Sustain. Water Resour. Manag. (2017) 3:479–489
DOI 10.1007/s40899-017-0117-4

ORIGINAL ARTICLE

Clean water and sanitation for all: interactions with other sustainable development goals

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Received: 5 October 2016 / Accepted: 1 April 2017 / Published online: 6 April 2017

Abstract Access to water and sanitation for all is a part of the recently (September 2015) approved Sustainable Development Goals (SDGs). However, natural constraints, climate change and the increase of population forecasts will challenge this goal and how it interacts with others. In particular, domestic water will compete with additional water demands essential for the achievement of other goals (i.e. SGD2 on zero huger or SDG14 life below water). We assess how future domestic water demand in cities will interact with other SDGs. First, we use an evaluation framework to identify positive and negative relations. We then calculate the required water to meet this demand and compare it with the performance of other water-dependent goals. Our results show that larger increases in domestic water demand will happen in countries underperforming in other water-dependent goals. How urban areas deal with water resources will shape these relations. Crucially, urban water decisions will determine the sustainability of global water resources and, ultimately, the performance of all SDGs.

Keywords Water stress · Urban water · Sustainable development goals · Policy interactions · Water governance

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Introduction

The United Nations (UN) General Assembly formally adopted the Sustainable Development Goals (SDGs) on September 5, 2015 to mark the path for a continued uniform development effort on a global level, replacing the Millennium Development Goals (MDGs) behind. They consist of a set of 17 goals expected to shape the social, economic and environment policy worldwide until 2030. The 6th SDG (SDG6) 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 2015a). Although the MDGs have shown progress in this regard, the target on improving basic sanitation through access to latrines and hygienic waste collection is still off-track (World Health Organization and UNICEF 2012). Furthermore, population forecasts to 9 billion by 2050 indicate that the work is far to be done (World Health Organization and UNICEF 2012). Responsibility lies on local authorities (UN Economic and Social Council 2003; Cook and Bakker 2012), but SDG6 performance and its effects on other SDGs depend on multiple factors at different spatial and time scales. Importantly, natural constraints, laws and local customs define the reality of SDG6 (Roth et al. 2005; Patrick et al. 2014).

Water is a finite resource and higher demand result in water stress, a function of water availability, demand and water quality. These stresses are due to the rising of the human population and per capita water use, growing concentrations of people in urban areas, climate change effects, demands for more irrigation water to increase food production and environmental requirements (environmental flows) for biodiversity and environment protection. While climate change affects water ecosystems and the availability of water resources (Ansuategi et al. 2015), socioeconomic factors increase water demand and deteriorate water bodies (Chen and Yang 2009; Kujinga et al. 2014). Given that the greatest increase in domestic water demand will come from urban areas (United Nations 2015b), urban contexts become extremely relevant not only for the achievement of SDG6, but also how it interacts with other SDGs (IPCC 2014; Revi et al. 2014). Local governments will face physical and financial limitations (Vairavamoorthy et al. 2008; Barbier and Chaudhry 2014; Mehta 2014) while dealing with increasing agricultural and industrial demand. Sustainable water management in cities will impact the overall performance of SDGs. Consequently, SDG6 does not only include targets on domestic water supply, but also on governance and technologically oriented targets (Table 1). Still, interactions between SDG6 and the rest remain unknown.

We fill in this gap by mapping positive and negative interactions between SDG6 and other SDGs. We further calculate SDG6 water requirements and compare it with other water-dependent goals to identify critical relations. "Methodology" describes the methodology used to evaluate this relation. "Results" presents both the quantitative and qualitative results. "Discussion" discusses the results, and highlights crucial factors that should be taken into account for SDG6 to be accomplished in line with other SDGs. "Conclusion" concludes the paper.

