The SDGs in practice: Measuring and managing sustainable development water targets

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Abstract

A framework and associated suite of indicators that reflect the use by different sectors in an integrated and policy-relevant way is needed to identify opportunities for development opportunities as well as to measure progress towards water-related targets of the Sustainable Development Goals. This paper presents a framework and approach to cost-effectively develop baselines, strengthen national reporting systems, and monitor national progress towards achieving SDG 6.4 and 6.6 specifically while also informing other SDG 6 targets.

Introduction

The Sustainable Development Goals (SDGs) of the UN’s 2030 Agenda for Sustainable Development recognize increasing global water insecurity and the importance of water management for development through the inclusion of a water goal, as well as various water-related targets across other goals. The dedicated water goal, SDG 6, which sets out to “ensure availability and sustainable management of water and sanitation for all”, moves away from the MDG focus on drinking water and sanitation to cover the entire water cycle. In addition to targets which build on the MDGs and address access to water and sanitation, Targets 6.3 to 6.6 address the broader water context which was not explicitly included in the MDG framework and includes water quality and wastewater management, water scarcity and use efficiency, integrated water resources management and the protection and restoration of water-related ecosystems. Importantly, two targets are also included on the means of implementing these outcome targets and address the importance of an enabling environment, the means of implementation, the needs for international co-operation and capacity building, and the participation of local communities.

Water is at the core of sustainable development, and as such SDG 6 has strong linkages to all of the other SDGs; a central challenge to achieving sustainable development is how to balance the competing uses of water, while maintaining healthy ecosystems. Attaining the SDGs requires not only a comprehensive understanding of these interactions, but also minimizing the trade-offs between them. Although the development challenges addressed by the SDGs such as food security and the sustainable management and use of water, marine and terrestrial ecosystems are addressed through different goals, the 2030 Agenda is described as an “indivisible whole” and the delivery of many of the goals is dependent on addressing interlinkages and identifying pressures within connected systems. In addition to environmental requirements, water is needed for agriculture, domestic use, and energy production. These uses are all interlinked and potentially in competition, and integrated water resources management is essential to harness synergies as well as to manage potential trade-offs across sectors and to ensure availability and sustainable management of water for all (UN Water 2016).

While several global initiatives currently exist which focus on monitoring various aspects of the water sector, a coherent framework is missing. The sustainable and efficient management of water resources requires a framework which can integrate and expand existing monitoring efforts, is applicable to a wide range of contexts, and enables reporting on global progress towards SDG targets. It is not feasible to express the use of water in complex river basins through a handful of indicators - a suite of indicators, rather than a single indicator needs to be used for monitoring progress towards sustainable water use, while maintaining healthy ecosystems. While the indicators need to rely on national data, their quantification needs to be complemented with advanced data sources and new cost-effective ways for data collection. Many countries have let their water monitoring networks decline for decades due to under-funding and low priorities, and currently, water resource monitoring is well below the levels needed to establish baselines and measure progress across much of the world. Remote sensing measurements, smart field sensors, ICT technologies and open access databases create complementary opportunities to express water resources quantitatively. Recent advances in data measurements and in water accounting science have contributed to new opportunities to make use of these concepts in the context of the water related SDGs.

A water accounting approach

Water accounting quantifies how much water is in a system, where, when and in what quality it is available, how much is demanded and consumed in time and place, and how well it is currently managed with respect to meeting those demands. Water accounting (WA) has emerged as an important tool to understand water availability and use and is practiced in some form in every managed watershed, although frameworks and available information vary hugely from one country to another. Water accounting is a means to provide a water resources assessment report on a regular time interval (months, seasons, years), essential for the identification of the major water related processes (such as water availability and withdrawals), thus providing an improved understanding of which water resources are exploitable, available and utilizable at the national level. Quantified water accounts can be used to set management targets, and subsequently to monitor these targets.

Water Accounts are applicable to a wide range of users across the water sector, and are essential for evidence based decision making. They allow donors to identify the impact of their investments; water managers to define and track targets; water planners to assess the impact of drought, climate and land use change; basin authorities to get a better understanding of what is happening in their basins; and government agencies to measure baselines and identify progress towards national level targets. In terms of the SDG goals, those dealing with water resources management bear the most direct links to water accounting. Within Goal 6 relevant targets include 6.4 on increasing water-use efficiency, 6.5 on implementing integrated water resources management, and 6.6 on protecting and restoring water-related ecosystems. Beyond Goal 6 targets of relevance include 2.4 on ensuring sustainable food production systems and implementing resilient agricultural practices that increase productivity and production, and 15.1 on ensuring the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services.

