. The Scopus database was selected on the basis that it has a larger total collection, due to the inclusion of low impact journals (Chade-gani et al., 2013). Scopus has search functions which display relevant information about search results. By utilising one of these functions, researchers were able to easily view the number of search results each year. The frequency of use of each term was recorded in 5-year periods and graphed over time.

The graphical representation of the frequency of use of terms over time enabled the researchers to draw correlations between the trends shown on the graphs and the broader global context, for example global summits and ideological movements such as the sustainable development agenda. In order to further understand the use of differing terms, the body of literature for each term was separated into subject areas. This was undertaken using a Scopus search function in the same way that the year of publication was determined.

Comparison of definitions

The third stage of this study involved collecting and interpreting the definitions given to terms.

This process took the form of collecting and then comparing the stated definitions of terms. The number of identified terms (31) was deemed too large to facilitate this process and therefore it was conducted for only the nine most used terms from Table 1. It was originally planned that for each of the selected terms, the two most cited academic papers featuring the term in their title would be collected, and have definitions extracted from them. However, it became necessary to adapt this plan mid way, as it was found that the most cited academic papers do not always include definitions of the terms that they are using. In such cases less cited papers were referred to. Definitions were then able to be compared within each term, and between each term. In keeping with previously conducted studies, an attempt was then made to analyse terms with regard to their conceptual content in order to ascertain what components are included within each of the terms.
Table 1. Frequency of use within initial readings and Scopus database, as well as earliest recorded use of the 10 most used terms.

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Initial readings</th>
<th>Scopus database</th>
<th>Earliest recorded use</th>
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</thead>
<tbody>
<tr>
<td>Integrated water resource management</td>
<td>32</td>
<td>992</td>
<td>1966</td>
</tr>
<tr>
<td>Integrated water management</td>
<td>39</td>
<td>523</td>
<td>1970</td>
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<tr>
<td>Sustainable water management*</td>
<td>3</td>
<td>484</td>
<td>1984</td>
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<tr>
<td>Integrated watershed management</td>
<td>2</td>
<td>196</td>
<td>1984</td>
</tr>
<tr>
<td>Integrated river basin management</td>
<td>2</td>
<td>181</td>
<td>1986</td>
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<tr>
<td>Sustainable water use*</td>
<td>1</td>
<td>171</td>
<td>1997</td>
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<td>Water sensitive urban design</td>
<td>1</td>
<td>124</td>
<td>1999</td>
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<tr>
<td>Integrated urban water management</td>
<td>7</td>
<td>89</td>
<td>1990</td>
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<td>Total water management</td>
<td>1</td>
<td>67</td>
<td>1970</td>
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<tr>
<td>Adaptive water management</td>
<td>3</td>
<td>36</td>
<td>1995</td>
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</table>

*Determined as not indicating the use of integrated approaches.

Results

Identification of terms

Terms were first identified from the initial readings and compiled into a list. The process identified 31 distinct terms that were seen to potentially include the use of integrated approaches; these are displayed in Appendix A1 (available online at http://www.iwaponline.com/wp/017/185.pdf). The count of the number of initial readings that included the respective term is shown in the column ‘Initial readings’. A search for the respective phrase was then conducted on the Scopus online database, and the total number of results and the year of the earliest result were recorded in the ‘Scopus database’ and ‘Earliest recorded use’ columns. The 10 overall most popular terms are displayed in Table 1. As predicted in the introduction, Integrated Water Resource Management has been the most frequently used term.

It became evident that Sustainable Water Management and Sustainable Water Use are terms that identify the goal of sustainability but do not indicate a method or approach. The literature is quite consistent in this matter (Liu et al., 2008; Makropoulos et al., 2008) and therefore it was decided that, as these terms do not include the concepts of integrated approaches, they should not be represented in the ‘frequency of use’ graphs.

With a few exceptions, such as Integrated Urban Water Management being over-represented in the initial readings, it can be said that there is a fair correlation between the counts in the initial readings and the relative number of results found during the Scopus database search. It should be noted that the earliest recorded use in the Scopus library is not necessarily the earliest actual use in the literature, as no online database contains the entirety of the literature on any topic.

Data collection

The total number of Scopus search results for each term was recorded in time periods, starting with pre-1979 and then in 5-year blocks from 1980 onwards. Figure 1 shows the results for the eight most used terms that include an integrated approach. The collected data can be seen in Appendix A2 (available online at http://www.iwaponline.com/wp/017/185.pdf).
Figure 1 clearly shows the rise in popularity of the term IWRM in the period 2000–2004. The graph also shows a steady increase in use for almost all terms. This is certainly partially due to an increasing interest in the field, but it also may be affected by the Scopus database being more likely to contain more recent papers, and a global increase in the total number of publications. It should also be noted that the period displayed as ‘2010–’ (meaning 2010 until August 2013) does not represent a full 5-year period and therefore the dips that can be seen on the right of the graph do not represent an actual decline. This same data is displayed in Figure 2 below as a percentage of total term use over the same time periods.
Figure 2 makes certain parts of the overall story easier to interpret, for example the dominance of the term Total Water Management prior to 1980. It also shows that the terms Water Sensitive Urban Design and AWM are relatively new, and that Integrated Watershed Management, Integrated River Basin Management and Integrated Urban Water Management have all maintained a relatively consistent percentage of the total field. As could be seen in Figure 1, Figure 2 also illustrates once more the decisive shift from Integrated Water Management to IWRM between 2000 and 2004.

