Blanca Fernandez Milan

Water security in an urbanized world

an equity perspective

Water security in an urbanized world: An equity perspective

Blanca Fernandez Milan[1,2,*]

Abstract

Ensure access to water and sanitation for all is one of the Sustainable Development Goals (SDGs) recently recognized at the international community. The combination of natural constraints, population forecasts and climate change threat this and other SDGs closely related. In cities, inequalities in water security become more explicit as complexity in water management given by institutional and market barriers increases. This looks at the threats to ensuring access to water in cities for different world regions and reviews recent literature on water governance and sustainable water management to identify drivers and barriers to just burdens on urban water security. Intrinsic factors related to individual characteristics influence the distribution of water in cities to a certain extent. The relevance of extrinsic factors such as governance structures and pricing schemes will increase in parallel to the forecasted water scarcity. In the discussion we group different measures into three lines of action: efficiency improvement, water democratization and holistic approaches in water governance. We call for further interdisciplinary between the fields of urban water governance and urban hydrology to address the increasing challenges of domestic water allocation under stronger equity objectives.

Keywords: urban water; equity; Sustainable Development Goals; water governance.

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1. Introduction

The United Nations (UN) General Assembly formally adopted the Sustainable Development Goals (SDGs) to mark the path for a continued uniform development effort on a global level, leaving the Millennium Development Goals (MDG) behind. They consist on a set of 17 goals expected to shape political policy worldwide for next 15 years. The 6th SDG refers to clean, accessible water for all. The right to water security entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for domestic uses (United Nations 2015b). Although access to safe water was reduced in many countries, this was often at the extent of an increase in disparities (Lu, Ocampo-Raeder, and Crow 2014; Roth, Boelens, and Zwarteveen 2005; Soares et al. 2002; World Health Organization and UNICEF 2012). Besides, the MDG target to improve basic sanitation, such as access to latrines and hygienic waste collection is one of the MDGs that is most off-track (World Health Organization and UNICEF 2012). Responsibility is placed upon public authorities to ensure no discrimination among their citizens (Cook and Bakker 2012; UN Economic and Social Council 2003), but the practical implementation depends on multiple factors at different regional scales. Together, natural constraints, national laws and local customs define the reality of water security (Niemczynowicz 1999; Patrick, Syme, and Horwitz 2014; Roth, Boelens, and Zwarteveen 2005).

These observations yield to a stronger focus on justice and equity when it comes to water accessibility in the proposed 6th SDG. Moreover, it closely interacts with other SDGs, particularly in cities. Water scarcity, poor water quality and inadequate sanitation negatively impact food security (SDG 12), livelihood choices (SDG 11), water-dependent ecosystems (SDGs 14,15) and educational and gender opportunities for poor families across the world (SDGs 6,10&16) (Revi et al. 2014). Drought will afflict some of the world's poorest countries, worsening hunger and malnutrition (SDGs 1,2&3) (see Figure 1) (IPCC 2014).

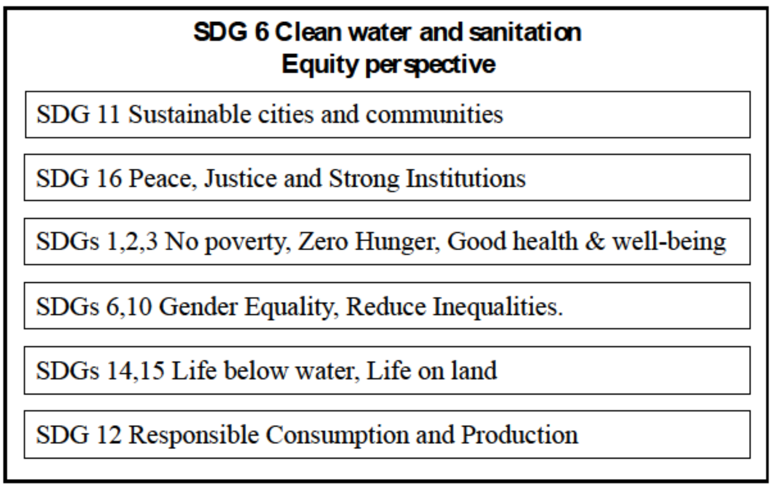

Figure 1 Relationship between 6th SDG and other SDGs relating to equity in urban water.

At the same time, population prospects highlight the importance of urban contexts in the future, with more than 70% population living in cites by 2050 (United Nations 2015a). The 6th SDG will find enormous challenges in future urban developments, where physical and financial limitations to water resources are spatially explicit (Mehta 2014; Vairavamoorthy, Gorantiwar, and Pathirana 2008; Barbier and Chaudhry 2014). Drinking and sanitation water will compete with agricultural demands under circumstances of scarcity due to depleted aquifers and environmental pollution (Pahl-Wostl 2015; Revi et al. 2014). Consequently, new low-income suburbs, often second priority for local water management agencies, will struggle with water security, being both a cause and consequence of their socioeconomic level (Barbier and Chaudhry 2014). Managing water resources sustainably and ensuring human water security is one of the most pressing environmental challenges of the 21st century.

