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SDG goal 6 monitoring in the Kingdom of Bahrain

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ABSTRACT

The 2030 Agenda for sustainable development goals (SDGs) is an ambitious, aspirational, and transformational in nature global development plan. It is comprised of 17 holistic, indivisible, and universally applicable goals that embed and integrate the three dimensions of sustainable development – the economic, social, and environmental dimensions. These goals are supported by 169 integrated targets and 232 global indicators to enable global monitoring and reporting on their implementation progress. Goal 6 (SDG 6) of this agenda – the water and sanitation goal – aims to ensure availability and sustainable management of water and sanitation for all. As opposed to goal 7 of the Millennium Development Goals (MDGs), which was limited to access to water and sanitation facilities, SDG 6 of the sustainable development goals covers the entire water – cycle in an integrated manner. It is extended to address drinking water, sanitation and hygiene, protection of water-related ecosystems, water use efficiency and scarcity, and water management at both national and transboundary levels. Water and sanitation services are at the very core of the 2030 Agenda; thereby SDG 6 is cutting across all the other goals on both targets and indicator levels. This paper attempts to establish a baseline and methodological mechanism for monitoring and reporting on SDG 6 in the Kingdom of Bahrain. A trend analysis approach was used for tracking progress towards meeting the SDG 6 targets. According to the monitoring results, progress varies considerably. Bahrain has fully achieved the targets of increasing the coverage of the population having access to safely managed drinking water and sanitation services, and halving the proportion of untreated wastewater, well ahead of the agenda deadline. Progress on attaining the targets associated with the protection of water-related ecosystems and water use efficiency and water scarcity are, however, falling short at various degrees of implementation. The monitoring efforts also reveal that, despite the modest progress made on enhancing the institutional structures and capacity building in the water sector, implementation of integrated water resources management (IWRM) is still facing enormous challenges. In general, our analyses have shown that the natural water scarcity, high population growth rates, accelerated socio-economic development, non-efficient water use, shortages in financial outlays, and the lack of adequate technical and institutional capacities are the crucial factors hindering or decelerating progress on achieving SDG 6. Although sufficient data were made available for our analysis, data gaps were inevitable and require focused attention during the 2030 Agenda time frame. Among others, a set of potential management measures and policy interventions that may help fill these gaps and accelerate progress are recommended.

Keywords: Sustainable Development Goals; SDG 6; Kingdom of Bahrain; Water and Sanitation; Sustainable Water Management

1. Introduction

In September 2015, the United Nations adopted resolution 70/1, "Transforming our world: the 2030 Agenda for Sustainable Development". The vision enshrined in this Agenda is ambitious, aspirational, and transformational in nature (UN-ESC, 2016). The 2030 Agenda comprises 17 integrated, indivisible, and universally applicable goals that embed the three dimensions of sustainable development – the economic, social, and environmental dimensions. The importance of the integration and interlinkages concept within the 2030 Agenda is well-documented by UN-Water (2017a) "If these interlinkages are recognized and actively managed, implementing one target can assist with

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implementing many others, thereby optimising the use of existing resources and capacity and realising the purpose of the 2030 Agenda". These 17 goals are supported by 169 integrated targets and 232 global indicators to enable global monitoring, streamlining, and reporting on their implementation progress.

The Kingdom of Bahrain has paved its way for sustainable development by launching its development strategy in 2008 "Bahrain's Economic Vision 2030" – the guiding principles of which are: sustainability, competitiveness, and fairness (EDB, 2008). This vision was then translated into a comprehensive strategy "National Economic Strategy 2009–2014" (EDB, 2008). Both initiatives are strongly in line with the global 2030 Agenda for SDGs in terms of vision, guiding principles, objectives, and development initiatives.

In alignment with the 2030 Agenda, the government led parliament to ratify the "Government Action Plan 2015–2018". This action plan is a short-term national development programme that aligns its objectives and national priorities with those of the SDGs (Bahrain Government, 2015). By way of example, targets 6.1, 6.4, and 6.5 of SDG 6 are consistent with and covered by the national priorities and strategic programmes contained in the infrastructure and environment and urban development pillars of this action plan. A resolution decree No. 21/2015 was issued by the Cabinet to establish a "National Information Committee".

SDG 6 – the water and sanitation goal – aims to ensure equitable and safely managed water and sanitation services for all, preserve healthy ecosystems, and address water use efficiency and availability. It also calls for promoting IWRM at all levels, protecting and restoring water-related ecosystems, expanding international cooperation and capacity building in water and sanitation-related programmes, and supporting a participatory approach in water and sanitation management. SDG 6 comprises eight targets (six technical targets and two means of implementation targets), and eleven global indicators (nine core indicators and two additional indicators).

These targets are closely interlinked in the form of target-level linkages to ensure sustainable and integrated management of water and sanitation for all. A few examples of these interlinkages include: providing safe drinking water for all (target 6.1) which is directly related to the quality of the raw and ambient water (6.2, 6.3, and 6.6), and is strongly dependent on the water management being adopted (6.5) and efficiency of use (6.4). Also, sound water recycling practises and safe wastewater reuse (6.3) improve water use efficiency (6.4); and according to UN-Water (2016a), a safely managed sanitation service (6.2) is essential to protect the environment and water related ecosystems (6.3 and 6.6), or potential sources of drinking water (6.1). In addition, expanding international cooperation and capacity-building support to developing countries in water – and sanitation-related activities and programmes (6.a), and strengthening the participation of local communities in improving water and sanitation management (6.b) are fundamental elements to achieve IWRM (6.5).

Water and sanitation are at the very core of sustainable development (UN-Water, 2016) because safe drinking water and adequate sanitation services and hygiene are pillars of human health, social and economic well-being, food, energy and industrial production, environment and ecosystems protection, and climate change (UN-Water, 2016b). Therefore, SDG 6 links and cuts across all the other 16 sustainable development goals, also at target-level. The vast majority of target-level linkages across the 2030 Agenda with SDG 6 are positive (synergetic), meaning that implementing SDG 6 targets mutually supports a large number of other targets, and vice versa (UN-Water, 2016b). Some SDG 6 targets, however, have conflict or trade-off relationships with other SDGs targets, but this may provide countries with opportunities and challenges for improving their management procedures and decision-making processes.

This paper draws upon a comprehensive work (Al-Noaimi, 2018b) that sought to monitor progress on achieving SDG 6 in the Kingdom of Bahrain, and set out the baseline and methodological mechanism for progressive SDG 6 integrated monitoring up to the 2030 Agenda deadline, using a trend analysis approach. In this paper we collect, evaluate, analyse, and monitor data-sets on SDG 6 targets, mainly covering the time-span 2000–2016, with the year 2016 being considered as the baseline year against which progress up to 2030 will be evaluated.

The key challenges and obstacles faced, barriers to progress, data gaps, and performance deficiencies were also identified and briefly assessed. Our main findings have shown that progress achieved on SDG 6 monitoring varies significantly, with the main targets of providing safe and affordable accesses to drinking water supply and sanitation services being considerably attained. Inevitably, however, there are areas where progress is lagging behind to various degrees. The paper stresses the importance of re-shaping some of the water policies and management measures, including strengthening of the national statistical systems to address monitoring requirements and improvements in data reporting mechanisms, enhancing adoption of IWRM approaches, and optimising the proportions of wastewater reuse.

2. Baseline monitoring of SDG 6 targets and indicators

Tracking progress on the sustainable development goals requires the collection, processing, analysis and dissemination of an unprecedented amount of data and statistics at all levels, including those derived from official statistical systems and from new and innovative data sources (UN-ESC, 2016). Therefore, a robust, harmonised, and internationally comparable statistical framework (to facilitate reliable data sharing and dissemination at the regional and global levels) will need to be established at national, subnational and regional levels to streamline and optimise monitoring and reporting mechanisms on the sustainable development goals.

The Kingdom of Bahrain has established a comprehensive, consolidated, consistent, and timely data storage and management system – the Bahrain Water Resources Database (BWRDB). The database contains detailed quantitative and qualitative water and water-related statistics and information, with a set of computed indicators and variables. These data are disaggregated, standardised, and adjusted for global comparability, with rigorous data validation, refinements and improvement processes, and well-established reporting mechanisms. The BWRDB is a work-in-progress project and is currently being reviewed and expanded in terms of concept, structure, and methodology to fulfil the SDG 6 monitoring needs and to address the specific requirements of the Bahrain National Water Strategy and the Gulf Countries Unified Water Strategy and Implementation Plan (Al-Noaimi, 2018a).

In the context of the 2030 Agenda, a global indicator framework has been broadly defined to track progress towards the SDGs at the global level (UN-Water, 2017). Countries are, however, encouraged to devise their own additional national, sub-national, and perhaps regional indicators, bearing in mind the level of development, available resources, existing capacity, national priorities and so on for each country. The core element of the global indicator framework is the disaggregation of data and the coverage of specific groups of the population (ethnic, gender, marginalised, migratory status, and other groups characteristics) to fulfil the main principle of the 2030 Agenda of leaving no one behind (UN-ESC, 2016).

The BWRDB has offered reasonable and appropriately disaggregated time series data for integrated monitoring and tracking progress on SDG 6 targets and global indicators. Our monitoring efforts are mainly based on the suggested metadata for global monitoring of SDG 6 (UN-Water, 2016c) and the integrated monitoring guidelines and methodologies for SDG 6 targets and global indicators (UN-Water, 2017 and GEMI, 2017). We have also closely followed the various step-by-step methodological and guidance notes and institutional information recommended for measuring each of the SDG 6 global indicators.

The following discussion outlines progress attained towards the implementation of the SDG 6 eight global targets (six technical targets and two means of implementation targets) in the Kingdom of Bahrain. It also highlights the status of data availability, the degree of indicator applicability, and key challenges and opportunities.

3. SDG 6 technical targets

Technical targets are those used to monitor real progress on the SDGs. As mentioned earlier, SDG 6 consists of six technical targets (targets 6.1–6.6) supported by nine core indicators to facilitate global monitoring.

3.1. Target 6.1 drinking water supply

By 2030, achieve universal and equitable access to safe and affordable drinking water for all. Target 6.1 builds on target 7.C of the MDGs on drinking water, though the former is broadened to the extent that it calls for universal and equitable access for all and specifies that drinking water should be safe and affordable.

3.1.1. Indicator 6.1.1 percentage of population using safely managed drinking water services

Target 6.1 is measured by the global indicator 6.1.1 which specifies the share of the population using safely managed drinking water services from the total population. In order to meet the criteria for a safely managed drinking water service, people must use an improved drinking water source that should be: accessible in premises, available when needed, and free of contamination (WHO and UNICEF, 2018). The service levels for drinking water are divided by the Joint Monitoring Programme (JMP) into five parameters: safely managed, basic, limited, unimproved, and surface water.

Sufficient data were made available on this indicator from the official administrative records, annual statistical reports, and population statistics. The data have shown that, between 2000 and 2015, the average proportion of the population using improved and safely managed drinking water services (piped drinking water in premises) was 99%. In 2016, the proportion of people who had gained access to piped supplies reached the 100% mark. Fig. 1 shows the proportion of the population using safely managed drinking water sources from 2000 to 2016. According to the service provider, the lesser proportions (less than 100%) during 2000–2015 are attributed to pending applications, but this may also be partially due to illegal connections.

Fig. 2 shows that, during the 12-year period spanning 2005 to 2016, drinking water quality has significantly improved, thanks to the expansion in the desalination capacity. Total dissolved solids (TDS) content decreased from 1,528 to 294 mg/L between 2005 and 2016. In 2016, for instance, sodium and chloride contents fell considerably to 42 and 58 mg/L, respectively – well below the recommended allowable limits. Throughout the same period, trace metals content also recorded concentration values well below the international standards. However, data on drinking water quality lack analyses on fluoride, arsenic, and mercury, which are essential for assessing drinking water quality. Inclusion of these parameters in the routine drinking water monitoring programme is essential for enhancing the progressive monitoring efforts.

