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Traditional water knowledge: challenges and opportunities to build resilience to urban floods

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Abstract

Purpose – Urban flooding in developing countries of the Global South is growing due to extreme rainfall and sea-level rise induced by climate change, as well as the proliferation of impervious, built-up areas resulting from unplanned urbanisation and development. Continuous loss of traditional knowledge related to local water management practices, and the de-valuing of such knowledge that goes hand-in-hand with globalised aspirations, is inhibiting flood resilience efforts. This paper aims to address the need to include traditional water knowledge (TWK) in urban living and development processes in the Global South.

Design/methodology/approach – This paper commences with a review of existing frameworks that focus on natural resource management, critically assessing two existing frameworks of traditional ecological knowledge (TEK). The assessment of the existing approaches contributes to this paper's development of a novel framework to promote TWK with regard to resilience and risk reduction, specifically for developing flood adaptive strategies, which is the second stage of this paper. Finally, the paper explains how the framework can contribute to the field of urban design and planning using examples from the literature to demonstrate challenges and opportunities related to the adaptation of such a framework.

Findings – The framework developed in this paper reveals three proposed vertices of TWK, named as place-based landscape knowledge, water use and management and water values. This framework has the potential to produce context-specific knowledge that can contribute to flood-resilient built-environment through urban design and practices.

Research limitations/implications – The framework developed in this paper reveals three proposed vertices of TWK, named place-based landscape knowledge, water use and management and water values. This framework has the potential to produce context-specific knowledge that can contribute to flood-resilient built-environment through urban design and practices.

Originality/value – Within the field of TEK research, very few researchers have explored the field of developing flood resilience in an urban context. The proposed TWK framework presented in this paper will help to fill that gap.

Keywords Resilience, Urban development, Flooding, Built environment, Water, Traditional ecological knowledge, Flood resilience

1. Introduction

Worldwide, flooding is considered as one of the most persistent natural hazards, causing a threat in urban design and planning (Jameson and Baud, 2016; Liao et al., 2016). Recently, the number of urban floods is growing due to extreme rainfall and sea-level rise induced by climate change (Jalilov et al., 2018; Jiang et al., 2018; Klijn et al., 2015). In combination with the proliferation of impervious, built-up areas resulting from unplanned urbanisation and expanded urban development into low-lying swamplands (Fratini et al., 2012), the risk of flooding in urban areas is increasing. Typical hard engineering-based responses to floods are built on the idea of controlling nature, rather than considering humans as part of it. The results of hard-engineered approaches may seem obvious, although are often ignored: the increase in dry, floodwater-free and stable conditions in urbanised areas creates an aversion and lack of knowledge of how to address any natural flooding by urbanised inhabitants; impervious surfaces in urban areas increases the risk of disastrous floods; annihilation of natural water systems and biodiversity prevents the interceding roles to reduce or prevent flooding; dropping underground water tables increases the risk (Jalilov et al., 2018; Liao, 2012; Yu et al., 2008; Liao et al., 2016). Recent shifting paradigms in flood research has initiated the idea of flood resilience that is interpreted not as the prevention of flooding but as the ability of a community to tolerate flooding and explores the role of spatial planning (Scott et al., 2013) to avoid disaster in the event of flooding or the ability to reorganise quickly in the event of physical damage and socio-economic disruption (Liao et al., 2016).

The concept of working with nature is reflected in the shifting focus towards practicing “ecological wisdom” (Young, 2016, p: 95), which assesses the wisdom of pre-modern society and landscapes, combining contemporary techniques and practices through scientific explanation and allowing the voice of ecological and social systems into urban planning and landscapes (Spirn, 2014; Steiner, 2014; Yang and Young, 2019; Young, 2016). Also known as traditional ecological knowledge (TEK), ecological wisdom is an information source that embodies different perspectives and knowledge on locally developed practices of resource use, focussed on the ecological relationship of different natural elements as understood through interaction between human communities and their local eco-systems (Bwambale et al., 2018; Iloka, 2016; Berkes, 2012; G,omez-Baggethun et al., 2013). The socio-cultural systems behind these practices have transformed over generations, further increasing the adaptive capacities of subsequent generations (Berkes et al., 2000; Leonard et al., 2013; Maclean and Inc, 2015). Researchers from different fields seek inspiration from TEK (Yu et al., 2008; Liao et al., 2016; Thaitakoo et al., 2013; Shannon, 2013) and define TEK in various ways with analogous forms of the term such as “local knowledge”, “indigenous knowledge”, “peasants’ knowledge” or “traditional environmental knowledge” (Mercer et al., 2010; Hiwasaki et al., 2014).