This paper provides valuable insights on the factors influencing equity in urban water security, with due attention to low income groups. First, we look at the upcoming challenges related to water security in cities for different world regions within the SDGs timeframe. We review literature on urban hydrology, water management and governance to identify influencing factors on water distribution among people in cities. We then discuss approaches in reducing water inequities and their efficiency, and finally suggest several key areas for action and research to ensure equalitarian domestic water provision in an urbanized world.

2. Urban water threats

We first look at figures on urban water accessibility and urbanization prospects to have an idea on future threats for different world regions. Urban population growth refers to the per cent change in the period 2015-2030 (United Nations 2015a). Access to an improved water source refers to the percentage of urban population using an improved drinking water source[3]. Access to improved sanitation facilities refers to the percentage of the urban population using improved sanitation facilities, which makes it likely to ensure hygienic separation of human excreta from human contact[4] (World Health Organization and UNICEF 2015). Domestic fresh water withdraw is the municipal water withdrawal as % of total withdrawal (%) (World Bank 2015). Data is from 2013.

We also compare blue domestic WF and water availability to look at future burdens on water ecosystems. Blue WF refers to the amount of surface water and

[3] Improved drinking water source includes piped water on premises (piped household water connection located inside the user's dwelling, plot or yard), and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection) (World Health Organization and UNICEF 2015).

[4] Improved sanitation facilities include flush/pour flush (to piped sewer system, septic tank, pit latrine), ventilated improved pit (VIP) latrine, pit latrine with slab, and composting toilet (World Health Organization and UNICEF 2015).

groundwater required (evaporated or used directly) to make a product (Hoekstra and Mekonnen 2012; Mekonnen and Hoekstra 2011). Domestic water relates to the standard of living and lifestyle choices of the country's residents (Hoekstra and Mekonnen 2012; Mekonnen and Hoekstra 2011). We use the latest data available; an average of the period 1995-2006 suited to making regional comparisons. Water stress measures total annual water withdrawals from domestic use expressed as a percentage of the total annual available blue water. Higher values indicate more competition among users[5] (Luo, Young, and Reig 2015). We use figures on the projected future country-level water stress for 2030 under a middle optimistic scenario[6]. We also compare the blue WF with the World Health Organization (WHO) minimum of 7.5 litres per capita per day[7].

Figure 2 provides the following insights: higher increase in future domestic water demand due to urban population growth will happen in countries where:

a) They show today´s lower performance in the 6th SDG (both for clean water and sanitation) (see Figure 2a, b).

c) They have limited financial resources (low and middle income countries) (see Figure 2a,b).

b) Accessibility to domestic water drastically affects fresh water withdraw (see Figure 2c).

Countries from the Sub-Saharan Africa, Middle East and North Africa will face the greatest challenge on providing urban water facilities to more population. Cities from Europe, Central Asia and North America with high urban dynamics draw from better levels of accessibility to urban water facilities. Countries with strong link between accessibility to domestic water and freshwater withdraw will face competitiveness issues with other uses (e.g. agriculture).

[5] Water stress scores and values: [0-1) Low (<10%); [1-2) Low to medium (10-20%); [2-3) Medium to high (20-40%); [3-4) High (40-80%); [4-5] Extremely high (>80%)(Luo, Young, and Reig 2015).

[6] Three possible scenarios: business-as-usual (BAU), pessimistic, and optimistic.

[7] 7,5 litres per person is the water needs that represents a tolerable level of risk. It does not account for health and well-being-related demands outside normal domestic use –e.g.- excluded: water use in health care facilities, food production, economic activity or amenity use- (Bartram and Howard 2003; UNESCO and WWAP 2012; WHO 2011).

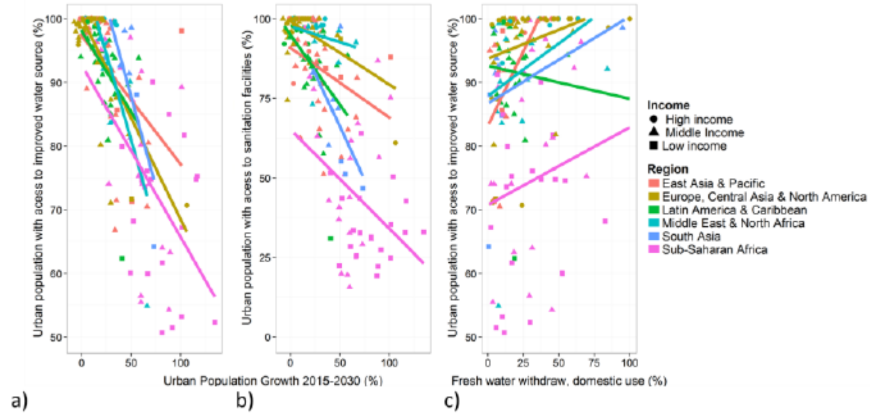

Figure 2 a) b) Urban population growth rates and access to improved water source and sanitation facilities; c) Fresh water withdraw due to domestic use and access to improved water (sample=182 countries; source: United Nations (2015); World Health Organization & UNICEF (2015)).