Methodology

Mapping interactions

The recently published report on SDGs′ indicators (United Nations Economic and Social Council 2016) presents the final list for consideration by the Statistical Commission. We use the evaluation framework from (Nilsson et al. 2016) to map the interactions between SDG6 and other SDGs by reviewing recent literature on urban water. The framework is a seven-point scale from the most positive (scoring +3) to the most negative (−3) (Table 2). We start with the SDG6 and map out interactions in relation to the remaining 16 SDGs. We use a bottom-up perspective to increase precision, starting from the indicator level, to the target and up to the goal level, using the following considerations: reversibility, directionality, impact level and certainty of the interaction (Nilsson et al. 2016).

Table 1 SDG6: Targets and indicators (United Nations Economic and Social Council 2016)

Target	Indicator
6.1 Achieve universal and equitable access to safe and affordable drinking water for all	6.1.1 Percentage of population using safely managed drinking water services
6.2 Achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 Percentage of population using safely managed sanitation services, including a hand- washing facility with soap and water
6.3 Improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1 Percentage of wastewater safely treated, disaggregated by economic activity 6.3.2 Percentage of bodies of water with good ambient water quality
6.4 Substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Percentage change in water use efficiency over time 6.4.2 Percentage of total available water resources used, taking environmental water requirements into account
6.5 Implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1 Degree of integrated water resources management implementation
6.6 Protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6.6.1 Percentage of change in the extent of water-related ecosystems over time support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
6.a Expand international cooperation and capacity building	6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government coordinated spending plan
6.b Support and strengthen the participation of local communities in improving water and sanitation management	6.b.1 Percentage of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

Table 2 Evaluation criteria: 1. Influence of one SDG on another (Nilsson et al. 2016) and variables for quantitative analysis

Quantitative analysis		
Interaction	Name	Explanation
+3	Indivisible	Inextricability linked to the achievement of another SDG
+2	Reinforcing	Aids the achievement of another SDG
+1	Enabling	Created conditions that further another SDG
0	Consistent	No significant positive or negative interactions
−1	Constraining	Limits options on another SDG
−2	Counteracting	Clashes with another SDG
−3	Cancelling	Makes it impossible to reach another SDG

Qualitative analysis			
Interactions with other SDGs		SDG6: Change in urban domestic water demand (%)	
SDG	Indicator	SDG moderate	SDG ambitious
2	2.1.1 Prevalence of undernourishment (% pop.)	Blue WF: Δ S0–S1 (%)	Blue WF: Δ S0–S2 (%)
2	2.3.2 Cereal yield (kg/ha)		
7	7.1.1 Electricity access (% pop.)		
6	6.3.1 Wastewater treatment (% of anthropogenic wastewater treated)	Grey WF: Δ S0–S1 (%)	Grey WF: Δ S0–S2 (%)
Difference between SDG moderate and ambitious scenario			
Δ S1–S2 blue (%)		Share (%) of total water available for domestic use (blue)	
Δ S1–S2 grey (%)		Share (%) of total water available for domestic use (grey)	

Quantitative evaluation: potential constrains of SDG6 on other SDGs

We explore the potential effects the achievement of targets 6.1 (drinking water) and 6.2 (sanitation facilities) could have on other SDGs. First, comparing urban population change for the SDG period (2015–2030) (United Nations 2015b) with how the targets perform today (World Health Organization and UNICEF 2015) indicates the water and infrastructure requirements. We calculate the urban domestic demand change for the same period,[1] focusing on urban population for two reasons: cities show higher probability to achieve target 6.1 and 6.2 (World Health Organization and UNICEF World Health Organization, UNICEF 2015), and most demand growth will take place in cities (United Nations 2015b). We use the blue and grey water footprints (WF).[2] Blue WF is the amount of surface water and groundwater used for all industrial, domestic and agricultural purposes. Grey WF is the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards, an important figure to estimate wastewater treatment requirements (target 6.3) (Mekonnen and Hoekstra 2011; Hoekstra and Mekonnen 2012).