While water accounting has emerged in recent years as a key approach to understanding water scarcity and identifying gaps and inefficiencies in water management, few countries have adopted sound and conceptually valid water accounting mechanisms. This is usually due to the lack of data needed to implement traditional approaches which rely on national level statistics and datasets which are typically fragmented and inconsistent. The System of Environmental-Economic Accounts for Water (SEEA-Water), for example, is a sub-system of the SEEA and provides a set of agreed concepts, definitions, classifications and accounts for water, through a conceptual framework for organizing hydrological and economic information in a coherent and consistent manner. Various countries with mature national reporting systems already implement national level water accounting on a regular basis. The Australian Water Accounting Standard (AWAS), for example, was developed by the Water Accounting Standards Board (WASB) of the Australian Bureau of Meteorology (BOM) as part of the National Water Initiative (NWI) and is based on several aspects of the SEEAW. A review of international water accounting frameworks has assessed the applicability of the various frameworks for implementation in South Africa (Clark et al. 2015).

SEEAW and other water accounting systems focus on flows in rivers, canals and utilities, and ignore the key biophysical processes in the natural part of watersheds that generate the renewable water resources. Incomplete and partially accessible water flow data in ungauged or poorly gauged basins is a fundamental problem in understanding hydrological processes and managed water flows in many parts of the world, and is one of the main reasons for the absence of operational national level water accounting systems. In addition, the integration of data and information across sectors that depend on access to water remains a challenge. In order to overcome the difficulty in measuring all water flows and fluxes in a river basin with multiple water users, a new framework, referred to as Water Accounting Plus (WA+) has been developed over the past few years. This approach is not reliant on national level statistics and characterizes the water resources situation for locations where hydrological monitoring networks are scarce. Developed by the International Water Management Institute (IWMI) in partnership with UNESCO-IHE, WA+ uses global hydrological models and public domain remote sensing datasets to analyze the water flows, fluxes, stocks, consumption, and services from complex river basins or at the national scale (Bastiaanssen 2009 and Karimi et al. 2013).

An indicator framework for monitoring progress towards water related goals

Over the past few years the increasing availability of data from Earth Observation satellites and derived thematic products such as Evapotranspiration (ET) has dramatically changed our ability to quantify water resources at different scales. With many countries facing increasing water scarcity, there is an urgent need to describe water resources in a standard context, using clear terminology and in a framework that is internationally recognized and accepted. In many parts of the world, however, operational water resource assessment and reporting systems are in their infancy. Addressing this gap, WA+ is designed with the following characteristics: based on open source data of consistent, uniform quality; uses standard and verifiable data acquisition methodologies; reports in formats and standard terms which are understandable for managers and policy makers across different sectors; is affordable for developing countries. Earth observation measurements secure the input data, so that similar analyses with a consistent data quality can be provided for different locations. Particular advantages of using an Earth Observation based approach include the measurement of large areas in a routine manner, and the data are publically verifiable and accessible ensuring access to data under all circumstances; and instead of hydro-meteorological measurements at point based locations with limited spatial representation, area integrated values of water balance components can be estimated.

The WA+ approach provides a coherent and consistent water resources reporting methodology, expressing the state of water by means of thematic sheets, tables, maps and geospatial data. A series of indicators are presented in thematic components which can be linked to decision making in different sectors, with water as the entry point. These thematic areas are shown in Figure 1 and detailed in Table 1.