The graph in Fig. 3 compares the percentages of bad and good samples for samples collected at the distribution points for the period 2000–2016. The trend is remarkably positive, showing compliance of between 98.2% and 99.5%. From 2000 to 2015, the average of bad samples was less than 0.99%. During 2016, the proportion of polluted samples was only 0.9%. As presented in Table 1, which compares the proportion of good and bad samples for samples collected at the consumer outlets for the period 2000–2012, the percentage of bad samples ranges from 1.6% in 2000 and 2011 to 5.8% in 2008. This translates into compliance of between 94% and

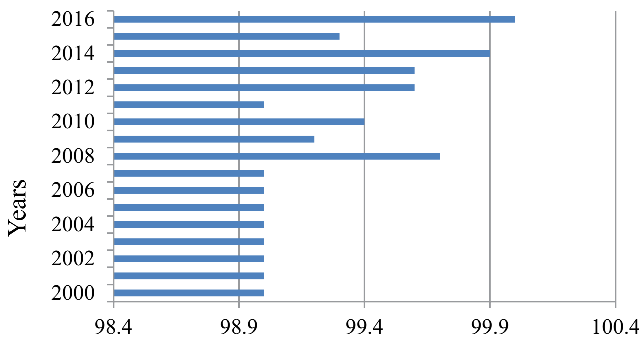

Fig. 1. Percentage of population using safely managed drinking water services (%).

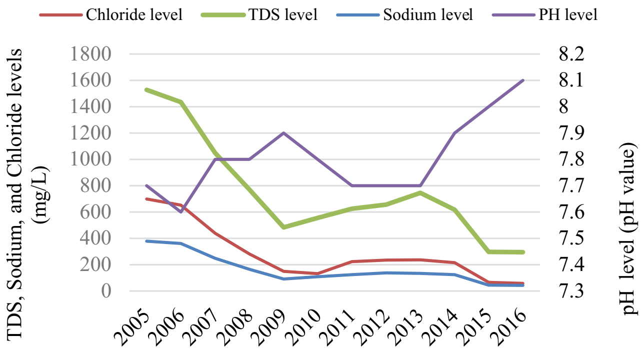

Fig. 2. TDS, Sodium, Chloride, and pH levels in drinking water 2005–2016.

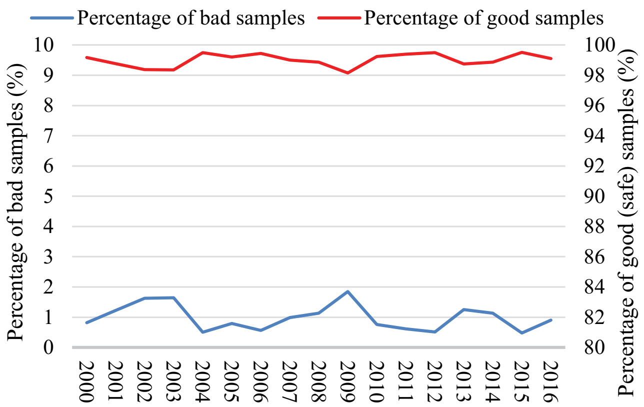

Fig. 3. Graphical representation of the good (safe) and bad drinking water samples 2000–2016.

Table 1
Percentages of good (safe) and bad samples at the consumer outlets 2000–2012

Years	Total samples	Sample status		Percentage of the good (safe) and bad samples	
		Safe	Bad	Safe	Bad
2000	1,340	1,318	22	98.4	1.6
2001	1,665	1,617	48	97.1	2.9
2002	1,666	1,630	36	97.8	2.2
2003	1,704	1,673	31	98.2	1.8
2004	1,565	1,544	21	98.7	1.3
2005	1,188	1,154	34	97.2	2.8
2006	1,134	1,083	51	95.5	4.5
2007	601	580	21	95.5	3.5
2008	447	421	26	94.2	5.8
2009	570	552	18	96.8	3.2
2010	502	484	18	96.4	3.6
2011	319	314	5	98.4	1.6
2012	674	662	12	98.2	1.8
Total	13,375	13,032	343	97.4	2.6

98%. On average, only 2.6% of the samples analysed at premises were found to be not suitable for drinking purposes.

In spite of the achievements made on the monitoring of drinking water quality, a significant drop in the number of samples analysed is noted (Table 1), falling to 674 samples in 2012, which represents a nearly 61% decline since the peak of 1,708 samples in 2003. Moreover, the reported data for 2013 to 2016 were unreliable for further evaluation and had been omitted from our analyses. These deficiencies reflect a decline in monitoring performance that needs to be seriously addressed. Performance must be maintained over time to support routine monitoring and to allow for more effective and standardised water quality monitoring, including the upgrade of sampling frequency and measurement procedures.

The majority of the drinking water in Bahrain originates from desalination sources. According to the 2016 estimate, 98.5% of the drinking water supplied to consumers is desalinated water. A study shows (Al-Noaimi, 2004) that consumers in Bahrain pay only 30% of the true unit cost of domestic water (i.e., the subsidy reaches around 70%); this is based on a calculated average unit cost of BD 0.113/m^3 (BD = 2.64 US$). Although water tariff restructuring has been implemented since 2017, subsidies are likely to remain an essential part of the tariff system, implying that payment for drinking water services does not and will not represent a burden at least to the national consumers. Affordability in SDGs is, however, still a debatable issue as further work is required to establish a commonly agreed method that will allow more systematic and consistent monitoring of affordability in the future (UN-Water, 2018; WHO and UNICEF, 2018).

The typical characterisation of the population to rural and urban areas is not precisely applicable to the Bahrain situation. Additionally, the drinking water distribution networks in the country are designed in a way that drinking water is distributed to mixed distribution areas, making it difficult to differentiate consumers based on their living areas. This indicates that progress accomplished represents the urban and rural population coverage (i.e., national coverage), meaning that Bahrain has fully achieved the target of increasing the coverage of the population having universal, equitable, and affordable access to safely managed drinking water services.

It needs to be noted, however, that bottled water is widely used in Bahrain, but only for drinking purposes. Even though, data from household surveys on the accessibility of this source were not made available, virtually all the population drinking bottled water or using any other type of packaged water (water tankers only supply drinking water in rare emergency cases) have access to piped and safely managed water sources. For this reason, the use of bottled water was not assessed here separately. This appears to confirm the need for greater clarity on a global level on this aspect of target 6.1.

3.2. Target 6.2 sanitation and hygiene

By 2030, 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*. This target also builds on target 7.C of the MDGs that calls for halving, by 2015, the proportion of people without sustainable access to basic sanitation. Target 6.2 addresses the use of safely managed sanitation services and ending open defecation practices to protect the health of the individual, community, and environment. It also highlights the importance of hygiene and handwashing facilities on premises to avoid the spreading of communicable diseases. More importantly, it pays special attention to the needs of women and girls, and to other marginalised groups and calls for providing them with equal services and necessary protection.

3.2.1. Indicator 6.2.1 percentage of population using safely managed sanitation services of wastewater safely treated

Indicator 6.2.1 is adopted globally to evaluate target 6.2. This global indicator seeks to specify the proportion of the population using safely managed sanitation services and those having handwashing facilities with soap and water. Because, as mentioned earlier, JMP has produced separate categorisation for hygiene service levels, indicator 6.2.1 is normally divided into two sub-indicators: 6.2.1a Proportion of population using safely managed sanitation services, and 6.2.1b Proportion of population using a handwashing facility with soap and water.

The updated ladder for sanitation services (WHO and UNICEF, 2018) includes five steps, namely: safely managed, basic, limited, unimproved, and open defecation, while the new ladder of the JMP for hygiene disaggregates handwashing facility on premises to three service levels: basic, limited, and no facility.

When viewed over the period from 2000 to 2016, the average proportion of the population having access to safely managed sanitation services via direct sewer systems was 77.5%. As shown in Fig. 4, the progress on 'population with direct connections to the sanitation services' has been erratic. While it rose by nearly 6% from 2000 to 2002, it fell considerably from 77% in 2002 to 65% in 2008, or a drop of around 16%. Progress remained almost constant between 2003 and 2005, but then slowed down until 2008. The most significant progress was made between 2008 and 2014, jumping from 65% in 2008 to 90% in 2014, corresponding to an increase of 39%. During 2016, the trend reversed, as the percentage of people with piped sewer systems dropped to 85%; this was less than in 2014 by approximately 6%.

The high population growth rates and rapid urbanisation developments appeared to have outpaced – at some stages – the rate of expansion in wastewater and sewerage infrastructures. It is evident that the compound effects of these factors contributed to this inconsistent trend. Much work remains to be done to accelerate progress on this target, as will be recognised when assessing progress on achieving target 6.3.

For SDG 6 monitoring, JMP defines safely managed sanitation services as those provided via piped sewer systems or on-site facilities such as septic tanks or pit latrines. In Bahrain, the population who lack access to direct connection to piped sewer networks, 15% in 2016 for example, enjoy safely managed sanitation services through on site sealed septic tanks (Fig. 4). These septic tanks are regularly emptied, and effluents are transported and delivered to treatment plants. The delivery of these effluents follows rigorous environmental standards and procedures to prevent risk to human health and the environment. This means that progress on meeting SDG target 6.2 of increasing sanitation coverage is fully accomplished in Bahrain well prior to the target deadline of 2030.

Another point worth mentioning is that both public drinking water consumers and industrial firms in Bahrain do not pay sewerage and/or discharge (pollution) charges. Farmers also receive tertiary treated wastewater for reuse for

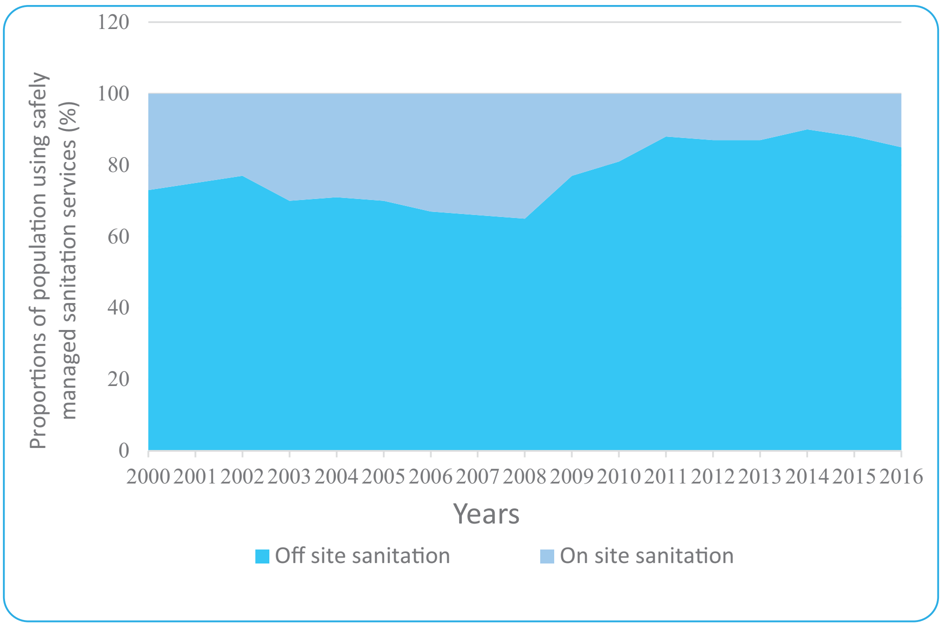

Fig. 4. Proportions of population having access to safely managed sanitation services 2000–2016 (In percentage).

restricted irrigation and sludge as fertiliser free of charge. However, proposals are being discussed in parliament regarding the imposition of a uniform tariff on connections to the sanitation services.