We develop three demand scenarios:

Scenario 0 (S0): Base scenario—WF of domestic water consumption for urban population in 2015.

Scenario 1 (S1): SDG moderate—WF of domestic water consumption for urban population in 2030. Including all urban population assumes the achievement of target 6.1 in urban areas. However, we use 2015 water footprint per capita.

Scenario 2 (S2): SDG ambitious—Includes the assumption of international standards for per capita blue WF with a minimum of 7.5 l daily per capita.[3] Grey WF increases proportionally.

Required domestic water is expressed as the difference between base scenario with (a) 2030 moderate (S0–S1) and (b) ambitious (S0–S2) scenario. We compare these numbers with today's performance of other water-dependent SDGs such as SDG1 (end poverty), SDG 2 (end hunger),

[1] We assume constant demand for other water uses to focus on the effect SDG6 on other SDGs.

[2] Available data: period 1995–2006.

[3] 7.5 l per person represent a tolerable level of risk. It does not account for health and well- being-related demands outside normal domestic use, excluding water use in health care facilities, food production, economic activity or amenity use (Bartram and Howard 2003; WHO 2011; UNESCO and WWAP 2012).

SDG 3 (ensure healthy lives), SDG4 (ensure quality education), SDG11 (ensure sustainable cities), SDG 14 (conservation of marine ecosystems) and SDG 15 (conservation of terrestrial ecosystems). In this way, we explore potential constrains and report the Pearson correlation coefficient and its statistic significance (p value). We select the most critical interactions arising from the qualitative analysis: SDG2 on zero hunger, SDG7 on electricity for all and target 6.3 on wastewater treatment (Table 2).

Finally, to evaluate the effects of S2 assumptions, we compute the difference between S1 and S2 demands and compare it with present share of domestic water demand required for S2 in terms of total WF of production—water footprint within a nation—to look at domestic water stress in countries where per capita consumption standards are not met.

Results

SDG6 strong interaction with other SDGs

Domestic water for drinking and sanitation is a basic need indivisible from numerous SDGs. We map the main linkages between the SDG6 and other SDGs, starting from the effect of the first one on the others, and also looking at the directionality of the interaction.

Importantly, targets 6.1 and 6.2 on drinking water and sanitation are crucial for the achievement of other SDGs like sustainable cities (SDG11), health and wellbeing (SDG 3)—(Vörösmarty et al. 2005; Douglas et al. 2008; Jimenez-Redal et al. 2014). It also reinforces access to education systems in communities where water provision requires effort and time (SDG4), enhances gender opportunities and reduces water conflicts (SDG16) (IPCC 2014; Revi et al. 2014). Given the water access stratification among people, it also increases equity, very much explained by socioeconomic factors (Vörösmarty et al. 2005; Ruijs et al. 2008; Awad 2012; Sampson et al. 2013).

Competition-driven counteractions (targets 6.1, 6.2 and 6.6)

Conversely, SDG6 requires a great increase in domestic blue and grey WF, affecting other water uses and related SDGs: food security (SDG2), hydropower stations for clean energy (SDG7) and economic water uses (SDGs 8, 9). In the same token, financial requirements for water infrastructure not only foster infrastructure development (SDG9), but also restrict investment in other "long-term" SDGs—e.g. climate action (SDG13). More polluted water also affects natural ecosystems (SDGs 14, 15). However, the total effects depend on two important considerations: if the amount of water required is then treated to avoid contamination (target 6.3) and how this new demand is managed considering other water uses (target 6.5) (Zgheib et al. 2012).

Water ecosystem protection and restoration (target 6.6) has mixed effects on other SDGs. Depending on the context, poverty eradication and hunger are positively or negatively affected. Economic activities and energy production may be constrained or even counteracted (SDGs 7, 8, 9) (Pires 2004; Yoo et al. 2013; Justes et al. 2014), while climate action (SDG13) and ecosystem preservation (SDGs 14, 15) benefit and even depend on this target. Ecosystem protection may also enhance peace and justice in local communities (SDG16)—e.g. through the avoidance of massive tourism—(Pires 2004; Smith et al. 2012; Abbott and Allen Klaiber 2013; Dumont et al. 2013).