Traditional knowledge of locals about their immediate environment and water systems are considered a major driver for solving water-related problems (Dean et al., 2016; Mavhura et al., 2013). A lack of acknowledgment of local wisdom by policymakers creates a problem for adopting traditional knowledge-based sustainable water use, management practices and flood adaptive strategies in an urban context (Ayeni et al., 2014). To fill this gap, this paper explores an offshoot of TEK, known as traditional water knowledge (TWK) – an approach to developing resilience to floods.

TWK encompasses traditional communities' greater socio- cultural understanding of water systems, and integrates the place-based knowledge, use and management techniques of those communities into a scientific and governance approach (Liao et al., 2016; Martin et al., 2010; Chen et al., 2014; Shannon, 2013; Thaitakoo et al., 2013). The long-term experience of adaptive strategies used in TWK can inspire urban planners, communities and government to deal with the future, where TWK can be viewed as "library of information" (Berkes et al., 2000, p: 1259). This research also demonstrates that the challenges and the opportunities provided by TWK, produced by local people, can build flood resilience in the urban built environment.

2. Research method

Despite the quantity of cross-disciplinary research on TEK, and to a lesser extent TWK, there exists very little guidance for the collection and categorisation of traditional knowledge, making it difficult to formalise the information and to embed engagement with traditional knowledge in typical government and managerial processes. To address the issue, this research proposes a framework to classify, understand and describe the various water-focussed forms of traditional knowledge and the relationships between them that has the potentiality to contribute to flood resilience research. To develop the TWK framework in this research, different themes are synthesised from different water-focussed planning literature and combined to derive a conceptual framework for analysing TEK through a TWK lens. Intensive literature reviews on related fields help to develop this research paper, and the step by step process followed to structure this paper is described below.

2.1 Stage 1 – synthesis of traditional ecological knowledge themes

In the first stage of this study, two existing frameworks of TEK that focus on natural resource management are critically assessed. These are the 1999 work of applied ecologist Fikret Berkes and the 2007 work of Nicholas Houde, an indigenous geographer. Our background research found that within the scholarly field of TEK, traditional knowledge has been considered in several themes of analysis (Houde, 2007; Kim et al., 2017; Berkes, 1999; Usher, 2000; Leonard et al., 2013). To complete this stage, this paper proposes a set of three TWK themes as:

- Place-based landscape knowledge.
- Water use and management.
- Water values, which align with those of Berkes and Houde, while applying a TWK perspective, as shown in Table 1.

2.2 Stage 2 – the Penrose tribar traditional work knowledge framework

The second stage of the research explains the levels and the co-relation amongst the themes, using water as a focus to transform previously established TEK themes into a TWK framework. This is conceptualised and represented through the Penrose tribar framework as shown in Figure 1. A–C are the three vertices of the Penrose tribar, which represent the three themes of TWK identified in this research (Place-based landscape Knowledge; Water Use and Management and water values, respectively). The first two vertices (A and B) at the bottom of the framework have a direct application of managing water resources, whereas C, indicating water values at the apex, representing socio-cultural and respectful relationships with water, based on belief systems. Developing a framework for TWK's fundamental importance is for developing contextual identity rather than "fit for all" strategies.