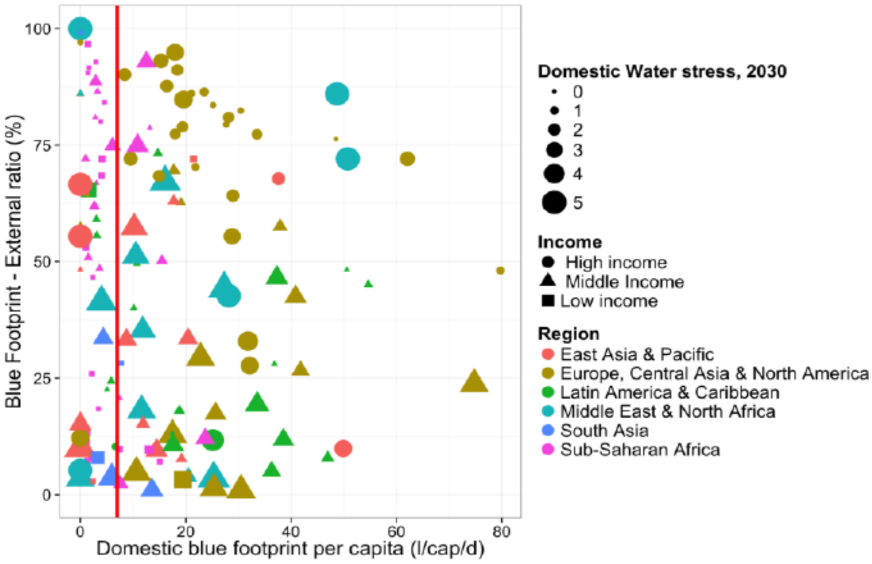

Figure 3 Threats on urban domestic water: water footprints, dependencies and forecasted water stress; red line represents WHO minimum (7,5 litre) (sample=154 countries; source: (Luo, Young, and Reig 2015; Mekonnen and Hoekstra 2011; World Bank 2015; World Health Organization and UNICEF 2015)).

Figure 3 shows that equity challenges in water security may be driven by different factors and thus influence countries differently. Countries with external water dependency in water scarce regions will face problems in keeping current water demands constant. But more challenges are ahead those countries that in addition will face an increase in water demand per capita. This could be due to a) increase in urban population and/or b) increase in per capita consumption following political mandates (e.g. the 6^{th} SDG). More than one third of the total sample is still below the minimum water access stipulated by the WHO. From these, those from Sub-Saharan Africa are highly dependent on external sources of water, which increases their vulnerability to water stress. In other words, multitude factors will increase water scarcity in cities, which consequently will affect equity in water distribution –e.g. skyrocketed prices due to large demand increase-.

Urban water management will embrace enormous challenges driven by insurmountable competition among different water demands. Available water from natural ecosystems will be jeopardised by climate change and human overuse. On the one hand, population prospects augur not only an enormous increase in human demand for water, but also great changes on the distribution to different water uses. Water competitiveness between industry, agriculture and domestic use will increase, causing changes in municipal water resources. On the other, climate change will exacerbate water scarcity, especially in regions where this resource is already limited (Hoekstra et al. 2012). The combination of these dynamics will multiply the equity effects of domestic water management, especially considering that most population growth will occur in cities not yet built. Ensuring water security under these conditions will increase the dependency on external water sources and/or the water stress depending on the country.

The global dimension of water consumption and pollution is given by the fact that several countries heavily rely on foreign water resources and that many countries have significant impacts on water consumption and pollution elsewhere. Technological and infrastructure betterments enhance the efficiency of urban water management. But decisions at the managerial level will definitely be fundamental in in achieving the 6^{th} SDG.

3. Inequalities in urban water security

Defining and ensuring water equity among populations is highly contested. First, ambiguities in the legal terms of equity and water security in international and national legal frameworks are compounded by the lack of enforcement mechanisms ensuring the existence of the principles agreed-upon (Sallam 2014; Barbier and Chaudhry 2014). Even the SGDs lack in regulatory specifications (United Nations 2015b). Second, different dynamics explain water inequalities at the global, regional and local level (Hoekstra and Mekonnen 2012; Lu, Ocampo-Raeder, and Crow 2014). We focus on local challenges but with the regional settings in mind. Thirdly, a wide variety of definitions and analytical approaches to water security across disciplines indicate its complexity (Cook and Bakker 2012). Data on drinking water and sanitation coverage may indicate distances to water sources, overlooking the reality given by affordability, reliability, quality and quantity (Smiley 2013; Euzen and Morehouse 2011).