Economic and equity considerations (SDGs 8, 9, 10)

SDG6 is indivisible from infrastructure development (SDG9). Still, the question of how to pay the required infrastructure raises new economic and equity concerns (SDG 8, 10). In this context, it is important to build long-term urban infrastructure that address system complexities, uncertainties and inequalities (Ferguson et al. 2013). For example, flexible payment options to the urban poor enhance equity outcomes (Whittington 2003; Jimenez-Redal et al. 2014). Also, as domestic water use leads inevitably to pollution, households should be aware of the costs (and benefits in terms of sanitation and water scarcity). Furthermore, they should be encouraged to reduce their grey WF through progressive systems calibrated according to water amounts and pollution levels. Internalizing externalities (economic and ecological) reduces overconsumption and its related negative effects on other SDGs (Elton 2015).

Indivisibility of SDG6 and a sustainable economy (SDG12)

Interactions depend on the extent to which responsible consumption and production is applied (SDG12). Investments in water and sanitation infrastructure that account for the total costs of the projects (SDG9) and avoid overexploitation and contamination will not harm local lifestyles and regional social values (SDG3) (Wilder and Romero Lankao 2006; Ioris 2012). This could be done through payments for environmental services, which are then invested in interventions that reduce water resource degradation, especially in medium to large cities (Lee 2000). Water use differentiation helps pricing and managing water resources sustainably; food preparation, personal hygiene and household cleaning require different water qualities (Justes et al. 2014). Crucially, strong institutional commitment is required for the sustainable use of water in production and consumption (SDG17) (Bakker et al. 2008; Herrera and Post 2014).

SDG12 is of particular importance in the tourism sector. Low- and mid-income countries show significantly higher water use for tourist than for local population compared to developed countries due to water sports, swimming, and water intense services such as laundry (Nunn 2007; Cole 2012; Becken 2014). In Zanzibar, for example, luxury resorts use up to 2000 l of water per tourist per day, while local people use only 30 l (Nunn 2007). Prioritize water supply to local communities ensures equity in water distributions (SDG10).

Key targets: wastewater treatment (6.3) and integrated water management (6.5)

Most interactions depend on the level of commitment to targets 6.3 and 6.5. Poverty (SDG1), unhealthy settlements (SDGs 3, 11) and natural ecosystem degradation (SDGs 14, 15) are some examples of the negative impacts that could be avoided if these targets are met.

In particular, integrated water management is crucial for dealing with climate change effects on water systems. More frequent and severe heat waves in drought-sensitive locations will be accompanied by long drought periods (Meehl and Tebaldi 2004; IPCC 2014) affecting mostly minorities (Figueiredo and Perkins 2013; IPCC 2014)—e.g. glacial retreat increases urban–rural competition, with low-income neighbourhoods worst affected (Lynch 2012). Traditional water infrastructures (SDG9) will face resilience issues that need to be addressed with decentralized systems enabling institutional, normative and regulative dimensional shifts (Ferguson et al. 2013; de la Barrera et al. 2016). Conventional water management focused on blue water serves the needs of engineers but represents only one-third of freshwater resources (Falkenmark and Rockström 2006; Mekonnen and Hoekstra 2011). Given the scarcity forecasts; the integration of rainfall, agricultural and grey water enhances socioecological approaches of water (Falkenmark and Rockström 2006; Hoekstra and Mekonnen 2012; Barbier and Chaudhry 2014). This can be done by adequate performance indicators that are suitable for different water uses and account for water availability, planning and operation, as well as complexities of direct versus indirect water consumption[4] (Falkenmark and Rockström 2006; Gössling 2015). These indicators should then be part of evaluation models on infrastructure projects that account for urban–peri-urban and rural interactions (Zhang et al. 2014; de la Barrera et al. 2016). Land use and land cover data should further assist these models to predict water demand variances that include the above water types. Only with such integrated approaches that combine supply and demand, water management in urban areas can achieve significant savings in water resources and infrastructure costs as well as enhance SDG6 relations with other SDGs (Evans et al. 2003; Luh et al. 2013; Willuweit and O'Sullivan 2013).