The research responds to the work of others in this field who acknowledge TEK as an adaptive system with constant feedback and interactions between different themes (Berkes et al., 2000; Gomez-Baggethun and Reyes-García, 2013; Ellis, 2005). This research also uses examples from literature to describe and propose how the framework can be adopted in urban design and planning practices. The vertices of the proposed TWK framework (as seen on the corners of the tribar) and their interconnected relationships are described using examples (collected from research by others) that demonstrate how this framework can function as an aid for the description or categorisation of TWK levels, as well as how professionals are using such knowledge in urban design and planning.

Framework for analysis	TEK themes Berkes (1999)	TEK themes Houde (2007)	TWK themes (this paper)	Key component
	Direct application to water resource management			
Knowledge	1. Knowledge	1. Factual observations	A. Place-based landscape knowledge	• Water sources • Vegetation • Argo-ecology
Practice	2. Management	2. Management 3. Past and current uses	B. Water use and management	• Age-old water infrastructure • Surface water resource • Harvesting rainwater
	In-direct application to water resource management			
	Social institutions	4. Ethics and values 5. Culture and identity	C. Water values	• Meaning of water • Socio-ecological and socio-cultural relation
Belief	World view	6. Cosmology		• Belief system

Table 1. Adaptation of traditional ecological knowledge (TEK) classifications systems

2.3 Stage 3: identification of challenges and opportunities

Western classifications of the natural world, notably those considering land and water as separate entities (Jackson, 2005), contradict TWK's holistic approach of "accumulated experiences, wisdom and know-how unique to cultures, societies and communities of people living in an intimate relationship of balance and harmony" (Haverkort and Reijntjes, 2010, p. 19). This viewpoint underlines the philosophical concept of holism, which retains that natural systems and their elements are intimately interconnected and should be viewed as a whole or more than an entire unit, not in disparate segments (Houde, 2007; Dudgeon and Berkes, 2003). It is difficult to compartmentalise TWK in the way that scientific knowledge is traditionally presented as this may mislead its meaning and disempower the users who are using a holistic approach. The last stage of this research paper discusses the challenges and opportunities of incorporating TWK into the typical western-based knowledge system, to contribute to better flood resilience.

3. Discussion on traditional water knowledge themes

3.1 Vertex A: Place-based landscape knowledge

Place often refers to the interrelationship of humans, animals, plants, animals and the physical environment with the indigenous community (Berkes, 1999; Berkes et al., 2000; Ellis, 2005). This thematic category includes local empirical knowledge of water relating to its place or other components of the landscape (Berkes, 1999) and the relationship that occurs between water and its surrounding biophysical environment (Houde, 2007), through a collection of generalised observations conducted over a prolonged period and supported by accounts of traditional knowledge holders (Usher, 2000). This knowledge may vary amongst individuals, particularly for specialised activities (Usher, 2000), for example, the knowledge of a person managing water resources for farming will differ from another's knowledge of a water ecosystem for fishing. TWKs that are based on knowledge acquired from the relationship with geographical locations have been demonstrated to provide insights on natural historical knowledge of local places that contribute to improved decision- making skills in environmental management (Berkes et al., 2000; Gomez-Baggethun et al., 2012).