Equity in water security is affected by climatic and hydrological conditions, population growth, urban migration, increased per-capita water use, pollution and over-abstraction of groundwater, among others (Kujinga et al. 2014). Urbanization itself deteriorates water shortage and increases water total and per capita water demand having direct equity implications (Chen and Yang 2009; Kujinga et al. 2014; Kiriscioglu, Hassenzahl, and Turan 2013). But inequities can sometimes attributed to failures in governance rather than the resource base itself (Pahl-Wostl 2015). Decisions lack in just and equalitarian approaches, especially in developing countries (Patrick, Syme, and Horwitz 2014; Sahin, Stewart, and Porter 2014). We review the issue of inequities in water security looking at intrinsic and extrinsic factors.

3.1 Intrinsic factors

Availability of potable and accessibility to water bodies stratifies among socioeconomic factors (Nogueira et al. 2005; Ruijs, Zimmermann, and van den Berg 2008; Sampson et al. 2013; Vörösmarty et al. 2005). Water accessibility, affordability, quality and quantity all vary greatly with income (Awad 2012; Ruijs, Zimmermann, and van den Berg 2008; Sampson et al. 2013)(Awad 2012). Water usage increases with income level especially in urban areas, as domestic use for food preparation, personal hygiene and household cleaning increases (Sallam 2014; Justes, Barberán, and Farizo 2014). Low incomers spend up to 4.7% of their income on water, whereas richer people typically pay no more than 0.5% (Ruijs, Zimmermann, and van den Berg 2008). Women, more vulnerable to water scarcity than men, are hindered by their social roles and position (Figueiredo and Perkins 2013) and have a secondary role in the participation of water governance and decision making, especially in settlements from developing countries (Das 2014). Ecosystem´s value perception and water conservation also varies between populations. Social, demographic and cultural factors influence attitudes and behaviours (Garcia et al. 2013; Justes, Barberán, and Farizo 2014). Some groups perceive ecological impacts to water bodies more intensely, but they care less about equity issues (Kiriscioglu, Hassenzahl, and Turan 2013). In water scarce communities urban bodies are extremely valuable (Abbott and Allen Klaiber 2013).

3.2 Extrinsic factors

3.2.1 Settlement characteristics and climate change

Population growth and rapid urbanization is a major challenge for the human right to water. Rapidly growing non-agricultural demands together with declining water quality and limited water quantity cannot be followed by basic water service provision in complex sub and peri-urban areas (Douglas et al. 2008; Hellberg 2014; Jimenez-Redal, Parker, and Jeffrey 2014; Jimenez-Redal, Parker, and Jeffrey 2014; Vörösmarty et al. 2005). Physical and environmental conditions such as urban form, climate, and hydrology also influence accessibility distributions. In sprawled settlements economies of density get lost and may provoke unequal distribution of water services (K. Bakker et al. 2008; Cook and Bakker 2012; García-Sánchez 2006). In highly dense ones, water pollution challenges clean access to water (Zgheib, Moilleron, and Chebbo 2012).

Climate change will threaten numerous SDG´s, and water in particular. Scenarios predict more frequent and severe heat waves in drought-sensitive locations that will be accompanied by long drought periods (IPCC 2014; Meehl and Tebaldi 2004; Vautard et al. 2013; Vörösmarty et al. 2005). World minorities and marginalized will be the most affected from new water distributions under different climate change scenarios (Figueiredo and Perkins 2013; IPCC 2014). Glacial retreat for example will increase competition between urban and rural water uses, affecting poor urban neighbourhoods the most (Lynch 2012).

3.2.2 Institutional failures

Governance structures play a key role in how water is distributed among population. Many problems and barriers are due to institutional failures rather than the resource base itself (Pahl-Wostl 2015; Rockstrom 2013; Sibly and Tooth 2014).

First, legal pluralism at different regulatory levels influence the effective implementation of water rights (Obani and Gupta 2014). The declining role of international water programs decreases awareness of low-income water issues and the financial resources reserved to these programs (Wescoat Jr, Headington, and Theobald 2007). Second, investments in water and sanitation infrastructure do not account for the total costs of the projects and avoid sustainability practices; very much relevant for lifestyles and regional social values (Ioris 2012; Wilder and Romero Lankao 2006). They tend to produce overexploitation and contamination, unequal access to water, and fragmented and weak institutional settings (K. Bakker et al. 2008; Herrera and Post 2014; Herrera and Post 2014; Romero Lankao 2011; Wilder and Romero Lankao 2006). These harmful practices have affected inequalities particularly in the African and Asian context (K. Bakker 2007; K. Bakker et al. 2008; Bowonder and Chettri 1984; Shah 1989; Smiley 2013; Truelove 2011).