Win–win situations: the role of institutional capacity and participation (targets 6.a, 6.b)

Institutional failures crucially shape SDG6 effects on other SDGs (Rockstrom 2013; Sibly and Tooth 2014; Pahl-Wostl 2015). Two factors predominate: justice and equity considerations in decision-making (Patrick et al. 2014; Sahin et al. 2014) and governance coherence between levels (Lee 2000; Obani and Gupta 2014).

International cooperation (6.a) greatly alleviates these shortages, particularly in developing countries. First, a stronger role of water programs increases awareness and financial capacity (Wescoat et al. 2007). It encourages clearer task assignments to governance agents at all levels, strengthens support between different regulatory frameworks, minimizes dichotomies and increases responsibility (Obani and Gupta 2014). It further broadens the solution spectrum for less developed countries through capacity building that helps them harmonize SDG6 with other SDGs and increases transparency in water-related transfer negotiations (Pfaff and Vélez 2012). International standards enhance accountability and transparency in monitoring (SDG 17), thus enhancing ecosystem protection (SDGs 14, 15), equity outcomes and justice (SDGs 5, 10, 16), particularly in places where environmental damages abound (Lundin and Morrison 2002; Mehta 2014; Mehta et al. 2014), e.g. prevent public authorities define different spatial contamination levels to avoid legal responsibilities (Christenson et al. 2014). Altogether, international cooperation fosters trust, risk perceptions and public acceptance (Justes et al. 2014; Ross et al. 2014). Ultimately, transparent and accountable water management enhances social awareness and triggers sustainable water consumption (Smiley 2013).

However, SDGs′ interactions with SDG6 require democratic water governance (6.b.2) (Bakker 2003). First, including preferences through public consultation fosters synergies and minimizes trade-offs (Zeng et al. 2012; Domènech et al. 2013). Active communication between actors –including women—helps identifying critical barriers and just water distributions (SDG10), particularly under scarcity conditions (Cai 2008; Figueiredo and Perkins 2013). Second, trust, information dissemination and

[4] Human water annual use for food in Sub-Saharan Africa: 700 m^3/person; North America: 1800 m^3/person (Mekonnen and Hoekstra 2011).

training are fundamental for the success of demand side solutions (Manzungu and Machiridza 2005)—e.g. using rainwater tanks and the use of recycled water for landscaping, infiltration trenches, retrofitting home with water efficient appliances and central basins, and constructed wetlands in housing allotments and grassed swales to reduce WF (Coombes et al. 2000; Vairavamoorthy et al. 2008).

Altogether, defined and influencing roles of public authorities together with committed civic participation enhance the discussion among shareholders to define priorities and needs and, ultimately, establish adequate short- and long-term strategies.

The average scores obtained from the evaluation (Table 3) highlights the importance of targets 6.a and 6.b; they show only positive interactions and further minimize negative effects arising from other SDG6 targets.

Targets 6.1 and 6.2 counteract with other water-dependent SDGs

Present water facilities and urban forecasts indicate that water infrastructure is most needed in low-income countries showing higher urban population growth. The Sub-Saharan Africa, Middle East and North Africa regions require great effort to meet targets 6.1 and 6.2. Higher increase in future domestic water demand due to urban population growth will happen in countries with today's lower performance in targets 6.1 and 6.2 and countries with today's limited financial resources (Fig. 1).