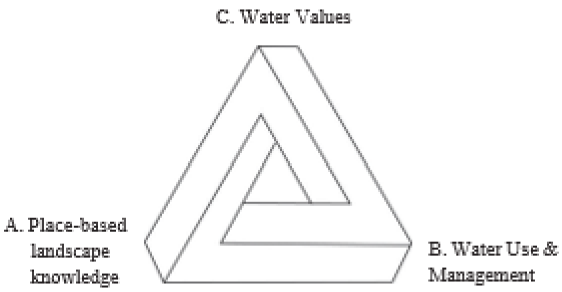

Figure 1. Penrose tribar framework for traditional water knowledge

Traditional knowledge of a specific environment lived and worked upon by successive generations that have typically tried to improve and preserve the ecological health of the place is extremely valuable, and this knowledge of place has proven a reliable and efficient (McGregor, 2014) contribution to water management planning (Wilson, 2014; Caponetti and Ripa, 2017; Finn and Jackson, 2011; Gautam, 2014). For example, the place- based landscape knowledge of local women in Mexico provided them the ability to choose the best water sources if some were getting used or rendered useless by pollution or dry conditions (Kernecker et al., 2017). Similarly, farmers of flood-prone areas in Bangladesh adopted indigenous floating agriculture for sustaining their lives and livelihoods, as well as better utilisation of long-term flood water (Chowdhury and Moore, 2017). Similarly, native vegetation in water-shedding landscapes can contribute in reducing flood risk and soil erosion for local communities and play an important role in setting water resources and retaining landscape topography (Mavhura et al., 2013; Bwambale et al., 2018; Lennon et al., 2014), as well as protecting mountainsides descending to rivers, which has been shown to ensure slope stability and prevent freshwater contamination (Kernecker et al., 2017).

In the Asian context, rice-fish farming is a unique ecological symbiosis, that introduced traditional water distribution management – combining watercourse and topographical characteristics with a unique social structure (Thaitakoo et al., 2013; Gao et al., 2015; Chen et al., 2014; Shannon, 2013). Traditional agro-knowledge inspires sustainable ecological solutions to present-day environmental problems (Martin et al., 2010). Influenced by traditional mulberry dike-fish pond, a 2014 project proposed a modified pond-land terrace system to conserve the shoreline and ecosystem services of the three gorges reservoir shorelines of China (Chen et al., 2014). With a functional arrangement of upstream water retention ponds, central vegetation areas and a downstream reservoir lake, the model was used to develop design solutions for Hanfeng lake, the second-largest urban park in China. The design promoted the combined values of traditional land-water management experiences, cultural practices, community participation and modern ecological analysis against the rapid urbanisation and growing complexity of environmental problems (Chen et al., 2014).

3.2 Vertex B: Water use and management

The second level of the TWK framework highlights age-old practices, tools and techniques related to basic knowledge of water. Traditional beliefs to ensure water availability for all living beings have been found to generate optimum use of water and guide locals to adopt different tools and techniques to store and conserve this natural resource (Ayeni et al., 2014; Wilson et al., 2019; Gautam, 2014). Decentralised and low-tech traditional knowledge based on the understanding of water dynamics led to the efficient use of periodic watercourses, storing of monsoon rains to be used in dry seasons, which are still relevant to the current challenges of water use, management and developing strategies adapted to deal with flooding and enhancing freshwater availability in modern cities (Pandey et al., 2003; Bhattacharya, 2015; Shannon, 2013; Molden and Meehan, 2018; Shrestha and Maharjan, 2016; Thaitakoo et al., 2013).

Rainwater harvesting is an ancient method to stimulate, accumulate, store and preserve local surface rainwater run-off for future productive use (Bhattacharya, 2015). Another evidence of TWK adaptation to current flood management includes research by Martin et al. (2010) who explains how modern cities in the US are using classic Maya civilisation water management techniques to store and reuse stormwater. Water- conservation approach of TWK management systems offers the minimisation of water loss and maximises the benefit of using surface and recharging groundwater (Ayeni et al., 2014). Re-investigation of traditional water infrastructures, such as Qants in Iran (Manuel et al., 2017) and Aflaj in Oman (Remmington, 2017) (both of these tap into natural water tables and use gravity to channel water underground), as well as dhunge dhara in Nepal (these are ancient water stone spout infrastructures that tap interconnected networks of natural water surface sources and aquifers) (Gautam, 2014; Molden and Meehan, 2018), may play a crucial role in promoting sustainable water use and can be considered as alternative socio-technical designs for urban development (Molden and Meehan, 2018; Shrestha and Maharjan, 2016).