Statistical data on handwashing facilities that are usually collected through household surveys and censuses are not available to track progress on the sub-indicator 6.2.1b. The standard of socio-economic development in Bahrain may suggest that access to these facilities is assumed to be universal. It can thus be argued that this sub-indicator is not applicable to the situation in the country, or at least it should be monitored in integration with SDG 1 on poverty and SDG 3 on health with possibly inter-ministerial and coordinated monitoring efforts.

At global level, however, to overcome the data gaps for middle and high-income countries for future reporting on this sub-indicator, JMP will develop a suitable proxy for the availability of handwashing facilities in the home, drawing on data that are more likely to be available for high-income countries, such as 'availability of piped water supplies, hot water, showers or bathroom in premises' (WHO and UNICEF, 2018).

3.3. Target 6.3 water quality and wastewater

By 2030, improving water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally. The focus in target 6.3 is on the protection of water-related ecosystems and human health by eliminating, minimising, and significantly reducing all types of pollution into water bodies. The target also calls for substantially increasing recycling practices and safe reuse of treated wastewater as a means for (1) reducing the amount of water discharged (normally untreated or partially treated) into water bodies, and (2) decreasing freshwater withdrawal and increasing water use efficiency.

Progress on target 6.3 is closely linked to that of indicator 6.2.1 as both are part of the so-called sanitary chain, and also contribute to safe drinking water (6.1.1) as water pollution limits opportunities for safe and productive use of drinking water sources (UN-Water, 2018; WHO and UNICEF, 2018). Target 6.3 is currently being measured by two global indicators: namely, indicator 6.3.1 which focusses on the safe treatment, reuse, and disposal of wastewater, and indicator 6.3.2 which concerns with the ambient water quality in certain water bodies.

3.3.1. Indicator 6.3.1 proportion of wastewater safely treated

Indicator 6.3.1 measures the percentage of wastewater safely treated compared with the total wastewater generated. It has two components: wastewater generated by households and wastewater generated by other economic activities (industrial), based on the ISIC Rev. 4 Coding (UN-DESA, 2008). Consequently, the indicator can be disaggregated by source into two sub-indicators – 6.3.1a Proportion of wastewater safely treated in urban wastewater treatment plants, and 6.3.1b Proportion of wastewater safely treated in industrial wastewater treatment plants.

Disaggregated data on municipal water supplies, volume of domestic wastewater collected, volume of domestic wastewater treated, and volume of domestic wastewater disposed of to the sea were made available from the BWRDB. These data were used to develop a set of important national indicators signifying the collection rate, treatment rate, reuse rate, and the rate of discharge. Table 2 provides quantitative data on these variables from Tubli Water Pollution Control Centre (TWPCC) – the main wastewater treatment plant for the years 2000–2016. The table also offers proportionate information on the proposed national indicators.

On average, the collection rate (proportion of the volume of wastewater collected to total municipal water supply) is nearly 49% – falling short of the global collection rate of 60%. Over the period of interest, the trend varies widely. While falling from 47.5% in 2000 to 40.3% in 2006, it substantially rose from 40.3% in 2006 to 51.4% in 2007, or by about 28%, yet it dropped again by 6% between 2007 and 2012. The recent years 2013–2016 have shown a positive trend. In 2016, the collection rate reached almost 58%, or within close reach of the global threshold value, up from roughly 48% in 2012.

The most significant progress has been made on the national indicator treatment rate (proportion of the volume of wastewater treated to the volume of wastewater collected), which recorded a proportion of 100% throughout the comparison period and implies that all the collected wastewaters are being treated normally at least to secondary or tertiary levels of treatment.

The proportion of wastewater reused to the volume of wastewater treated – the reuse rate, gradually increased from 20% in 2000 to around 41% in 2008, or a slightly more than double rise of 105%. In the subsequent years, 2008–2015, progress slowed considerably to reach the 20% mark in 2015. After that, in 2016, it rose again by almost 31% compared with the 2015 level. Between 2000 and 2016, the volume of treated wastewater reused averaged at only 28%. It thus becomes clear that this rate of progress is insufficient and that a strong push is needed to reverse this trend by improving the existing sewerage infrastructures and the adoption of a more efficient wastewater management programme.

In the reference period from 2000 to 2016, the proportionate volume of wastewater treated and disposed of to the marine and coastal environment, or the so-called discharge rate, also developed a highly fluctuated trend similar to that of the reuse rate, naturally in opposite directions. The considerable increase in the proportion of discharge rate observed from 2014 onward is mainly due to the commissioning of the Muharraq Sewerage Treatment Plant (Muharraq STP), a BOOT scheme that collects around 73,000 m^3/d (27 Mm^3/year) of wastewater and treats it to tertiary level. Of this quantity only 2 Mm^3/year is currently being used for landscape irrigation; the remaining volume is dumped to the environment due to the absence of an effective wastewater reuse strategy.

An average discharge rate of 72% indicates that significant amounts of secondary and tertiary treated effluents are being discharged to the environment, which represents major lost opportunities for augmenting freshwater supplies, especially under the prevailing water scarcity conditions in Bahrain.

The accelerated socio-economic development and high population growth rates continue to overtake expansion in

Table 2
Wastewater collected, treated, reused, and disposed of to the sea from urban wastewater treatment plants 2000–2016

Years	Description								
	Municipal water use(2)	Wastewater collected(3)	Wastewater treated(3)	Wastewater treated and reused(4)	Wastewater treated and disposed of to the sea(5)	Percentage of wastewater collected to the municipal water use	Percentage of wastewater treated to wastewater collected	Percentage of wastewater reused to wastewater treated	Percentage of wastewater treated and disposed of to sea to wastewater collected
2000	128.0	60.8	60.8	12.4	48.4	47.5	100	20.4	79.6
2001	136.1	61.1	61.1	12.8	48.3	44.9	100	21.0	79.0
2002	138.1	64.7	64.7	13.1	51.6	46.9	100	20.3	79.7
2003	146.0	62.2	62.2	15.1	47.1	42.6	100	24.3	75.7
2004	152.6	64.1	64.1	15.1	49.0	42.0	100	23.6	76.4
2005	157.4	66.1	66.1	14.8	51.3	42.0	100	22.4	77.6
2006	164.7	66.3	66.3	26.1	40.2	40.3	100	39.4	60.6
2007	169.0	86.8	86.8	31.6	55.2	51.4	100	36.4	63.6
2008	197.4	97.7	97.7	39.6	58.1	49.5	100	40.5	59.5
2009	216.0	108.4	108.4	38.2	70.2	50.2	100	35.2	64.8
2010	231.5	115.2	115.2	35.4	79.8	49.8	100	30.7	69.3
2011	240.8	116.9	116.9	37.6	79.3	48.6	100	32.2	67.8
2012	242.4	116.7	116.6	36.7	79.9	48.1	99.9(6)	31.5	68.5
2013	248.6	124.0	123.95	32.4	91.55	49.9	99.95	26.2	73.8
2014	258.6	148.6	148.53	31.4	117.13	57.5	99.95	21.1	78.9
2015	256.7	145.7	145.7	29.6	116.1	56.8	100	20.3	79.7
2016	257.8	148.2	148.2	39.2	109.0	57.5	100	26.5	73.5
Average values for wastewater indicators (in percentage)						48.6	99.99	27.8	72.2

Notes:
All in Mm^3/year, unless otherwise stated.
Not includes municipal water used for agriculture.
Not includes wastewater collected and treated in other plants (industrial).
Not includes wastewater reused in other plants, wastewater reused within premises at TWPCC, as well as sea outfall or TSE surplus quantities.
Includes secondary and tertiary treated wastewaters.
The difference represents wastewater lost within plants operations.

the sewerage infrastructures, resulting in high infiltration rates and deficiencies in treatment performance particularly in events of hydraulic overloading (partially treated wastewater often being dumped to the surrounding environment in such events). The design capacity of TWPCC is 200,000 m^3/d, with a peak design capacity of 220,000 m^3/d. In 2016, for example, the plant received 303,000 m^3/d, or a hydraulic overload of 52%. During the years 2007 to 2016, the average daily flows received by the plant amounted to 291,000 m^3/d; this represents a daily carryover volume of 91,000 m^3, or an overload of 46%.

Although major improvements have taken place over the last 10 years, these limitations call for further actions to enhance the wastewater collection and treatment infrastructures. Among others, these may include improving the treatment and collection facilities, conveyance systems, and reuse transmission networks. A wastewater reuse programme with a clear national policy on Treated Sewage Effluents (TSE) reuse and an effective inter-ministerial coordination mechanism should be established at the national level to plan and substantially increase the reuse of wastewater for irrigation, industry, and perhaps groundwater recharge.

As illustrated in Table 3, quality of the secondary treated effluent from TWPCC has shown elevated concentrations with respect to total suspended solids (TSS), volatile suspended solids (VSS), total coliforms, *E. coli*, and parasites, considerably exceeding the national and local guidelines values. Notably, in 2016, abnormally high values were reported for TSS, VSS, turbidity, biological oxygen demand (BOD), and chemical oxygen demand (COD). However, the TDS content decreased significantly from 3,641 mg/L in 2004 to 1,352 mg/L in 2016.

The table also shows that, apart from the slightly elevated values of total coliforms, *E. coli*, and parasites, the tertiary treated effluent from TWPCC is generally of good quality, with the TDS level being remarkably reduced from 3,423 mg/L in 2004 to 1,060 mg/L in 2016, thanks to the improvement observed in the drinking water quality as revealed in Fig. 2.

Sufficient and good quantitative and qualitative data were made available to monitor progress on the component of wastewater flows in industry (indicator 6.3.1b). These data were collected from five industrial firms and include volumes of wastewater collected, volume of wastewater treated, volume of wastewater reused, and volume of wastewater discharged of to the coastal and marine environment. These industries comprise oil and gas, aluminium, petrochemical, steel, and ship repairs economic activities, and represent the only industrial firms owning private wastewater treatment plants.

The data have shown that the total volume of industrial wastewater collected reached 9.6 Mm^3 in 2016, up from only 0.192 Mm^3 in 2005 (Table 4). A similar trend is observed with the volume of wastewater treated, jumping from 0.175 Mm^3 in 2005 to around 7.8 Mm^3 in 2016. The majority of treated industrial wastewater is treated up to the secondary level, reaching 6.8 Mm^3 in 2016. By contrast, during the same year, only 0.60 Mm^3 or 8% of the industrial wastewater was treated to the tertiary level. The total volumes of industrial wastewater treated and reused increased significantly to 0.76 Mm^3 in 2016 as compared with 0.175 Mm^3 in 2005.

Despite the fact that almost 90% of the wastewater treated in the industrial plants is disposed of to the marine environment (6.7 Mm^3 in 2016), evidence has shown that such a practice is not causing damage to the environment. Table 5 presents data on annual average values of selected parameters of wastewater collected and treated at three industrial firms for the year 2016. It is evident that the treated effluents from industry are of good quality, showing values complying with the environmental standards set out by the Supreme Council for Environment – the agency which regulates and control industrial effluent quality and

Table 3
Analysis results of selected parameters for secondary and tertiary treated effluents from TWPCC for selected years

Parameters	Secondary treated effluent			Tertiary treated effluent		
	2004	2011	2016	2004	2011	2016
Total dissolved solids (TDS)	3,641	2,200	1,352	3,423	2,407	1,060
Total suspended solids (TSS)	11.8	11.7	90.4	11.0	4.0	5.1
Turbidity (NTU)	23	1.3	36.1	2.2	0.8	0.5
Volatile suspended solids (VSS)	109	7.9	58.2	2.0	1.3	1.9
Biological oxygen demand (BOD)	1.0	6.8	38.4	0.9	5.0	3.0
Chemical oxygen demand (COD)	–	23	91.6	29.0	16.0	19.6
Nitrite (NO_2)	1.9	2.4	2.8	1.46	1.0	2.4
Phosphate (PO_4)	–	3.2	2.3	–	1.25	1.77
Total Coliform (count/100 mL)	–	0.62×10^6	3×10^6	1.0	13.2	18.0
E. coli (Count/100 mL)	–	0.32×10^6	2.6×10^6*	–	2.2	3.2
Parasite (worm) (worm/litre)	–	815	333*	–	1.2	1.3

Notes:
All in mg/L, unless otherwise stated.
All are annual average values.
A dash indicates no data.
*Data of 2015.

disposal procedures as well as the issuing of effluent discharge permits (see Resolution No. 3/2001 Regarding the Environmental Standards (Air and Water)).