The distribution and regulation of different water uses also contributes to water inequalities. In China and India, groundwater extraction from agricultural fields to be use in cities supply, de facto creates private property rights for the farmers who sell water and create imbalances in the distribution of the resource (Cai 2008; Ruet, Gambiez, and Lacour 2007). Low and mid-income countries show significantly higher water use for tourist than for local population compared to developed countries (Becken 2014). In Zanzibar, luxury resorts use up to 2000 litres of water per tourist per day, while local people use only 30 litres (Nunn 2007). Lack of managerial leadership –e.g. local governors give priority to the tourist faculties (Becken 2014; Cole 2012; Hazou, 2008; Tourism Concern 2009; Zagt 2014)-, and awareness both by local and tourist groups (Cole 2012; Page, Essex, and Causevic 2014) create inequalities and threaten local's water supply (Goodwin 2007). In Kerala (India), the tourism industry buys or steals water from local communities and contaminates water with chemicals (Hickman 2007). -. Embodied water[8] also contributes to the imbalance between tourists and locals (Gössling 2015).

Dichotomies in land and water management also influences (Evans et al. 2003). Inexistent or poor environmental quality assessments and monitoring hampers transparency and creates inequalities specially in places where environmental damages abound (Lundin and Morrison 2002; Mehta 2014; Mehta et al. 2014). Public authorities strategically define different contamination levels for different locations to avoid such problems (Christenson et al. 2014; Smiley 2013). Lack of clear task assignment and unplanned intermittent water supply to face water scarcity creates chaos and water spatial inequalities (Lee 2000; Vairavamoorthy, Gorantiwar, and Pathirana 2008).

Finally, water pricing policies fail to accomplish their strategic objectives, especially in developing countries. They generate insufficient revenues to ensure that utilities can recover their financial costs. They cannot send the correct economic signals to households to include the long-term viability of the resource and fail to help poor households, many of whom are not connected to the piped distribution system (Abbott and Allen Klaiber 2013; Whittington 2003). Consultants, international organizations and investors continue to recommend increasing block and rate tariffs (IBT and IRTs), but these practices are neither fair nor efficient (Bithas 2008; Boland and Whittington 1998; Chen and Yang 2009; Dahan and Nisan 2007; Foster and Yepes 2006). They price commodities at a low initial rate up to a specified volume of use (Foster and Yepes 2006; Sibly and Tooth 2014). The rationale is that it results in higher marginal prices to the customer and thus higher average prices for higher-income households and subsidized services to the poor. But non distinction is made on household size and large households, also likely to be poor given the negative correlation between income and household size, are charged a relative higher price (Dahan and Nisan 2007; Liu, Savenije, and Xu 2003; Sibly and Tooth 2014). Under water shortages IBTs are not flexible in the face of changing availability of water (Sibly 2006), and fail to place the welfare burden of conservation on large water users and benefit low- income people (Griffin and Mjelde 2011; Ward and Pulido-Velázquez 2008). Overall, they introduce inefficiency, inequity, complexity, and lack of transparency for no apparent reason.

3.2.3 Water privatisation

The provision of water and sanitation services in the past decades has focused on private sector participation, mainly through Public Private Partnerships (PPPs) and subcontracting. Sufficient evidence demonstrates the failure of Private sector partnerships (PSPs) in supplying households equally. Although the positive record on service and efficiency improvements reaffirms the value of PPPs (Marin 2009), the equity outcomes of such structures are somehow unclear, depending on the stage

[8] Water used in the production of goods somewhere else but consumed in in resorts and other touristic facilities.

of market development (K. J. Bakker 2003; Castro 2007; Jepson 2014). Different prices of water services apply depending on the nature of the provider, lower in the case of town councils (García-Valiñas, González-Gómez, and Picazo-Tadeo 2013). Also unclear is the possibility to have equity under monopolistic markets, independently of their private or public nature (K. Bakker et al. 2008).

In developing countries, market-centred governance using a pro-poor rhetoric has driven water management since the 1980s. Reforms enhancing the role of corporations and private sectors swept through the water sector. But results are disappointing. They not only did not achieve their pro-poor intentions, but also increased water inequalities (Castro 2007; Herrera and Post 2014; Jepson 2014). Priorities to middle and high-income households (Awad 2012; K. Bakker 2007; Kujinga et al. 2014) together with short-term profit oriented approaches threat the long-term viability of water ecosystems and foster inequalities such as the ones emerging in Latin America, Africa and Asia (Aurélio Peres, Simara Fernandes, and Glazer Peres 2004; K. Bakker 2007; Castro 2007). Private water monopolies may weaken the role of public authorities and citizens and thus, the social and ecological aspects of water management.