Comparison of definitions

Appendix B1 (available online at http://www.iwaponline.com/wp/017/185.pdf) displays two definitions for each of the eight most used terms that include the use of integrated approaches. Definitions have also been shown for Sustainable Water Management, a term that does not include the use of integrated approaches, and also for ‘integrated approach/assessment’, which was used by this paper as an overarching term in the introduction.

As stated earlier, after a careful reading of the provided definitions it can be confirmed that Sustainable Water Management differs from the other terms. Sustainable Water Management is a term used to describe the goal of sustainability. As a goal rather than a management style, it can be determined that this term does not include the use of integrated approaches. Once definitions were collected, an attempt was made to compare the terms against each other regarding their conceptual components.

The process involved in the creation of Table 2 was unavoidably subjective and based only on stated definitions rather than underlying concepts and practices. In the opinion of the researchers, all of the terms shown include the use of integrated approaches.

Figure 3 shows the use of terms within a number of subject areas. The actual data can be found in Appendix A3 (available online at http://www.iwaponline.com/wp/017/185.pdf). IWRM, Integrated Water Management and AWM display similar distributions across subject areas. Integrated River Basin Management and Integrated Watershed Management display a decreased proportion of use in engineering, and an increased proportion in earth and agricultural sciences. Finally, the terms Total Water Management, Water Sensitive Urban Design and Integrated Urban Water Management show an increased proportion of use in the business, engineering and mathematics areas, and a decreased proportion in the areas of earth and agricultural sciences.

Discussion

Integrated approaches, in different forms and identified by different names, have gradually become widespread in the field of water management over the past few decades. The use of many of the terms increased dramatically around the year 2000. This increase can be partially attributed to the 2002 World Summit on Sustainable Development, and subsequent actions taken by the UN and other international organisations, such as the Global Water Partnership, to promote the uptake of IWRM plans throughout the world.

The study has discovered that there are at least 26 different water management terms being used that include the concepts of integrated approaches. Interestingly it can be shown that terms are still being coined, with twelve new terms being created over the past 10 years, as can be seen in Table 1. Figure 2 indicates that prior to 1980 the most popular term was Total Water Management; since that period, the
Table 2. Concepts included in each term.

<table>
<thead>
<tr>
<th>Water</th>
<th>Other resources/fields</th>
<th>Economic &amp; financial considerations</th>
<th>Environmental considerations</th>
<th>Social considerations</th>
<th>Strategic (long-term) and demand</th>
<th>Water supply and demand</th>
<th>Fit-for-purpose water use</th>
<th>Management system</th>
<th>Adaptive learning processes</th>
<th>Coordination between institutions</th>
<th>Urban areas</th>
<th>Always hydrological boundaries</th>
<th>Agriculture &amp; rural areas</th>
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<td>Integrated water resource management</td>
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<td>Water sensitive urban design</td>
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<td>Integrated urban water management</td>
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<td>Total water management</td>
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<td>Adaptive water management</td>
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terms Integrated Water Management and IWRM have dominated the research field, although the results indicate a recent shift towards the use of less well-known terms.

**Differences between terms**

After analysing the definitions of the 10 most popular terms it was determined that the meaning of all except Sustainable Water Management and Sustainable Water Use included the concepts of integrated approaches. Sustainable Water Management is a goal or aspiration rather than a management style (Liu *et al.*, 2008).

Of the remaining eight popular terms that do include the concepts of integrated approaches, there are fundamental differences between some of them. The authors of this study propose that the differences between the definitions of terms are largely caused by two factors. The first is variance in the spatial context both between and within countries, meaning that different situations require different management styles, and the second is personal experience, including the discipline that authors are versed in. As Biswas (2004) states: ‘water problems of the world are neither homogeneous, nor constant or consistent over time’ and clearly different circumstances call for different responses. These differences in context have partially contributed to the proliferation of terms. The most obvious distinction between terms is whether they relate to an urban or rural area; however, some distinction can also be made between the socio-economic status of countries and the management review process.