As highlighted above, though some positive steps have been attained, progress on monitoring the urban component of indicator 6.3.1 is falling short to some extent, as challenges and problems responsible for the marginal reuse rate and high discharge rate are yet to be solved. The quality of the secondary treated effluent remains a major challenge and poses a risk to marine and coastal environments.

In contrast, Bahrain has achieved commendable progress with regards to the component related to the proportion of safely treated industrial wastewater flows. The major industries have their own wastewater treatment plants and their effluents are disposed of in compliance with the standards.

Table 4
Volumes of wastewater collected, wastewater treated, wastewater reused, and wastewater disposed of to the sea for selected years from the industrial wastewater plants

Description	Years		
	2005	2013	2016
Wastewater collected	0.192	0.71	9.6
Wastewater treated	0.175	0.691	7.42
Of which:			
Treated to the secondary level	0.011	0.149	6.82
Treated to the tertiary level	0.164	0.542	0.60
Wastewater treated and reused	0.175	0.68	0.76
Wastewater disposed of to the sea	0.0	0.012	6.7

Notes:
All in Mm^3.
The difference between the collected and treated wastewater quantities represents wastewater lost within plant operation.
Total wastewater treated does not equal the volumes of wastewater reused and wastewater discharged to the sea due to rounding.

3.3.2. Indicator 6.3.2 proportion of bodies of water with good ambient water quality

Indicator 6.3.2 is closely interlinked with indicator 6.3.1 as increasing levels of wastewater treatment, and reuse of wastewaters improve ambient water quality in water bodies, while unsafe disposal of wastewaters into water bodies damages ecosystems and poses risks to public health. To report on this indicator, water bodies are classified into three types: rivers, lakes, and groundwater.

Ambient water quality refers to untreated natural water in river, lakes, and groundwater, and represents a combination of natural and anthropogenic influences (UN-Water, 2018). The indicator is concerned with water pollution or the evaluation of human and development impacts on the ambient quality in these water bodies, and measures the

Table 5
Analyses of selected chemical, nutrients, and microbiological parameters from wastewater plants of three major industrial firms 2016

Parameters	BAPCO	ALBA	FOULATH	Guideline values
Temperature (°C)	33.6	–	28.7	3 + TRW
Acidity (pH – Unit)	7.7	7.2	8.1	6–9
Total dissolved solids (TDS)	30,948	–	491	NGV
Total suspended solids (TSS)	1.1	0.3	4.5	35
Turbidity (NTU)	0.6	0.6	4.4	75
Residual chlorine (RC)	0.02	0.002	<0.05	2
Biological oxygen demand (BOD)	4.8	8.0	8.2	50
Chemical oxygen demand (COD)	91.1	18.8	26.2	350
Ammonia – Nitrogen (NH_3 – N)	0.74	0.16	0.44	3
Phosphate (PO_4)	0.58	0.08	0.83	2
Total Kjeldahl Nitrogen (TKN)	2.63	2.2	1.4	10
Total organic carbon (TOC)	–	1.8	5.5	50
Oil and grease	5.8	0.2	<1	15
Phenols	0.06	0.01	<0.002	1
Lead (Pb)	0.03	0.001	<0.05	1
Total Coliform (MPN/100 mL)	12	ND	<1.8	1,000

Notes:
All values are in mg/L, unless otherwise stated.
A dash indicates no data, ND value not detected, and NGV indicates no guideline value suggested.
TRW = Temperature of receiving water.
BAPCO is Bahrain Petroleum Company (Oil industry), ALBA is Bahrain Aluminium Company (Aluminium industry), FOULATH is Bahrain Steel Company (Steel industry).
Guideline values are based on Table 4 "Standards for Effluent Discharge from Industry" of the Resolution No. 3 (2001) regarding the amendments to the tables attached to Resolution (10) /1999 regarding the Environmental Standards (Air and Water) amended by Resolution No.2 (2001).

proportion of all water bodies that have good water quality compared with the total water bodies in the country.

Globally, in order to evaluate and examine indicator 6.3.2, a number of core parameters have been selected for each of the water bodies under investigation. The selection of these core parameters is mainly based on the simplicity of measurement and the assumed basic technical capacity. Countries are, however, encouraged not only to set their own standards for the definition "good ambient quality" depending on their specific conditions but also to improve their monitoring programmes over time by increasing the number of data points and frequency of measurements, and inclusion of more progressive monitoring parameters as national capacity increases.

With regard to the Bahrain situation, out the water bodies of concern, only groundwater body is applicable. Shallow groundwater bodies in the country are represented by two aquifers: the Alat Limestone aquifer and the Khobar aquifer, both of which are part of the so-called Dammam Aquifer System. Groundwater in Bahrain is of poor quality when compared with the national water quality standards, and has always been at risk due to overexploitation of the already limited groundwater resources. Roughly, the best groundwater quality ranges between 3,000 and 4,800 mg/L.

The selected core parameters for groundwater body are: electrical conductivity (EC), nitrate, and acidity (pH). Recommended progressive monitoring parameters for groundwater body includes, among others, temperature, hardness, major anions, major cations, orthophosphate, nitrite, ammonia nitrogen, arsenic, fluoride, and heavy metals.

Indicator 6.3.2 calls for the monitoring of water quality status and percentage changes over time at the suggested water bodies. Fig. 5 shows the changes in EC and TDS values in the Alat Limestone aquifer, together with the EC percentage changes over time for the period 2006–2016. Between 2006 and 2009, EC values significantly increased from 7,457 μmohs/cm in 2006 to 9,159 μmohs/cm in 2009, but then substantially decreased to 7,055 μmohs/cm in 2016. Though still very high, this translates into an improvement of 23%. Over the same period, pH values (not shown in the figure) demonstrated minor inconsistency with slight variations outside the normal range being observed during the last 2 years.

In order to qualify a water body as having "good" water quality, countries need to define threshold target values for the respective core parameters for the water bodies as a whole or each water body separately (UN-Water, 2017b). For reporting on indicator 6.3.2, a country-specific EC target value for the Alat Limestone aquifer is set at 4,800 μmohs/cm (Fig. 5). This is merely a historical target value based on the aquifer average EC content during the 1960s. Despite the improvement witnessed on this parameter, it appears that progress during the last 17 years is insufficient to meet this target value by 2030. This is true unless a drastic improvement in the aquifer water quality has been reached. It is imperative, however, to frequently refine this target value throughout the 2030 Agenda time-frame.

Nitrate is not monitored as part of the routine groundwater monitoring programme, and historical data on this parameter are scant. Limited data have shown that Alat groundwater has a nitrate range of between 2.8 and 6 mg/L

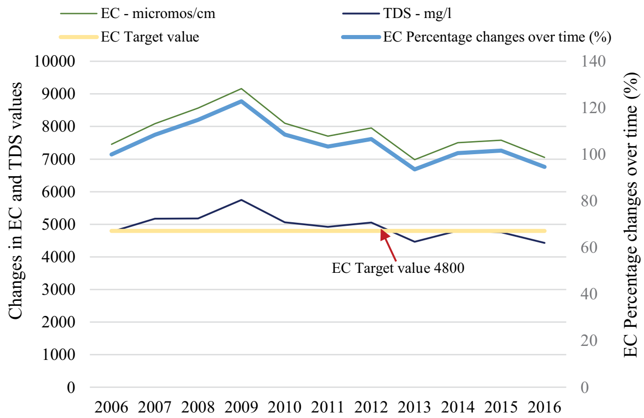

Fig. 5. Changes in the EC and TDS values in the Alat Limestone aquifer and percentage changes in the EC values over time 2000–2016, together with the EC target value.

(Al-Noaimi, 2004). Nitrate pollution normally arises from agricultural activities. Bahrain is not an agricultural country and groundwater is not likely to be used for drinking any longer (only in emergency cases); hence, a nitrate baseline value of 10 mg/L may be considered reasonable. Alternatively, the international guideline value (WHO, 2004) might be adequate to monitor progress on this parameter. Geological considerations and historical groundwater quality data indicate that noticeable changes in the pH values are unlikely to occur. As a result, the WHO guideline value of 6.5–9.5 could be adopted for this core parameter as a target value.

Groundwater in Bahrain suffers from continuous salinity degradation essentially caused by the saltwater intrusion. Hence, parameters such as sodium, chloride, and magnesium are necessary to assess the degree and extent of this phenomenon. Fortunately, these progressive monitoring parameters are generally part of the existing national monitoring programme. Between 2006 and 2016, their concentrations generally exhibited decreasing trends, driven by the notable improvement in the TDS levels. For instance, from 2008 to 2016, sodium and chloride contents in the Alat groundwater, respectively, decreased from 1,777 to 1,286 mg/L, and from 3,239 to 2,682 mg/L.

Fig. 6 shows the changes in EC and TDS values in the Khobar aquifer, along with the percentage changes in the EC values over time during 2006–2016. EC values vary from a maximum of 11,672 μmohs/cm in 2006 to a minimum of 8,531 μmohs/cm in 2015. Khobar's EC values decreased by about 22% between 2006 and 2016 – marking a percentage improvement almost equivalent to that reported for the Alat. The figure indicates that the trends of EC and TDS have almost identical patterns as those of the Alat Limestone aquifer unit (Fig. 5), confirming that the two aquifer units are in hydraulic connection and they are more or less behaving as one unit.

Historical evidence from the 1960s shows an average Khobar EC value close to 4,500 μmohs/cm (Fig. 6), this historical value is designated as the target value on track to meet target 6.3. According to Al-Noaimi (2004), nitrate contents in the Khobar aquifer ranged from 1.2 to 11.5 mg/L. With the

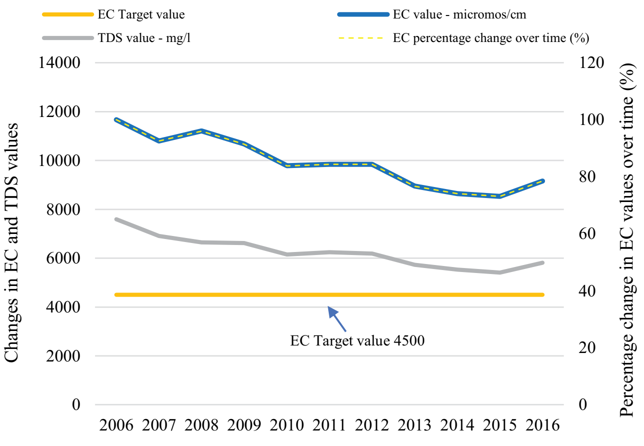

Fig. 6. Changes in the EC and TDS values in the Khobar aquifer and percentage changes in the EC values over time 2000–2016, together with the EC target value.

limited opportunities for sensible agricultural development, a target value of 20 mg/L appeared to be reasonable for this parameter over the SDGs schedule.

It follows from the foregoing discussion that progress on the issue of ambient quality of the groundwater body is simply lagging behind. EC average values of 9,919 and 7,831 μmohs/cm for the Khobar and Alat aquifer units, respectively, in the years 2006–2016 are possibly pointing out important gaps in the data point distribution, which needs to be seriously addressed. This suggests that there are still many monitoring challenges ahead, embracing the urgent need for improving the national groundwater quality monitoring programme in terms of spatial coverage of data points and frequency of measurements, as national capacity increases to support regular monitoring and reporting.