Water can be valued as a place for social interactions and social cohesion, building the communal identity that can keep the water landscape active for the city (Buurman and Padawangi, 2017). Historically, “cut and fill” is a well-known traditional technique in low- lying regions of South and South-East Asia to ensure elevated living, through digging adjacent land that, in turn, creates in ponds or tanks (Novotny et al., 2010; Shannon, 2008). Such ponds, tanks and lagoons are the main source for storing excess wet season rainwater in tropical regions (Ness and Asad, 2017; Mowla, 2013; Yu et al., 2008). These places act as a productive landscape for domestic rearing of ducks, fish and water-based vegetation in many developing countries (Ayeni et al., 2014) and also work as social space as people gather regularly for washing, bathing and collecting drinking water (Ahmed, 2017). Using such TWK, landscape architect Konjian Yu designed a 34-hectare urban park in China, with a pond and dyke system across the edge of the site. Ponds collect stormwater from surrounding dense urban areas and use it in wetlands with native vegetation after filtration. Stormwater, which was once considered a source of flooding is managed into an environmentally aesthetic public space for city dwellers while serving different eco-systems (Yu, 2017; Saunders, 2013).

3.3 Vertex C: Water value

The concept of value is interpreted as something that has worth or significance, is of interest or is of concern (Jackson, 2006; Wilson et al., 2019). Water is valued in one way as part of economic systems as it works as a resource and productive activity for human well-being, as well as having a value derived from its social ties to the place in the natural and cultural world (Orlove and Caton, 2010). Water values proposed in this TWK framework relate to the expression of appropriate attitudes (showing respect towards water systems) (Wilson et al., 2019); the value is given to environmental ethics (Berkes, 1999); the religious or socio- cultural attitudes towards the environment (Houde, 2007), as well as organisation of facts and actions in connection with belief systems (Wenzel, 2004). This vertex is the process of "social memory, creativity and learning" (Berkes, 2012, p. 18), which includes claims of importance about where things stand in the present or should be for the future for the environmental benefit (Usher, 2000).

Traditional societies highly value water as a "life-giving" force, regulated by certain duties and responsibilities (Jackson, 2005; McGregor, 2008, p. 27; Wilson et al., 2019), where people have substantial involvement in the management of water resources arising from customary socio-ecological relationships, in which water is an extremely valued component or estate (Jackson, 2005). In such socio-ecological relationships, indigenous people consider that their acts can affect water systems – negative activities might stop water flow in the river and disturb the movement of aquatic animals (Finn and Jackson, 2011). On the flip side, culturally appropriate actions, such as maintaining cultural lore, visiting sacred sites, undertaking "water dreaming" (Maclean and Inc, 2015, p. 149) and "mother earth water walk" (McGregor, 2008, p. 28), are considered to bring assurance of freshwater availability and healthy water eco-system.

Cultural cosmology plays an important role in the lives of people who live in distinct environments, as they build and vigorously interpret their experiences and knowledge. The interrelation between cosmology and ecology reverberates in many ancient landscapes as a continuous cycle maintaining sustainable co-existence throughout the world (Watson, 2013b). For example, Watson has explained how cosmology and ecology can coincide and be experienced by practicing water urbanism to conserve the cultural landscape of Bali. To preserve 19,500 hectares of sacred rice terraces (an ancient agrarian eco-system) as a part of the conservation project of Tri Kita Kirana Cultural Landscape of Subaks and Water Temples, A retrofit with bio-cultural restoration and educational programmes, across water- based planning was designed. Ecological watershed cleaning strategies and psychological cooling responses are combined in this approach to protect the ancient rice terraces, as well as intensify the spiritual responses from tourists. Vertical wetlands are introduced to remove fertilisers and effluent from agricultural lands. In addition, water harvesting and cleansing techniques combined with wind tunnelling are proposed to increase the amount of water particles in the air; thus, the visitors can feel the cool environs through evaporation (Watson, 2013b, 2013a).