4. Equitable water governance for the urban future

The concept of sustainable water management has increased its popularity in all regions and levels of governance. Complex links between poverty and water security challenge nations striving for universal access to water (Patrick, Syme, and Horwitz 2014; Wescoat Jr, Headington, and Theobald 2007). The underestimation of institutional barriers -including normative values, risk perception, lock-in effects of legal measures, stakeholder's plurality of preferences, and investment requirements- hampers the process of transforming agendas (Marlow et al. 2013). This creates a rushing need to include justice in water allocation decision both at regional and local levels of governance (Patrick, Syme, and Horwitz 2014). We review the literature on water governance and sustainable water management focusing on cities and domestic water. We group different measures into three lines of action: efficiency improvement, water democratization and holistic approaches in water governance.

4.1 Increase efficiencies

4.1.1 The true costs of domestic water

First, governments should base their decisions on data that gives a true view of the situation. Local documentation (e.g. official documents, reports, neighbourhood white documents), and other secondary data (e.g. household's questionnaires and interviews) help understand the actual circumstances (Cook and Bakker 2012; Mehta 2014; Kolokytha, Mylopoulos, and Mentes 2002). Water footprints (WF) are also useful to look at virtual water flows between production and consumption, and the water appropriation of different water uses (Dumont, Salmoral, and Llamas 2013; Sallam 2014). Quantitative indicators help evaluating the various aspects of social sustainability in water security (Popovic et al. 2014; Luh, Baum, and Bartram 2013; Davidson et al. 2013).

Second, the domestic use of water leads inevitably to pollution. Households must pay the process in which used water is brought again to the environment in the best conditions possible. That is, internalizing in the user prices the externalities (economic and ecological) to avoid overconsumption (Elton 2015). Public authorities should find ways to increase awareness of water scarcity and pollution, which leads to either higher willingness to pay (WTP) or lower consumption patterns. Enhancing the accountability and transparency of sustainability indicators for urban water systems is fundamental. Avoiding subsidies and including payment for environmental services (PES) will reduce water resource degradation rates, specially in medium to large cities (Lee 2000). Although the WTP heterogeneity among population calls for attention to the affordability and distribution issues of a water pricing reforms that includes externalities (Jiang, Jin, and Lin 2011), the full-cost price approach seems to be the most efficient instrument from a sustainable point of view, promoting both social equity and smaller water footprints (Chen and Yang 2009; Lundin and Morrison 2002; Lynch 2012).

Third, every claimed advantage of an IBT can be achieved with a simpler and more efficient tariff design that does not use blocking (Boland and Whittington 1998). For example, an increasing rate tariff based on water consumption per capita (IRT-cap), where the water price depends on two things: total household water consumption and the household size has better equity outcomes, but also simplicity and transparency and economic efficiency (achieve cost recovery) taking the ability to pay of water consumers into account. Water fee percentage -water fees calculated on a per year income- may be another alternative, however they do not account for the water consumption per connection (Liu, Savenije, and Xu 2003). A tariff in which a households' water bill is based on a volumetric charge set equal to marginal cost and a fixed monthly rebate (negative fixed charge), -uniform price with rebate (UPR) – also offers important advantages. It has a smaller probability of inducing economic inefficiency and is more effective at transferring income. It is simple, transparent, easy to implement, appears fair and equitable in most circumstances, and requires less data for design and revenue estimation (Whittington and Boland 2000).

Under water shortages conditions low-income households prefer scarcity-inclusive uniform rates or two-tiered pricing. Temporary drought pricing (TDG) regimes not only lower the frequency and severity of water insecurity events but also reduces the long-run marginal cost of water supply when compared to traditional reactive planning approaches that focus on restrictions to affect demand in scarcity periods (Sahin, Stewart, and Porter 2014). Seasonal water pricing (SWP) determine water prices on meteorological observations based on an ex-post price determination for diminishing excessive fresh water use purposes, thus serving as price signal to water users on resource scarcity. Not knowing ex ante how high their monthly bill is going to be, but aware of the price-setting rule makes consumers change their pattern of behaviour, pushing them towards rationality (Pesic, Jovanovic, and Jovanovic 2013). However SWP induces inequalities based on the WTP of different households. Two-part tariffs may be the better mix. On the one hand, an efficient volumetric rate accounts for the erratic rainfall patterns reflecting the expected availability of water. On the other, the fixed charge satisfies the residual revenue requirement and serves as a mechanism to address equity concerns (Sibly 2006). Regardless of the pricing type, metered connexions ensure the implementation of pricing policies (Whittington 2003).

Finally, it is also important to offer flexible payment options to the urban poor, especially in new urbanized areas. Even though residents perceive connection fees very expensive, their WTP increases if payments are spread in time. Subsidies to upfront connection costs, not volumetric water use can both bring utility services within reach of low-income households and expand the customer base for utility service providers (Jimenez-Redal, Parker, and Jeffrey 2014; Whittington 2003). In any case, governments should ensure all households having a water connection if they want it. For example, they could provide public taps as a water source of last resort for the very poor, legalizing water vending and selling by neighbours, and not giving private operators exclusive rights to provide water within a service area (Whittington 2003). A careful evaluation of the differences in the demand curve of the poor and rich consumers should be reflected it in the price policy; it is not enough to know the cost curve –e.g. private taps will improve the access to piped water and consequently increase the use of appliances for the poor consumer- (Moilanen and Schultz 2002).