3.4. Target 6.4 water use and scarcity

By 2030, 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. This target aims to ensure that there is sufficient water for the people, the economy and the environment, by reducing water withdrawals and increasing water use efficiency across all sectors of society (UN-Water, 2018).

Target 6.4 is strongly related to targets 6.1, 6.2, 6.3, and, more importantly, to target 6.5. It is assessed using two global indicators: Indicator 6.4.1 which focusses specifically on the change of water use efficiency over time in the various economic activities, and Indicator 6.4.2, which intends to address and alleviate levels of water stress. These indicators are interlinked to provide a full picture of target 6.4 regarding the relation between water use efficiency and water scarcity.

3.4.1. Indicator 6.4.1 change in water use efficiency over time

This indicator is concerned with the component substantially increase water use efficiency across all sectors. Sectors of the economy for reporting on this indicator are delineated according to the ISIC Rev. 4 coding referred to earlier. The indicator is defined as the change in gross value added in a given sector divided by the volume of water used by this sector, expressed in US$/m^3 (FAO, 2017a). This means that the indicator addresses the economic component of target 6.4 by assessing the impact of economic growth on water use. However, it differs from the concept of water productivity in which it does not consider the productivity of the water used in a given economic activity as an input to production, or even better, the marginal productivity of the extra dose; instead this indicator shows the level of decoupling of economic growth from water use, or the increase of value added produced by the economy in relation to the increase in water use (FAO, 2017a).

When time series data are available, this indicator monitors the trend of change in water use efficiency over time as related to the economy value added. For global monitoring, mathematical equations were developed to allow for the computation of water use efficiencies and for providing some economic information (FAO, 2017a; FAO, 2017b). The SEEA – Water (UN-DESA, 2012) terminologies, concepts, and recommendations on consumption-based statistics are adopted for components explanation and calculation of these equations.

Following ISIC Rev. 4 industrial standards, economic sectors are defined as: agriculture including livestock and aquaculture and excluding fishing and forestry; industry comprising manufacturing, mining and quarrying, construction, and energy; and services sector. Water use efficiency is computed separately for each sector, and total water use efficiency is then computed as the sum of the three sectors weighted by their proportionate use from total water use. The computing formulas of each sector, including component descriptions, are described in FAO (2017a) and FAO (2017b).

The main interpretation rationale for this indicator is the comparison between water use efficiency and the economic growth of the country; the indicator should at least follow the same trend of the economic growth in order to be acceptable (FAO, 2017b). This means that if the water use efficiency is growing more than the economy value added, the indicator is on the right track of progress. The opposite may suggest that progress is not on the right path, and that policy interventions may be required to reverse the trend and remedy the situation.

3.4.1.1. Change in water use efficiency in the agriculture sector

Agriculture water use efficiency may be defined as the irrigated agriculture value added divided by the volume of water withdrawn by the agriculture sector, including livestock and aquaculture and excluding forestry and fishing, expressed in US$/m^3. Although it uses more than 70% of the already limited groundwater resources, and about 90% of the available treated sewage effluent, agriculture in Bahrain is in a poor condition and has a limited potential for improvement. In 2016, for example, the contribution of agriculture (excluding forestry and fishing) to the gross domestic product (GDP) was limited to only 0.20%.

Our data have shown that the lowest value of agriculture water use efficiency was 0.26 US$/m^3 in 2000, while the highest value was 0.53 US$/m^3 in 2016; the average being

0.39 US$/m^3. This positive trend can easily be explained by the widespread adoption of protected agriculture and hydroponic systems which tend to save large amount of irrigation water; the abandonment of many agricultural lands during the two decades might also be contributed. Given the current pattern of agricultural development, an increase in water use efficiency in agriculture is expected to persist over the coming years. Although these results appear to be encouraging, they have to be interpreted with care, taking into consideration the poor condition of the agriculture sector in the country and its trivial value added to the economy.

Fig. 7 relates the percentage changes in water use efficiency in agriculture and agriculture gross value added for the period 2001–2016. The figure shows that the change in water use efficiency is outpacing the growth in the agriculture value added, with only slight inconsistencies, suggesting relatively good performance. On average, between 2001 and 2016, the agriculture sector grew by only 2.2%, while the percentage change in water use efficiency in agriculture recorded a 5% increase.

3.4.1.2. Change in water use efficiency in industry

Water use efficiency in industry is defined as the gross industrial value added per unit of industrial water withdrawn, expressed in US$/m^3. Water withdrawn for industry includes water used for manufacturing, energy, mining and quarrying, and construction activities.

In general, the trend in water use efficiency in industry revealed a wide range from 585.9 US$/m^3 in 2000 to 853.8 US$/m^3 in 2016, with an average efficiency of 716.8 US$/m^3. A rather erratic progress has been observed up to 2011. For example, it rose by about 28% between 2004 and 2006, or from 663.04 to 846.7 US$/m^3 in absolute values, but then dropped between 2007 and 2012 from 653.9 to 585.9 US$/m^3, or by 10%. After 2013, considerable progress was attained increasing from 648.3 to 853.8 US$/m^3 in 2016. This corresponds to an increase of 32%.

The graph in Fig. 8 shows that, on average, from 2001 to 2016, the percentage change in water use efficiency in industry was found to be 1.5%, while the industry value added grew on average by 2.7%. This indicates that the industrial value added was generally growing more than the sector water use efficiency. The exceptions to this tendency were evident in the years 2005 to 2006 and 2014 to 2016. Surprisingly enough, during the periods mentioned, the change in water use efficiency in industry experienced several sharp rises and falls. Such a behaviour is difficult to explain given the limited data to hand regarding the overall economic development and water use characteristics in industry.

3.4.1.3. Change in water use efficiency in services

The services sector covers a wide range of economic activities (ISIC 36–39) and (ISIC 45 – 99). Water use efficiency in services is defined as the services value added divided by the volume of water withdrawn for distribution by the water collection, treatment, and supply industry, expressed in US$/m^3 (FAO, 2017a). This suggests that data on water use efficiency in this sector are to be collected from different sources, and perhaps require further disaggregation as conceptually dictated by SEEA-Water. For this reason, computation of water use efficiency in services requires careful attention.

The emerging trend in water use efficiency in services reveals a significant increase from 42.5 US$/m^3 in 2001 to 64.3 US$/m^3 in 2007. This matches an increase of almost 52%. From 2008 until 2011, a slight decrease of 4% was documented. Subsequently, it increased to 64.8 US$/m^3 in 2016 compared with the 2011 figure of 56.8 US$/m^3. This equates to an increase of 14%. The average water use efficiency in services was found to be 56.02 US$/m^3; the highest and lowest efficiencies being 64.83 and 42.50 US$/m^3, reported for the years 2016 and 2001, respectively.

The relationship between the change in water use efficiency in services and the gross services value added is illustrated in Fig. 9. It shows that while services gross value added is increasing, water use efficiency is decreasing. In the years 2001 – 2016, the average growth in water use efficiency in services was 2.6%, against an average growth of 7.1% in services gross value added, indicating that this sector is the weakest element, with a low absolute value of efficiency.

It is interesting to note, however, that the two trends have comparable profiles with evident erratic progress. Both components increased from 2001 to 2004, then decreased

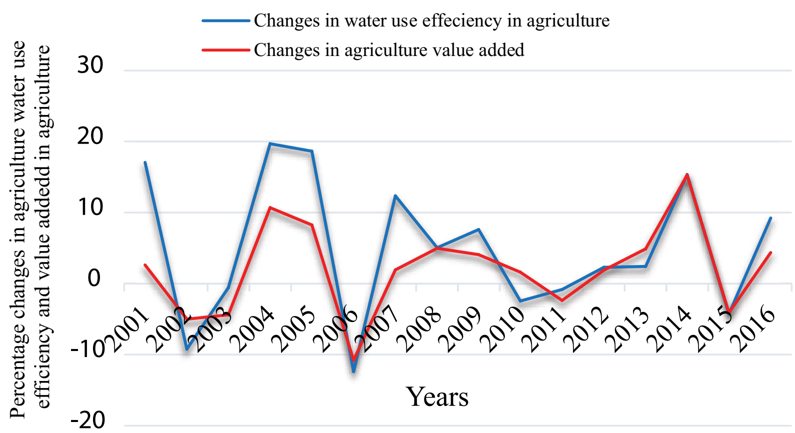

Fig. 7. Percentage changes in agriculture water use efficiency and value added in agriculture 2001–2016 (In percentage).

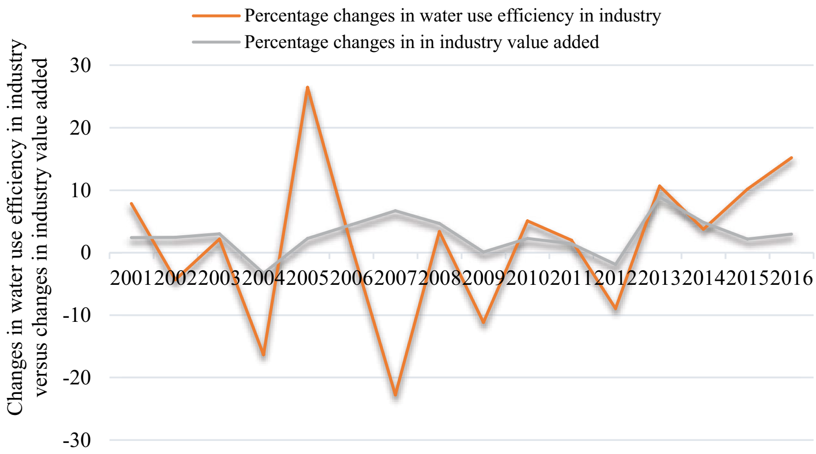

Fig. 8. Percentage changes in the water use efficiency in industry and industry value added 2001–2016 (In percentages).

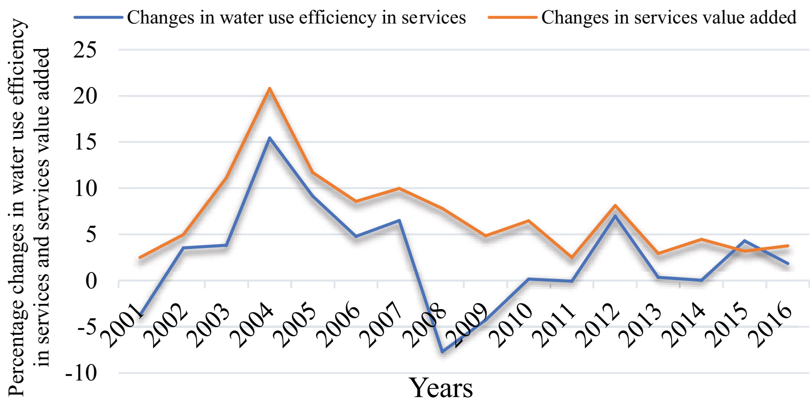

Fig. 9. Percentage changes in services water use efficiency and services value added 2001–2016 (In percentage).

from 2005 to 2009. The trend from 2010 onward witnessed another cycle of rise and fall. The substantial and quite sharp fall in the degree of water use efficiency between 2005 and 2009 may be partially explained by the increase in the water supply, most likely as a result of the commissioning of more desalination plants. In part, the complex structure coupled with the intermingling with respect to the water use in this sector of the economy may have contributed to this performance.

3.4.1.4. Change in total water use efficiency

As mentioned earlier, total water use efficiency is computed as the sum of the three major sectors, weighted according to the proportion of water withdrawn by each sector over the total withdrawal, expressed in US$/m^3 (FAO, 2017b). It means that the percentage share withdrawal of each economic sector from total withdrawal is crucial in computing this indicator.