The scenario analysis shows that urban domestic water demand greatest increase will happen in places where other water-dependent SDGs currently underperform (Table 4). This tendency becomes starker for S2—population gets the minimum stipulated by the WHO. The higher the increase in domestic water demand the lower the current agricultural production (S1: -0.50, $p = 0.00$; S2: -0.55, $p = 0.00$) and the higher the current prevalence of undernourishment (S1: 0.59, $p = 0.00$; S2: 0.66, $p = 0.00$). Countries underperforming in SDG2—highly water-dependent SDG—will face enormous water competition between domestic and agricultural use: SDG2 and SDG6 counteract each other. Also, countries performing worse on SDG7—clean energy access—will face higher increase in domestic water demand (S1: -0.78 $p = 0.00$; S2: -0.82, $p = 0.00$). Importantly, if SDG7 planning in water scarce regions goes hand in hand with SDG6, negative outcomes could be minimized—e.g. by fostering other renewables for energy production: SDG6 constrains SDG7 but does not cancel it.

As explained in Sect. 3.1.4, whether anthropogenic wastewater receives a treatment or not determines the effect of SDG6 on other SDGs. Countries with present lower share of wastewater treated will face higher increases in grey WF (S1: -0.58 $p = 0.00$; S2: -0.60, $p = 0.00$). Importantly, if they fail in target 6.3, the negative consequences of SDG6 on other SDGs will escalate and may even cancel their achievement within and beyond national boundaries.

Finally, the scenario comparison shows that complying with international standards on water provision increases

Table 3 Influence of SDG6 on other SDGs (R indicates regional, context specific)

SDGs		SDG6							
		6.1	6.2	6.3	6.4	6.5	6.6	6.a	6.b
1	No poverty	3	3	0	2	0	R	1	2
2	Zero Hunger	−2	−1	0	R	2	R	1	2
3	Good health and well-being	3	3	2	R	2	0	0	0
4	Quality education	2	3	1	0	1	0	0	0
5	Gender equality	1	0	0	0	0	0	1	2
7	Affordable and clean energy	−1	−1	−1	2	2	−1	1	1
8	Decent work and economic growth	−2	−1	0	R	1	−2	1	1
9	Industry, innovation and infrastructure	−1	2	1	R	1	−1	1	1
10	Reduced inequalities	1	0	0	0	0	0	0	2
11	Sustainable cities and communities	3	3	3	2	3	0	1	2
12	Responsible consumption and production	−1	−1	2	2	2	0	1	1
13	Climate action	−1	−1	1	−1	2	2	2	1
14	Life below water	−1	−2	3	−1	2	3	1	1
15	Life on land	−2	−2	3	−2	2	3	1	1
16	Peace and justice, strong institutions	2	2	1	−1	1	1	1	1
17	Partnership for the SDGs	0	0	0	0	1	0	2	1