Water management concepts that need to be considered vary between rural and urban areas; therefore the differentiation between rural and urban is a logical distinction. For example, it is common for water managers working in rural/agricultural areas to take the view that decisions should be made along hydrological boundaries, as this is generally considered to be the ‘natural’ unit for water management, although that claim is thoroughly contested by some authors (Warner *et al.*, 2008). In rural areas it is also typical that land use planning, stakeholder consultation and water allocations take high priority (Jaspers, 2003). The terms that typically align with these priorities are IWRM, Integrated River Basin Management, Integrated Watershed Management and AWM. Davis (2005) argues that IWRM is often used within developing countries and is almost always carried out along hydrological
boundaries. Warner et al. (2008) state that IWRM is Integrated River Basin Management at the broadest scale. AWM was designed as a conscious objection to the one-size-fits-all approach of IWRM (Pahl-Wostl et al., 2007).

In contrast to this, an urban water manager is likely to be of the view that decisions should be made along urban planning or metropolitan zones, and centred on the three major sectors of water supply, sewage and stormwater (Mitchell, 2006). This leads to an emphasis on infrastructure solutions that provide benefits to more than one sector, such as sewage and stormwater recycling plants (Chanan & Woods, 2006). Some of the terms commonly associated with these priorities are Integrated Urban Water Management, Total Water Management, Whole-of-water Cycle Management and Integrated Water Cycle Management. In the opinion of the authors of this paper there is no clear distinction between the meanings of these terms. There are some cases in the literature where urban water managers in developed countries have used the history of IWRM as justification for urban-centred theories around integration (Wallington et al., 2010). This practice is questionable as there are distinct differences between IWRM practices and those used in urban areas.

Integrated Water Management as a term is often used in both a rural and urban context. There are many cases within the literature where authors appear to use certain terms interchangeably with Integrated Water Management. In these cases the other terms used typically align with the urban/rural distinction. Some examples of this are Geldof (2002), who uses Integrated Urban Water Management interchangeably with Integrated Water Management, and Rahaman & Varis (2005) with IWRM and Integrated Water Management.

The findings above provide justification for sorting terms into three categories: rural-centred, urban-centred and the umbrella term of Integrated Water Management. The subject area results in Figure 3 provide further support for these categories, with the proportions of engineering increasing in urban areas, and the proportions of earth sciences and agricultural sciences increasing in rural areas.

There are also many cases where the definitions of terms appear highly similar but differences can be noted in associated concepts and practices. Further analysis supports this finding that the terms’ definitions alone are not able to convey all of the associated concepts and practices, as well as the different ways ideas are applied across the world. One example of this is IWRM, the broad and vague definition of which does not carry all of the varying opinions about how it should be put into practice (Biswas, 2004). Integrated Watershed Management has a definition very similar to that of IWRM, however, in practice, there are differences. Integrated Watershed Management appears to be more often used in developed countries and often takes polycentric organisational forms (Blomquist & Schlager, 2006).

Within each term there are also many debates surrounding how these terms should be implemented on a practical level. One example of this is within AWM where there are differing opinions on whether water management should have a formal, regulatory approach or a more decentralised approach (Lankford & Hepworth, 2010).

The implications of term proliferation

The creation of different terms has the potential for leading to a belief that each term identifies a distinctly different field of study, creating pockets of knowledge that do not fully share or interact with each other. In the corporate world, this concept is referred to as the creation of ‘knowledge silos’ (Pemsel & Muller, 2012). The researchers found many examples where an author using a particular term explains...
why that term/ideology is different and in some way a necessary advancement in understanding. In such cases the author often appears to have a tendency to refer to papers that use the same term.

There are of course other factors contributing to the lack of knowledge sharing in the water management field. There are knowledge gaps created by language and geographical and political barriers. There is also a knowledge-sharing problem between academia (that often publishes theoretical research but does not always have practical experience) and industry (that has practical experience but often does not consult the available research or disseminate findings in the scientific literature).

If knowledge silos are being created, this represents a significant risk to the continuing development of the water management field and may impede knowledge sharing, preventing researchers from developing a clear understanding of what research has previously been conducted and causing studies to be repeated unnecessarily rather than learning from previous research.

Perhaps the most compelling evidence that term proliferation hampers knowledge sharing and contributes to the creation of knowledge silos is the case mentioned in the introduction, which can now be considered in the context of the popularity of terms. It can now be demonstrated that, by only searching for IWRM and Integrated Water Management in the literature review, Gallego-Ayala (2013) could potentially access only 1515 out of the 3050 papers (less than 50 per cent) available on Scopus that relate to the concepts under consideration.

Conclusion

Knowledge silos have the potential to negatively impact water policy objectives. In order to reduce the impact of knowledge silos, it is the recommendation of this paper that researchers and water managers need to start actively considering term proliferation when searching and publishing literature. It is also recommended that the umbrella term ‘Integrated Water Management’ be used in place of all the urban-centred terms or, as a minimum, that they are mentioned in the key words of journal papers. In the case of rural-centred terms, it has been found that there are some fundamental differences between terms and they should therefore not be conflated, although Integrated Water Management should still be mentioned in the key words. It is considered that these actions will improve knowledge sharing in the water management community.

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