The highest water use efficiency value was 77.26 US$/m^3 in 2016, while the lowest was reported in 2000 at 46.07 US$/m^3, suggesting a very positive progress. In detail, total water use efficiency significantly rose from 46.07 US$/m^3 in 2000 to 69.97 US$/m^3 in 2007; this corresponds to an increase of nearly 52%. Between 2009 and 2012, water use efficiency virtually remained unchanged, but has gradually risen again from 2013 onward.

On average, water use efficiency is 63.34 US$/m^3. Globally, preliminary data show that water use efficiency accounts for 15 US$/m^3, with country values ranging from about 2 to 1,000 US$/m^3 (UN-Water, 2018). It should be noted, however, that the global assessment might hide some details.

It was found that the positive and negative trend values in the change in water use efficiency virtually coincide with those of the change in water use efficiency in services, confirming the supremacy of this sector on total water use (67% in 2016). Examples of these performances may be perceived between 2004–2005 and 2008–2009. High water use efficiency values were reported for the years 2004 and 2005, 15% and 9%, respectively.

Fig. 10 compares the percentage change in water use efficiency and the percentage change in GDP growth from 2000 to 2016. It shows that, during the period 2000–2016, the percentage change in water use efficiency recorded an average value of 3.4% against a GDP average percentage growth of 4.8%, meaning that more water is proportionally needed by the growing economy. This could lead to the conclusion that water use efficiency in Bahrain remains an important

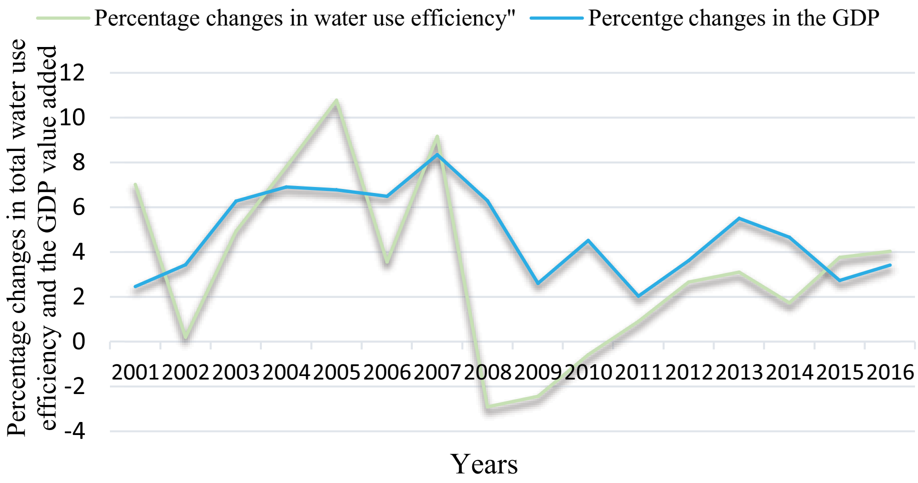

Fig. 10. Percentage changes in the water use efficiency and the GDP 2001–2016 (in percentage).

challenge and places more pressure on the available water resources, despite the fact that recent years demonstrate a few encouraging signs.

Although these percentage changes appeared to be anomalous, a similar picture is evident for all the economic sectors. A possible explanation for this anomaly could be the surge of additional water supply. From the water management perspective, this trend is worthy of closer analysis.

Fig. 11 shows the decoupling relationships between the percentage changes in water use efficiencies and values added in the three major economic sectors and percentage changes in the total water use efficiency and the GDP over time for the years 2000–2016. It can be seen that the obtained results coincide with our detailed separate analyses for each economic sector and the economy as a whole, possibly indicating limited effects of the external factors.

3.4.2. Indicator 6.4.2 level of water stress: freshwater withdrawal in percentage of available freshwater resources

This indicator measures the degree of pressure placed on the available freshwater resources in a country; thereby the extent of challenge on the sustainability of these resources. The level of water stress may be defined as the ratio between total freshwater withdrawn by all major sectors and the total available freshwater resources, after having taken into account environmental flow requirements (EFRs), expressed in percentages (Un-Water, 2017c).

Building on the MDGs indicator 7.5 on water stress, which is equivalent to the SDG indicator 6.4.2, three levels of water stress were considered as thresholds: low stress: 0–25%, high stress: 25%–70%, very high stress: >70% (Navarro, 2018). The world's average water stress stands at almost 13%, although

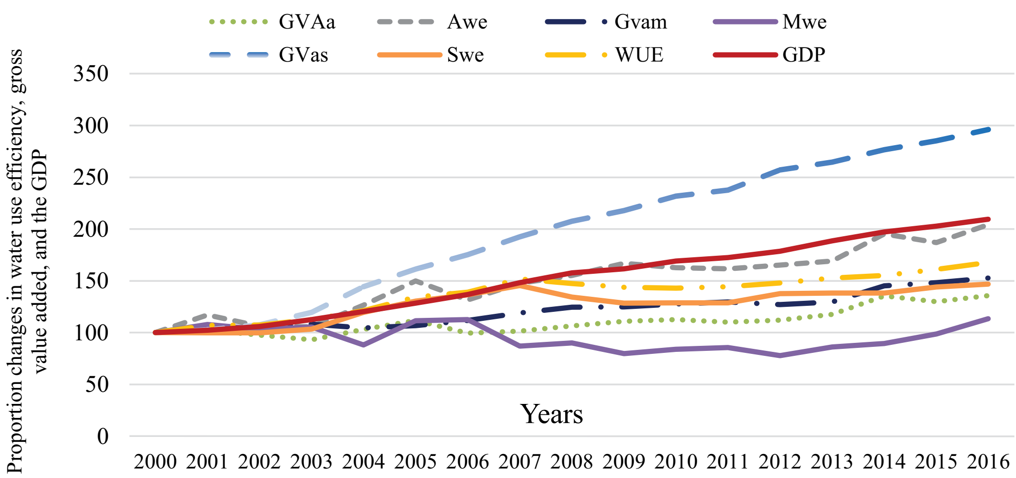

Fig. 11. Proportion changes in water use efficiencies, gross values added in the major economic sectors and total water use and the GDP 2000–2016 (In percentage).

Notes:

GVAa = agriculture value added, Awe = water use efficiency in agriculture, Gvam = industry value added, Mwe = water use efficiency in industry, GVas = value added in services, Swe = water use efficiency in services, WUE = water use efficiency, and GDP = Gross domestic product.

Values added are at constant prices.

evidently, there are significant differences among world regions, a fact that a global assessment hides (FAO, 2018).

In water scarce countries, such as Bahrain, progress on this indicator is expected to be insufficient always, even though some countries have exerted significant efforts to improve their water management policies. Countries are, however, encouraged to identify their own threshold values depending on several factors; among which are level of development, population density, climatic conditions, etc.

Bahrain depends primarily on very limited groundwater resources as the only renewable natural resources to meet its water demand. Currently, demand for freshwater is largely being met from desalinated water and treated sewage effluents. Data required for calculating indicator 6.4.2 are already captured in the computation of indicator 6.4.1, as the two indicators are interlinked to address water use efficiency and water scarcity. Sufficient historical time series data are available on the total withdrawal from both the renewable and non-renewable groundwater resources.

Time series data on renewable freshwater resources are, however, scant. Previous estimates have shown that the external renewable water resources are about 112 Mm^3 (Al-Noaimi, 1993). This represents the average annual inflow from Saudi Arabia mainland. The same study has estimated the internal renewable water resources at about 0.270 Mm^3/year. Therefore, the total renewable freshwater resources may be taken at 112.3 Mm^3/year. Unfortunately, this represents the most recent recharge estimate made available for our analysis and was, therefore, assumed to be constant over the monitoring period. The EFRs component was excluded from our calculations on the reasoning that it is not applicable to the Bahrain situation.

Level of water stress is monitored over the period 2000 to 2016, as shown in Fig. 12. It revealed water stress ranging from a minimum of 138% in 2016 to a maximum of 234% in 2000; the average being 179%. It can be seen that, although appreciable improvement has been attained over the reference period, thanks to the supply increase from non-traditional water resources, Bahrain is a seriously water stressed country.

Because of the quality constrains related to the non-renewable groundwater resources (only available for use after desalination), a country-specific national indicator for the global indicator 6.4.2 was created as shown in Fig. 13, with only freshwater withdrawn from the renewable groundwater resources being considered. Though still high at 96% in 2016, water stress declined remarkably from a peak of 195% in 2000. Progress from 2001 to 2009 witnessed a substantial decrease from 174% to 100%. This corresponds to a water stress decline of 74%. From 2010 until 2013, water stress increased by 20%. The indicator then developed a positive direction over the next 3 years.

3.5. Target 6.5 water resources management

By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate. Implementing a holistic IWRM approach will provide institutional structures and multi-stakeholder processes to balance the development and use of water resources for people, for sustainable economic growth and for supporting vital ecosystem services (UN-Water, 2018). Target 6.5 highlights the great importance of sound development, management and use of water resources, including transboundary cooperation over water resources in solving water resources problems. Therefore, the target is not only essential for SDG 6 alone but also all SDGs.

The global Indicators 6.5.1 Degree of IWRM implementation, and 6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation

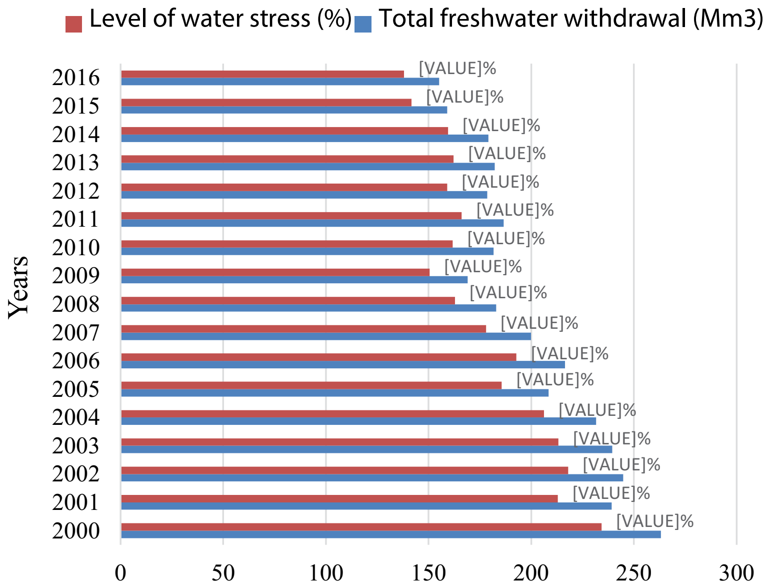

Fig. 12. Indicator 6.4.2 Level of water stress (Global indicator).

Notes:

EFRs were not considered in our calculations.

Low stress: 0%–25%, High stress: 25%–70%, Very high stress: >70%.