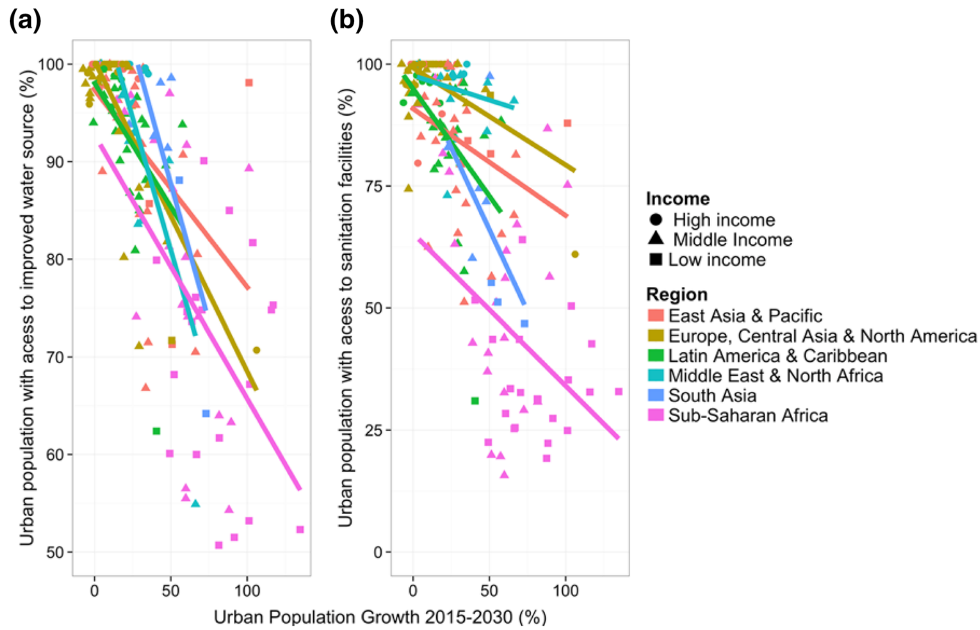

Fig. 1 Urban population growth and **a** access to improved water source (target 6.1) and **b** access to sanitation facilities (target 6.2). Sample = 182 countries. Source: United Nations (2015); World Health Organization & UNICEF (2015)

Table 4 Interactions between SDG6 and other SDGs: statistical results (Pearson correlation coefficients and *p* values (*significant at $p < 0.01$)

SDG	Indicator	2030 Domestic water demand	
		S0-S1 (Blue WF)	S0-S2 (Blue WF)
2	2.1.1 Cereal yield (kg/ha)	−0.50*	−0.55*
2	2.3.2 Prevalence of undernourishment (% pop)	0.59*	0.66*
7	7.1.1 Electricity access (% pop)	−0.78*	−0.82*
	Target 6.3	S0–S1 (grey WF)	S0–S2 (grey WF)
6[a]	6.3.1 Wastewater treatment	−0.58*	−0.60*
Scenario comparison		Share of total water available for domestic use	
		Blue WF	Grey WF
% Change S1-S2 blue		0.28*	–
% Change S1-S2 grey		–	0.62*

6[a]: crosscutting target, see Sect. 3.1.4 for rationale

domestic water demand more steeply in countries where the share of total water available for domestic use is higher (blue WF: 0.28, $p = 0.00$; grey WF: −0.62, $p = 0.00$). Countries underproviding drinking water on a per capita basis will require additional efforts to commit to international standards that directly constrain water resources for other purposes.

Discussion

SDG6 closely interacts with many of the proposed SDGs, particularly in urban contexts. As water is a finite resource, the magnitude of the increase in domestic water use will affect industrial and agricultural demands. Crucially, current performance of targets 6.1 and 6.2 indicates that countries with the greatest challenges ahead also show limited financial resources that compete with other SDG steering demands. Harmonizing SDG6 with other SDGs requires a serious commitment to all water targets, particularly targets 6.3, 6.5, 6a and 6b.

How can this be done? First, by using a context-specific approach to understand these dynamics: global frameworks provide moral imperatives; however, it is difficult to bring them down to the local level. Scarcity management at the regional and local level requires not only resource efficiency, but also new principles for social and ecological system integrity, adaptive capacity, civility and democratic governance, and intra- and inter-generational equity considerations (Bakker et al. 2008; Larson et al. 2013). This creates a rushing need to include justice in water allocation decision-making (Patrick et al. 2014).

Yet, the underestimation of institutional barriers—including normative values, risk perception, lock-in effects, stakeholder's plurality of preferences and investment requirements—hampers the process of transforming agendas (Marlow et al. 2013; Linton and Budds 2014). This calls for an urgent reduction of legal ambiguities in international and national frameworks and the implementation of enforcing mechanisms that ensure the existence of the principles agreed-upon[5] (Barbier and Chaudhry 2014; Sallam 2014). Also, governments should base their decisions on data that give a true view of the situation. Local documentation, e.g. official documents, reports, neighbourhood white documents; secondary data, e.g. household's questionnaires and interviews (Cook and Bakker 2012; Mehta 2014); and WF for virtual water flows and water appropriation help understand context-specific particularities (Dumont et al. 2013; Sallam 2014).