4.1.2 Water use differentiation

Food preparation, personal hygiene and household cleaning require different water qualities. Understanding the heterogeneity among population on how direct users valuate these different uses helps pricing and managing water resources (Justes, Barberán, and Farizo 2014).

Also, social trust, risk perceptions and public acceptance of different water sources influence the sources used for water supply –e.g. recycled water, desalinated water, tap water and rainwater from tanks- (Justes, Barberán, and Farizo 2014). Policy interventions transfer economic value from one use to another and influence users perception of water value for different uses (Liu, Savenije, and Xu 2003). Higher levels of public trust lowers risk perceptions and enhances public acceptance of mix water sources supply schemes (Ross, Fielding, and Louis 2014). Water attributes and branding makes water more attractive to consumers (Dolnicar, Hurlimann, and Grün 2014). Preferences for the different domestic water uses should be used to price them differently for equity purposes.

4.1.3 Demand management

Shifts from traditional supply to demand management paradigms enhance the use of limited water supplies. Traditional approaches have no future in contexts with limited finance and water resources. Spatially explicit demand models help identifying efficient and equitable allocation strategies (Zeng et al. 2012). Rainwater tanks, infiltration trenches, grassed swales, central basins, and constructed wetlands can be used in housing allotments and subdivisions to reduce blue WFs (Coombes, Argue, and Kuczera 2000; Vairavamoorthy, Gorantiwar, and Pathirana 2008). These strategies depend on settlement characteristics (K. Bakker et al. 2008), and should be promoted with adequate information dissemination and training, and water supply infrastructure and institutional capacity (Manzungu and Machiridza 2005).

4.2 Water democratization

4.2.1 Governance structures

Clear task assignment to particular agents at all levels of responsibility helps institutional outcomes. Although defining a minimum water quantity has limited significance due to the great variations among regions and circumstances (Bartram and Howard 2003; WHO 2011), strong mutual support between different regulatory frameworks minimises dichotomies (Obani and Gupta 2014).

The main focus of urban water services should not be about attracting private investment, but use private operators to improve service quality and efficiency under strict parameters of social equity and ecosystem preservation. This approach fosters a virtuous circle whereby the utility improves its financial situation and gradually becomes able to finance a larger share of its investment needs (Marin 2009). Privatisation complicates the clear differentiation if the regulator and the operator are in the same institution. It is thus recommendable to have institutional and legal differentiation through decentralization to autonomous operators (Lee 2000).

In well-developed markets, partnerships between the public and the private sectors are a valid option to turn around poorly performing water utilities. Although concessions have worked in a few places, contractual arrangements that combine private operation with public financing of investment appear to be the most sustainable option. Including local investors reduces dependencies, risks and enhances social and ecological outcomes compared to international ones (Marin 2009). In any case, governments and donors need to remain heavily engaged in the water sector (Marin 2009).

In developing countries, governments should have various options to tackle the different challenges of water security. The rationale to decentralize and enhance the role of private sector as a tool to enhance equity is clearly contradictory (Castro 2007). Reforms in this direction intends to foster community's influence in decision making process, but the parallel corporatization and privatization process depoliticize the management and have contrary effects in terms of democratic governance (Herrera and Post 2014). Privatization is a legitimate tool for private capital accumulation and for public authorities to transfer the burden of water management to non-state institutions (Ruet, Gambiez, and Lacour 2007). Water cannot be addressed by merely passing over responsibilities along with their complex set of social and environmental problems (Romero Lankao 2011). Besides, resource transfer negotiations have limited transparency conditions. These should include governance mechanisms to promote trust, accountability, and consequently a more efficient and equitable water allocation (Pfaff and Vélez 2012).

Finally, municipalities should have defined and influencing roles, and foster strong and committed civic participation. Responsibilities transfer to local levels of governance may difficult the insulation of water systems in practice (Herrera and Post 2014), but democratization outcomes prevail on general basis. It enhances the discussion among shareholders in terms of priorities, needs etc. which helps establishing policy frameworks adequate for each settlement short and long term need (Lee 2000).