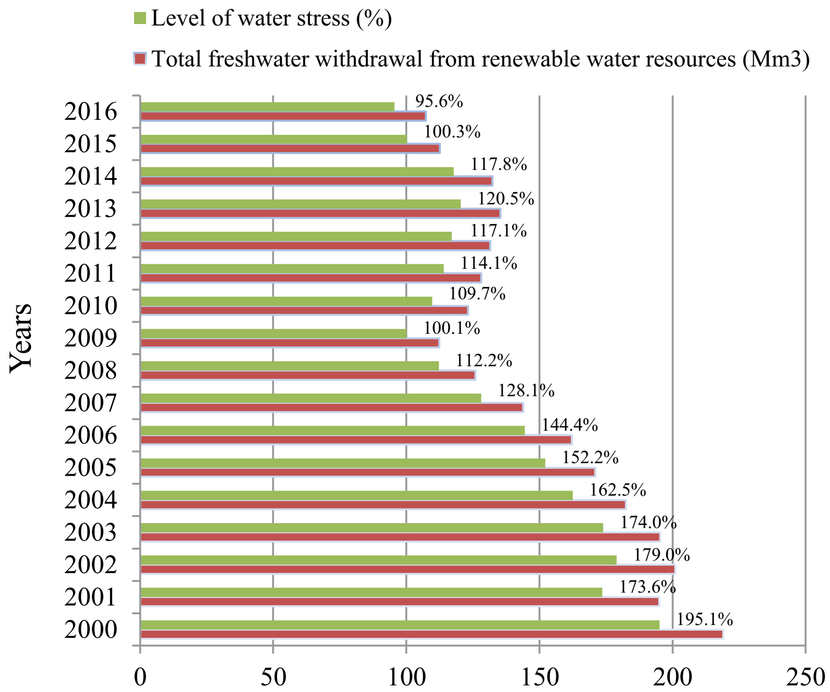

Fig. 13. Level of water stress (national indicator).
Notes:
EFRs were not considered in our calculations.
Low stress: 0%–25%, High stress: 25%–70%, Very high stress: >70%.

are proposed to track progress towards target 6.5. The two indicators complement each other in the way that they combine to address the IWRM implementation at all levels.

3.5.1. Indicator 6.5.1 Degree of water resources management implementation (0–100)

This indicator intends to measure the degree of IWRM implementation in different stages of development and implementation, expressed in percentages. It reflects the extent to which IWRM is implemented as scores between 0 and 100. Zero "0" percentage score indicates IWRM not implemented and "100" corresponds to IWRM being fully implemented.

Globally, progress on this indicator is monitored through a self-assessed country survey questionnaire (UNSD/UNEP Questionnaire) structured in four sections: (1) enabling environment, (2) institutions and participation, (3) management instruments, and (4) financing. Each of these sections contains two sub-sections; the first covering the national level and the second covering the all levels, which includes sub-national, basin/aquifer and transboundary levels as appropriate (UNEP, 2017). The questions for all sections are then averaged to compute the overall score for the indicator. The questionnaire also provides reasoning and justifications for the scores for each question to help in qualification of scores, enable better understanding of the scores, and to assist in identifying areas of good progress and those which hinder implementation of IWRM.

Bahrain has contributed to the 2017/2018 UNSD/UNEP IWRM questionnaire, with questions completed are only those related to national and aquifer elements of IWRM implementation as other levels are not applicable to the Bahrain situation. The country section scores and average score are presented in Table 6. The table shows that Bahrain reported medium to low levels of IWRM implementation (40%), with scores ranging from 28% to 48%. The lowest level of implementation (28%) was reported for the enabling environment, while the highest (48%) was for institutions and participation, which was also a medium-low degree of implementation. It also reported having a medium to low score, about 43%, for management instruments. The country scored 40%, or medium-low level of implementation for financing.

In 2017/2018, the global average degree of implementation of IWRM was 48%, corresponding to medium – low, but with great variations among countries (UN-Water, 2018). As can be seen, Bahrain reported a limited to modest progress with an average indicator value of nearly 40%; this is within a close reach of the global average. This indicates that elements of IWRM are generally institutionalised and implementation is underway. This progress, however, could have been much lower prior to the re-creation of the water resources council and the formulation of the national water strategy (under way), respectively.

According to UNEP-DHI and UN-Water (2018), countries with medium low implementation and below, are unlikely to reach the global target of "very high" implementation. This means that, although good progress has been made in some aspects of IWRM, significant efforts are needed to enhance the element of IWRM implementation and promote cooperation and coordinated actions in all aspects related to management and development of water resources.

Table 6
Indicator 6.5.1 Degree of integrated water resources management implementation (0–100)

Section	Definition	Average score
1. Enabling environment	Creating the conditions that help to support the implementation of IWRM, which includes the most typical policy, legal and strategic planning tools for IWRM.	28.0
2. Institution and Participation	The range and roles of political, social, economic and administrative institutions and other stakeholder groups that help to support the implementation of IWRM.	48.3
3. Management Instruments	The tools and activities that enable decision-makers and users to make rational and informed choices between alternative actions.	42.5
4. Financing	Budgeting and financing made available and used for water resources development and management from various sources.	40.0
Indicator 6.5.1 Degree of integrated water resources management implementation (0–100)		39.7

Future efforts need to be focussed on the establishment of a favourable enabling environment that helps to support IWRM implementation, including enhancing of the national legal, institutional, administrative frameworks, and promoting water policies and strategic planning tools. Allocating sufficient financial resources for water supply and sanitation infrastructures and water resources management should also be given a higher priority. The establishment of the IWRM implementation process and coordination mechanism for future monitoring of progress on indicator 6.5.1 is also imperative.

3.5.2. Indicator 6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation

This indicator measures and monitors transboundary water cooperation covered by an operational arrangement, and is expressed in percentage share of the transboundary surface areas. The indicator defines the term "operational arrangement" as any sort of treaty, convention, agreement or other formal arrangement that meets established criteria. It also stresses the importance of transboundary cooperation to implement IWRM of shared water resources, and closely integrates with indicator 6.5.1 to provide full coverage of elements of IWRM implementation.

The Dammam Aquifer System is delineated as a shared aquifer between Bahrain and the Kingdom of Saudi Arabia, yet the two countries have not entered into formal transboundary operational arrangements for the development and management of this aquifer system. The UNSD/UNEP Questionnaire referred to earlier contains questions on transboundary water cooperation. Bahrain gave an indicator value of (0), or a very low level of IWRM implementation to Question (1.2.c) of Section I "Enabling Environment" of the survey questionnaire, regarding arrangements for transboundary water management in most important aquifers, signifying that development in this aspect was not started and not progressing (Table 7). It also reported, "not applicable" to Question (2.2.d) of Section II "Institution and Participation" on gender-specific objectives and plans at transboundary level. This was also the case with Question (2.2.e) of the same section, addressing the availability of an organisational framework for transboundary water management for most important aquifers.

In Section VI of the questionnaire "Financing", Bahrain reported "not applicable" on Question (4.2.c) on financing for transboundary cooperation on the reasoning that frameworks for transboundary water management do not exist. Limited data and information sharing, however, exist through some regional mechanisms (i.e., Gulf Cooperation Council committees), mutual groundwater studies, and on an ad-hoc or informal basis. This was clearly reflected on the answer to Question (3.2.d) of Section III "Management Instruments" on transboundary data and information sharing between countries, where a low to medium low (30) IWRM implementation value was reported.

3.6. Target 6.6 water-related ecosystems

By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes. Freshwater aquatic ecosystems are the world's most biologically diverse environment and provide many products and services on which human well-being depends (UN-Water, 2018). Target 6.6 seeks to halt the degradation and destruction of water-related ecosystems such as vegetated wetlands, rivers, lakes, reservoirs and groundwater as well as those occurring in mountains and forests, which play a special role in storing freshwater and maintaining water quality.

Therefore, the global ambition of this target is to protect and restore these ecosystems; as the loss of water-related ecosystems can lead to increasing water insecurity (Dickens, et al., 2017). Global progress towards target 6.6 is monitored through the global indicator 6.6.1.

3.6.1. Indicator 6.6.1 Change in the extent of water-related ecosystems over time

This indicator is a measure of change in the extent of water-related ecosystems over time, expressed in % change/year. Indicator 6.6.1 seeks to provide data and information on the spatial extent of these ecosystems to enable management and protection of water-related ecosystems, so that

Table 7
Summary results of questions in the UNSD/UNEP Questionnaire related to Indicator 6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation

Section	Sub-question	Question	Score
Enabling environment	1.2.c Presence of arrangements for transboundary water management in most important basin/aquifer	1.2	(0) Very low
Institution and participation	2.2.d Gender-specific objectives and plans at transboundary levels	2.2	Not applicable
Institution and participation	2.2.e Presence of organisational framework for transboundary water management for most important basins/aquifers	2.2	Not applicable
Management instruments	3.2.d Transboundary data and information sharing between countries	3.2	(30) Low-medium low
Financing	4.2.c Financing for transboundary cooperation	4.2	Not applicable

ecosystem services, especially those related to water and sanitation, continue to be available to society (UN-Water, 2017d). Considering the complex nature of these ecosystems in terms of diversity, indicator 6.6.1 is divided into four sub-indicators to enable describing the aspects of each ecosystem and to assist with implementation of monitoring procedures for target 6.6 at a global level. The sub-indicators describe the spatial extent of ecosystems (sub-indicator 6.6.1a), the quantity of water contained within these ecosystems (6.6.1b), the quality of water in ecosystems (6.6.1c), and the state/health of ecosystems (6.6.1d) (Dickens, et al., 2017; UN-Water, 2017d).

Indicator 6.6.1 is closely related to indicator 6.3.2 on monitoring ambient water quality as the two indicators are combined to address the aspects of ecosystems management in qualitative (6.3.2 and 6.6.1c) and quantitative/health (6.6.1a, 6.6.1b, and 6.6.1d) terms. The two indicators, in turn, are interlinked with SDG 13 on climate change and SDG 15 on terrestrial ecosystems.

For global monitoring and reporting on target 6.6, change in the extent of ecosystems over time is assessed against a reference condition, before which ecosystems were assumed to be in a natural condition. Regarding benchmarking, these are categorised into five stages conditions: unmodified natural, largely natural, moderately modified, largely modified, and seriously modified. For further details on this categorisation in terms of percentage change equivalents, refer to UN-Water (2017d).

Groundwater ecosystem is the only ecosystem category that is applicable to the Bahrain situation. Vegetated wetlands at Tubli Bay Preserved Area, including Sanad, contain saltwater but receive large amounts of treated sewage effluent. Whether this ecosystem is included in this indicator or not remains to be answered.

Storage in groundwater aquifers is normally estimated from numerical modelling taking into consideration the areal extent of aquifers, their saturated thickness, transmissivity and storage coefficient. For SDG 6 indicator 6.6.1, however, change in volume of groundwater stored in these aquifers is difficult to quantify. In this situation, changes in groundwater volume may, however, be inferred from changes in groundwater levels.

The quantity of water in groundwater aquifer ecosystems was assessed using data provided by the related line ministry, including historical records on groundwater levels. In addition, groundwater levels data are made available from various documents, including consultant reports, groundwater studies, and academic and journal papers.

In order to satisfy the SDG 6 monitoring and reporting requirements, changes in groundwater level and percentage changes over time in the Alat Limestone and Khobar aquifers were monitored and assessed for time series data covering the period 2000 to 2016, as shown in Figs. 14 and 15, respectively. The figures also present target values against which future progress will be gauged. It is important to mention here that the proposed target values are merely baseline references, which need to be constantly evaluated and improved as SDG 6 monitoring continues and more data become available.

Fig. 14 shows that, between 2000 and 2010, the Alat water level dropped from 0.07 m in 2000 to –1.01 m in 2010, a significant drop of 1.08 m. By the end of 2014, it rose to 0.01 m, or a recovery of slightly more than 1.0 m. Although it declined again by 0.13 m in 2016, the general trend reveal a positive sign over time. The percentage changes in the Alat water level over time range from around –1,500% to about 230%.

The natural "reference" condition for the Dammam Aquifer System is that of 1924 when the system was in a steady-state condition. Ideally, for SDG reporting, this natural condition is difficult to attain. Therefore, an indicator target value of 1.7 m was established for the Alat aquifer based on the historical reference condition criterion. This virtually represents the average water level during the 1990s (Al-Noaimi, 1993); analysis of data prior to the 1990s produced unreliable results. It can be seen that the observed rate of progress appears to be insufficient to meet the proposed target value before the target deadline of 2030.