4. Challenges and opportunities

"Tradition" has been a controversial term for researchers, as many consider it as old and outdated and is not compatible in the modern world (Berkes, 2012). In urban design, learning traditional approaches was – until recently – only considered as "native" and "rural" – different from modernity (Molden and Meehan, 2018, p. 766). Post-colonial criticism explained that "universalism" was the notion of urban modernity, where modern cities of the global north were always idealised as "civilised" and "dynamic". In contrast, cities of the global south are considered as "troubled by tradition: as old, backward, repetitive, atemporal and irrational" (p. 766), which remain unexplored, divergence from visions, ideals for modern urban growth (Molden and Meehan, 2018). Western knowledge-based education systems promoted the idea of keeping the tradition as an ontological marker, which is different from modernity, whereas different ways of knowing amongst professionals and traditional people considered as one of the major barriers of accepting TWK in the urban planning decision-making process (Molden and Meehan, 2018; Nguyen and Ross, 2017; Bussey et al., 2015). Moreover, a lack of recognition has been found to demotivate the knowledge holder to share their knowledge in the context of water management issues (von der Porten et al., 2016). However, incorporating TWK in urban flood issues can work as a platform for knowledge-sharing and relationship-building amongst the local people and the scientific community has been identified by many scholars (Bussey et al., 2015; Escott et al., 2015). It has also mentioned that being the ultimate user, local people can find themselves more attached to the education system and experience self-awareness about their surrounding environment (Escott et al., 2015; von der Porten et al., 2016).

Poor institutional frameworks, bad governance and misuse of power practice are some challenges that are linked with water use and management (Escott et al., 2015; Nguyen and Ross, 2017; von der Porten et al., 2016). Conventional urban planning and practices explain water as a resource for human explorations, developing rules and regulations created by professional specialists from a central bureaucracy and administered by representatives

who are not the resource users (Berkes et al., 2000). Ross et al. (2011) argue that bureaucratic arrangements and government structures may be difficult for local people to negotiate. In contrast, traditional knowledge systems assume that nature cannot be controlled, uncertainty is characteristic of all ecosystems and the unpredictability of natural hazards is part of life. Interdisciplinary research explains how TEK practices around the world hold great potential to benefit society as more nature-oriented sustainable solutions are sought (Martin et al., 2010; von der Porten et al., 2016) and helps protect surface water resources for better flood adaptation on the urban built environment.

Water values have faced a significant challenge where the different views of traditional people are not accepted in the formal planning process (Berkes et al., 2000; Houde, 2007). Additionally, cultural change has become a significant challenge to the incorporation of TWK in the urban planning process. Escott et al. (2015) argue that cultural practices relevant to TWK are difficult to fit with modern-day water management systems. Besides, it is often difficult to identify the appropriate knowledge holder of TWK to use the information (Yli-Pelkonen and Kohl, 2005). However, Escott et al. (2015) argue that incorporating TWK in the present-day planning process has the potential to give value to local people as stakeholders and appreciate their participation in the decision-making process. Active participation of appropriate knowledge holders can help to improve the socio-economic condition of the locals and create an identity with the appropriate cultural landscape (Schwann, 2018).

5. Conclusion

This paper has reviewed the ways in which different researchers have conceptualised TEK that allow for the identification of the three vertices of TWK, each of which is an important dimension of to consider in building flood resilience. It has identified some of the examples that are already practice in urban design and planning as flood adaptive strategies, as well as suggestions that have been made to involve local people. This research paper has also pointed out the challenges and opportunities posted by each vertex of TWK to integrate it with the present practice of urban design and planning.

Evidence of TWK provides crucial insights into distinct complex attributes that cannot be observed in a single study and allow for the identification of a framework. Lessons learned from TWK may be characterised through a resilience point of view, such as:

- Keep options open to minimise risk through ensuring diverse use of water resources for lives and livelihood.
- Awareness of existing or/and past traditional water infrastructures and surface water sources.
- Facilitating multipurpose use of surface water resources in urban context.
- Paying attention to local adaptation techniques that can be carried out through practicing rules that are culturally crafted and socially imposed by the local users.

In the face of today's environmental degradation around the globe, especially in the context of developing countries, this proposed framework could be beneficial to explore the knowledge and values of local people towards their environment and, in turn, this documentation helps the urban planners, scientific researchers and landscape designers to improve the water management and build flood resiliency in urban areas, particularly when applied using an appropriate framework.

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