4.2.2 Transparency and public participation

Transparency increases social awareness, understanding of current and future water challenges, and helps gathering community-based knowledge (Smiley 2013). Policy makers should exploit these synergies. For example, users perceive scarcity of common water resources differently and tend to alter altruistic and selfish behaviours depending on the trade-offs between equity and efficiency (D'Exelle, Lecoutere, and Van Campenhout 2012). Communicating decisions of water reallocation to all community levels helps identifying critical barriers to smooth water redistribution, particularly under scarcity conditions (Cai 2008). Using guidelines and network analysis looking at the duration and timings of the supply, pressure at the outlet, and the type of connection required enhances intermittent water distribution systems (Vairavamoorthy, Gorantiwar, and Pathirana 2008). Environmental education and non-governmental organizations also expand the equitable involvement of citizens, raise consciousness and confidence (Figueiredo and Perkins 2013). The role of women is increasingly praise; they possess knowledge on effective social technologies for coping with and adapting to climate change (Figueiredo and Perkins 2013).

The SDG on clean water and sanitation requires a re-democratization of water management. Trade-offs between returns and social equity call for a process of re-regulation (K. J. Bakker 2003), overcoming mismatches between organizational scales, and including marginalized groups in water decision-making processes with new governance practices that strengthen trust among stakeholders and identify common preferences (Hu et al. 2013).

4.3 Holistic water management

The conventional water-resource planning and management focus is on liquid water, or blue water. It serves the needs of engineers involved in water supply and infrastructure projects quite well. However, it represents only one-third of the real freshwater resource (Falkenmark and Rockström 2006; Mekonnen and Hoekstra 2011)[9]. Considering future scarcities, it is necessary to incorporate the rainfall or green water, largely embedded in agricultural products (Falkenmark and Rockström 2006; Hoekstra and Mekonnen 2012). In this context, urban hydrology is gaining relevance (Niemczynowicz 1999; Barbier and Chaudhry 2014). Significant savings in water resources and infrastructure costs can be achieved when applying holistic water management. For example, it is important to use adequate sets of performance indicators suitable for different water uses, considering water availability, planning and operation, as well as complexities of direct versus indirect water consumption (Gössling 2015). Including them in modelling the effect of individual infrastructure projects on urban-peri-urban-rural (Zhang et al. 2014), and land use and land cover models to predicts water demand accounting for storm water runoff enhances efficiency and equity outcome (Evans et al. 2003; Willuweit and O'Sullivan 2013). Such models could also help to develop indexes to measure progressivity (Luh, Baum, and Bartram 2013), and the realization of the SDG.

Climate change will provoke extreme weather events and water-related challenges affecting the marginalized first and worst (Figueiredo and Perkins 2013; IPCC 2014). Traditional water infrastructures will face resilience issues that need to be addressed with decentralised systems enabling institutional, cognitive, normative and regulative dimensional shifts (Ferguson, Frantzeskaki, and Brown 2013). Water alternatives in different scenarios should be considered and consulted through social multi-criteria to all stakeholders (Domènech, March, and Saurí 2013), and path-dependencies in long-term urban infrastructure addressed with new normative transition scenarios through transformative changes in governance structures, a better understanding of system complexities and uncertainties (Ferguson, Frantzeskaki, and Brown 2013).

Equal access to clean drinking water and adequate sanitation and hygiene facilities closely interacts with many of the newly proposed 17 SDGs, and this link becomes starker in urban contexts. The right to water may itself reduce distinctions between different forms of life, and thus inequalities. As water is a finite resource, environmental injustices and rights violations often go hand in hand. It seems valid to apply the global environmental justice approach to the problem of universal access to safe and potable water, especially in rapidly expanding urban areas. The water sector has many features that set it apart from other infrastructure sectors. A careful consideration of these together with context-specific factors is important for

[9] Human water use for food varies from less than 700 m3/person/ year in Sub-Saharan Africa to 1800 m3/person/year in North America, expressed by the differences in calorie intake.

successfully reconcile ostensibly conflicting goals. Global frameworks provide moral imperatives, however it is difficult to bring them down to the practical side at the local level. City planners should aim at redistributing water resources, political power, and participation toward disadvantaged urban populations (Krumholz 2001). In situ applications of human development approaches to urban water challenges beyond utilitarianism (Mehta et al. 2014) based on principles for social and ecological system integrity and interconnectivity, resource efficiency and maintenance, civility and democratic governance, intra- and inter-generational equity, and adaptive capacity (K. Bakker et al. 2008; Larson, Wiek, and Withycombe Keeler 2013) will assist in overcoming future trade-offs. How urban resources, services and functions are governed strongly influence ex-urban, rural and natural areas; acquiring local, national and even global relevance.

5. Conclusion

Water resources for domestic use will face tremendous challenges, especially in the new settlements to come. Our ability to manage these trade-offs and encourage long-term viability will affect numerous SDGs. Demand outstripping supply, unplanned settlements, poor planning, financial mismanagement and lack of robust governance structures exacerbate inequalities in water security. Interconnections across natural and anthropogenic systems, the incorporation of justice, decentralized governance at all levels of decision-making processes, and integrative management approach promoting collaborations and social learning between stakeholders will be required to ensure water security to all. In doing so, urban water integrative approaches could foster good governance practices, and bring promising outcomes to urban sustainability as well as global water resources.

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