From Fig. 15, the Khobar aquifer has an almost similar pattern as the water level in the Alat aquifer, with the water

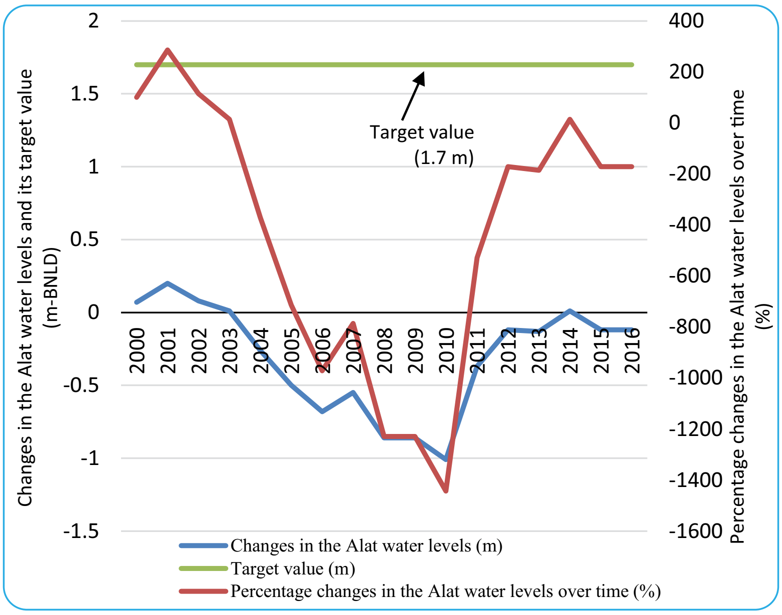

Fig. 14. Hydrograph for the changes and percentage changes over time in the Alat Limestone aquifer water levels 2000–2016, together with the aquifer target value.
Note: BNLD = National Level Datum.

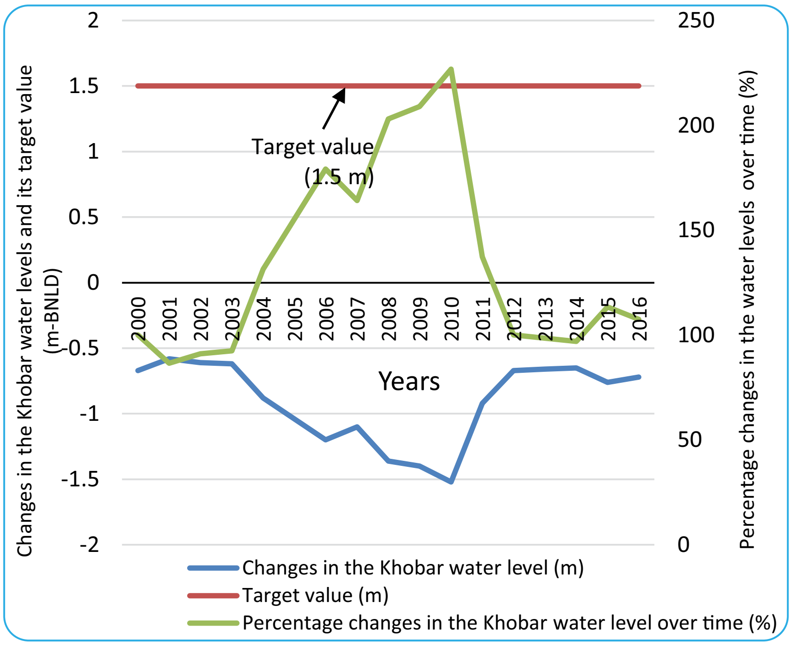

Fig. 15. Hydrograph for the changes and percentage changes over time in the Khobar aquifer water levels 2000–2016, together with the aquifer target value.
Note: BNLD = National Level Datum.

level in the latter aquifer generally exceeding that of the former by almost 0.5 m. The percentage changes in the Khobar water level over time range from a minimum of about 80% to a maximum of around 230%. A target value of 1.5 m was established for the Khobar aquifer, which is also a historical reference value set based on the calculated average water level observed during the 1990s (Al-Noaimi, 1993). Again, the observed trend indicates that the progress achieved is insufficient to meet this value.

3.7. SDG 6 means of implementation targets

The means of implementation targets may be defined as a set of coherence policies and measures, finance, capacity building, technologies, innovations, trade, level of stakeholder participation, and robust national data collection systems that are required to be mobilised in order to support the implementation of the water and sanitation goal. SDG 6 comprises two means of implementation targets: target 6.a on cooperation and capacity building, and target 6.b on stakeholder participation. These targets are closely integrated with SDG 17 targets, which address the means of implementation of all SDGs goals, and are supported by two additional global indicators to report on their progress. In the following paragraphs, the means of implementation targets and their global indicators will be discussed.

3.8. Target 6.a international cooperation and capacity building

By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination water efficiency, wastewater treatment, recycling and reuse technologies. Expanded international cooperation and capacity building support are vital to accelerate progress on achieving SDGs targets. This target is being measured by indicator 6.a.1, which focuses specifically on the, external financial and capacity building support for developing countries in water and sanitation.

3.8.1. Indicator 6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan

The amount of water- and sanitation-related official development assistance that is part of a government coordinated spending plan is expressed here as the proportion of total water and sanitation-related Official Development Assistance (ODA) disbursements that are included in the government budget (UNSD, 2017). A low indicator value indicates that international aids on water and sanitation are not appropriately aligned with government plans for water and sanitation, while a high value would suggest that these aids are aligned with the government spending on this sector. In quantitative financial terms, ODA is used here as a "proxy" for international cooperation and capacity development support.

As mentioned, the indicator focusses on the international financial support directed to the developing countries. Given its socio-economic status and high GDP per capita level, Bahrain do not receive overseas development assistance directly from international donors. Therefore, this indicator may be not applicable to the Bahrain situation. However, in 2011, the Gulf Cooperation Council (GCC) endorsed the so-called "Gulf Development Programme" – a 10-year regional development plan aimed at financially supporting the Kingdom of Bahrain and Sultanate of Oman to promote economic and infrastructure development.

Concerning Bahrain, a major amount of this financial assistance is directed to water and sanitation projects and constitutes part of the government coordinated spending plan on water supply, wastewater and sanitation, and water resources management. The available data on these flows are not sufficient to assess and monitor this target. On the other hand, the question of whether these amounts are included in indicator 6.a.1 or not is still open for debate.

3.9. Target 6.b stakeholder participation

Support and strengthen the participation of local communities in improving water and sanitation management. Stakeholder participation in all aspects related to water and sanitation services is essential to ensure the sustainability of these services. Participation implies provision of mechanisms to enable affected individuals and communities to contribute meaningfully to decisions related to water and sanitation planning and management (UN-Water, 2018). Target 6.b is monitored by indicator 6.b.1, which addresses the need for the effective participation of local communities and other stakeholders on matters associated with water and sanitation.

3.9.1. Indicator 6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

Indicator 6.b.1 is proposed to evaluate target 6.b. It measures the proportion of local administrative units having established policies and procedures for the participation of local communities in water and sanitation management. A low proportionate value of this indicator would suggest that participation of these communities in water planning and management is marginal; the opposite would indicate high participation of local communities. This indicator is strongly interlinked with indicator 6.1.1 on drinking water, indicator 6.2.1 on sanitation services and, more importantly, with indicator 6.5.1 on the implementation of IWRM.

Owing to the political, geographical, and social environments dominant in Bahrain, public and stakeholder participation play a minimal role in water planning and management. To a certain degree, this indicator is built on the data collected for the status of IWRM reporting in SDG target 6.5. On the answer to Question 2.1.c, of the 2017/2018 IWRM questionnaire, regarding public participation in water resources policy, planning and management at national level, Bahrain reported medium low (40), meaning that government authorities only occasionally request information, experience, and the opinions of stakeholders.

In the same section "Institution and Participation", the answer to Question 2.1.d on the business participation on water resources development, management and use at national level, was zero (0) or very low, which indicates that there is no communication between government and business about water resources development, management, and use. Finally, Question 2.2.b of the same section, also addressing public participation in water resources, was considered not applicable to the Bahrain situation.

4. Conclusions and recommendations

The 2030 Agenda for sustainable development is an ambitious, aspirational, and indivisible in nature global development plan of action that aims to transform our world drastically. Water and sanitation are at the core of sustainable development. Therefore, water is evident as a cross-sectoral issue that affects the achievement of all the other 16 SDGs. In this paper, progress towards achieving SDG 6 targets in the Kingdom of Bahrain was assessed and monitored using a trend analysis approach for time series data covering the period from 2000 to 2016. This research has provided a realistic baseline and sound methodology for monitoring and reporting on SDG 6 targets. The major findings, key challenges, and recommendations of this research are as follows:

- It becomes evident that natural water scarcity, high population growth rates, accelerated socio-economic development, non-efficient water use, shortages in financial outlays, and the lack of adequate technical and institutional capacities are the crucial factors hindering or decelerating progress on achieving SDG 6 targets.
- The monitoring results have shown that progress on achieving SDG 6 targets varies significantly.
- Bahrain has fully achieved the targets of increasing the coverage of population who have access to safely managed drinking water and sanitation services, and halving the proportion of untreated wastewater, well ahead of the SDGs deadlines.
- In contrast, progress achieved in targets related to the protection and restoring of water-related ecosystems, reducing water pollution, and increasing recycling and safe reuse are considerably lagging behind at various degrees of implementation.
- Evidence shows that disposing of large quantities of secondary treated effluents of somewhat inferior quality to the marine environment has resulted in severe environmental problems. Although efforts are assumed to be already under way to substantially upgrade the TWPCC, there exists a need at this stage to establish an efficient wastewater reuse programme to coordinate and optimise safe wastewater reuse and sludge management, and to reduce wastewater discharge into the environment. Moreover, some gaps remain to be addressed with regard to the status of water quality monitoring programmes and laboratory infrastructures, including the nonexistence of an independent quality regulator and/or a surveillance agency.
- Also noteworthy is the importance of enhancing the national capacity about data collection and analyses, and analytical capabilities. Greater efforts are needed to improve laboratory infrastructures and quality assurance measures. More efforts are also needed to establish effective intersectoral coordination on issues related to water quality monitoring and analyses of data. Building on the existing positive changes in the groundwater quality is also imperative.
- Our monitoring efforts indicate that progress towards attaining the targets associated with water use efficiency and water scarcity are falling short. Trends in water use efficiency reveal that the economy is growing more than the water use efficiency, indicating low efficiency and that more water is proportionally needed for economic growth. Unexpectedly, the agriculture sector demonstrates remarkable progress, while the services sector shows the weakest performance. This means that greater efforts are necessary to improve water use efficiency in the various economic sectors.
- In spite of the water supply augmentation during the last three decades, Bahrain is still a seriously stressed country. Reducing the level of water stress should remain a priority over the SDG targeted time-reference.
- An important finding is that, despite the progress made in enhancing the enabling environment for water resources planning and management, implementation of IWRM is still facing enormous challenges. Much work remains to be done in the strengthening of the technical and institutional capacities and enhancement of the legal and policy instruments. Additional investments and provision of sufficient financial resources are also needed to accelerate progress in all aspects of SDG 6.
- Stakeholder involvement in water resources planning and management is significantly falling short. Further efforts are necessary to ensure effective stakeholder participation in various issues of water management.
- Finally, and most importantly, although a large amount of water data and related statistics were made available for our analyses through the BWRDB that assist in the establishment of a baseline for monitoring progress on SDG 6, strengthening of the national statistical capacity and creation of a harmonised data collection system should be deemed necessary to fill data gaps and solve discrepancies; thereby allowing for more effective progressive monitoring. In this context, the incorporation of census data and household surveys (monitoring at consumer level) may be considered to supplement the available data and to facilitate micro-analysis that might improve the monitoring capability.

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