Third, integrated management, international cooperation and participation in decision-making processes are fundamental to build strategies across sectors (Linton and Budds 2014). Together, they enhance the understanding and accountability of space and time relations (Swyngedouw 2004). Negative interactions could be minimized or counteracted by institutions, legal rights and governance procedures—e.g. public incentives to invest in technological innovations that relax regional water stress conditions. Finally, water governance should increase the level of awareness. Influencing attitudes and behaviours through social and cultural factors as well as ecosystem's value perception is crucial to trigger sustainable lifestyles (Swyngedouw 2009; Kiriscioglu et al. 2013; Abbott and Allen Klaiber 2013; Garcia et al. 2013; Justes et al. 2014)—e.g. awareness campaigns to minimize tensions between local and tourist domestic water use (Cole 2012; Page et al. 2014).

This paper is a pioneer exercise on evaluating the relationship between SGD6 and other SDGs, only partially being studied until now. Further research is required on how best to track interactions, and how to address differences in geography, governance, technological development, timescales and the effects of climate change. Importantly, climate change could undermine achieving SDG6 and global water security in the future via the following ways: (a) sea-level rise (SLR) would cause deterioration of surface & groundwater in coastal freshwater aquifers due to salinization or increase of salinity (EC); (b) the expected rise in water temperatures in several world rivers (as projected) may enhance proliferation of harmful algae (such as blue-green algae/cyanobacterial blooms), and this would cause water quality problems for drinking water and other uses; (c) rivers depending on glaciers could face water shortages or reduced river run-off due to the retreat of glaciers, and this would cause a dramatic impact on drinking water supplies; (d) climate change-related flooding and excessive rainfall would facilitate the entry of human and animal pathogens into waterways and drinking water supplies, which is potential for water-related diseases (Kibria et al. 2016). Therefore, future research should also be focused on how SDG6 related to clean water and sanitation would be impacted and performed in a changing climate, and what are the appropriate measures required to reduce threats and risks posed by climate change on water security and achieving goals and targets of SDG6.

In light of the existing knowledge gaps in such an urgent matter, it is crucial to share case-based knowledge to allow for synergies and, ultimately, accelerate the learning process (Brown et al. 2011; Marlow et al. 2013; Neto 2016). There are signs that this is starting to happen, even within institutional spheres. The EU is unifying efforts through expert workshops to set up an urban water agenda that identifies important water issues for cities, sets objectives for 2030 and proposes concrete actions at the EU level.[6] The OECD that has recently published a survey on urban water governance is another example of the relevance of the issue (OECD 2016). Setting a SDGs′ research agenda that emphasizes the potentials and challenges arising from an urbanized world is a precondition to achievement of the SDGs.

Conclusion

Water resources for domestic use will face tremendous challenges, especially in the new settlements to come. Demand outstripping supply, urban planning, financial management and governance structures together with climate change will affect water stress and its effects on numerous SDGs. Our ability to manage these trade-offs and encourage long-term viability will affect numerous SDGs. Interconnections across natural and anthropogenic systems, the incorporation of justice, strong governance at all levels of decision-making processes and integrative management approaches promoting collaborations and

[5] Data on drinking water and sanitation may indicate distances to water sources, overlooking the reality given by affordability, reliability, quality and quantity (Euzen and Morehouse 2011; Smiley 2013).

[6] Cities and Water Conference. City of Leeuwarden (Netherlands), 2016.

social learning between stakeholders will enable the success in reconciling conflicting SDGs. Our evaluation serves as a starting point for further research on the characterization of interactions for specific temporal and spatial contexts and the identification and testing of development pathways that minimize negative interactions and enhance positive ones. How urban water is governed in cities will strongly influence anthropogenic and natural ecosystems, thus acquiring a global relevance.

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