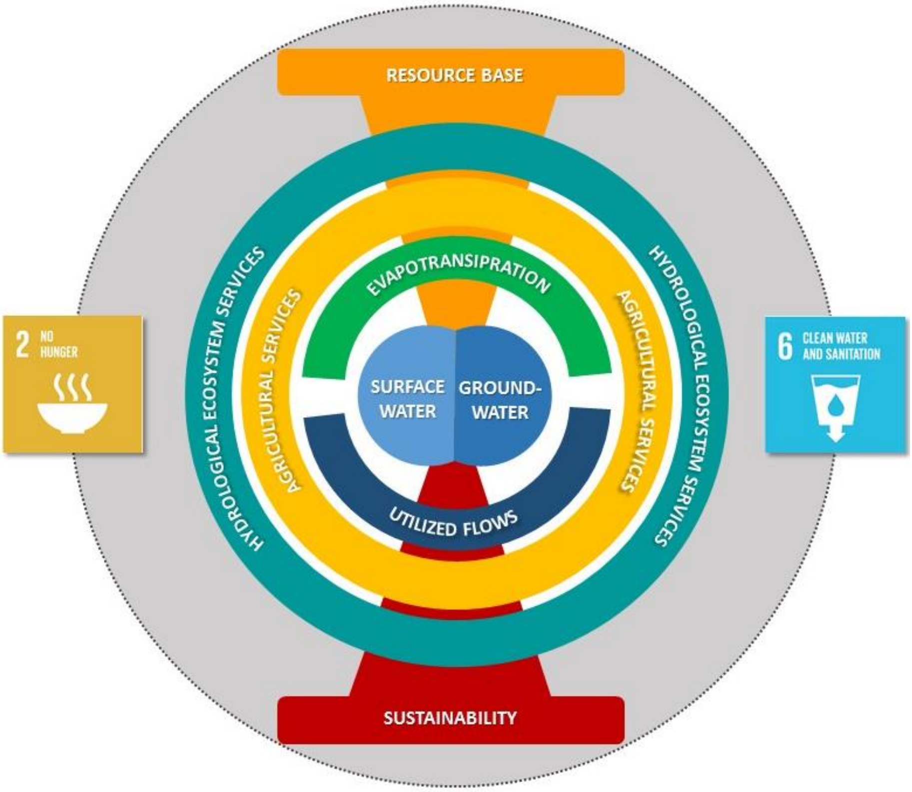

Figure 1: The Water Accounting + framework in the context of the Sustainable Development Goals

Table 1: WA+ Thematic Components

Component	**Thematic purpose**	**Hydrological processes**

Resource base	Overview of resource exploitation, unmanageable, manageable, exploitable, reserved, utilized and utilizable flows; separation of landscape ET (from rainfall) and incremental ET (from manmade and natural withdrawals); quantification of atmospheric recycling	Rainfall, evaporation, storage, outflow, net withdrawals, atmospheric moisture flow
Evapotranspiration	Identification of water consumption by land use class and user groups; manmade impact on ET, beneficial and non-beneficial consumption; breakdown of beneficial consumptive use in agricultural, ecological, economy, energy, leisure	Evaporation from soil and water bodies, transpiration, and interception
Agricultural services	Overview of food production; assess land productivity and relative water productivity; identify possibilities for saving water in agriculture, with an emphasis on non-beneficial water consumption and shifts from irrigated to rainfed crops and agroforestry systems	Land productivity, consumptive use and water productivity
Utilized flows	Identify multiple uses of water; provide an overview of all manmade and natural withdrawals; distinguish between consumed and non-consumed water, recognizing recoverable and non–recoverable flow; quantify terrestrial water recycling	Withdrawals, consumptive use, return flow, drainage, recharge, water quality degradation
Surface water	Defines surface water availability and utilizable withdrawals at any location	Runoff, drainage, withdrawals, actual flow, virginal flow, return flow, storage changes

Groundwater	Asses the role of groundwater in renewable water resources; assess aquifers as a storage reservoir for droughts and a buffer for floods through managed aquifer recharge; identify safe groundwater withdrawal plans	Recharge, withdrawals, return flow, lateral flow
Hydrological Ecosystem Services	Maintain hydrological ecosystem services	Recycled rainfall, surface runoff, baseflow, river flow, water yield, erosion, exchanges between land and atmosphere, i.e. greenhouse gases (H20, CO2, CH4, N2O), carbon sequestration, water storage capacity
Sustainability	Monitor changes in levels, volumes and stocks, changes in duration and extent of floods and droughts, changes in land use, changes in agricultural and environmental services	Time series of rainfall, soil moisture, land use changes, ET anomalies

A key objective of the framework is to provide the information required by decision makers to determine water availability and to identify sustainable pathways for the management of the resource. As a result, the WA+ framework is of direct relevance to SDG 6, while the linkages between SDG 6 and 2 and the focus of a thematic component within the framework on agricultural services (see Table 1) provides information needed to identify opportunities to improve food security and to inform the sustainability of agricultural practices using water as an entry point. The delivery of many of the SDG goals is dependent on addressing interlinkages and identifying pressures within connected systems. Due to the multi-sectoral uses of water, as well as the transboundary nature of the resource pursuing goals in one country can interact with the goals of others. An indicator framework which enables consistent assessments of water use and availability beyond national borders is essential to address interlinkages and trade-offs, identify pressures and ensure that ecosystem health is maintained. While the WA+ framework provides the information needed to identify sustainable development opportunities using water as the entry point, determine baselines and measure progress to various SDG targets, the remainder of this paper will focus on a single thematic component - the assessment of water use in agricultural production and opportunities for improving agricultural water productivity.

Agriculture is the largest user of water, using approximately 70 percent of all fresh water withdrawals globally, and up to 95 percent in several developing countries (FAO 2014). Efforts are increasingly being made to identify opportunities to improve agricultural yields and water productivity (although improvement in one does not necessarily translate to an improvement in the other) to enable reallocation of water from agriculture to other users. Such efforts, however, are often less successful than expected due to inadequate analysis of actual water consumption and the interaction of multiple water users at different scales of analysis (ref). The agricultural component of the WA+ framework (Figure 1 and Table 1) is designed to address these issues.

Implementation of the WA+ framework has been undertaken in the Nile Basin over the six-year period from 2005 to 2010 (Baastianssen et al. 2014). Analysis of the results demonstrate that almost all of the rainfall within the basin is consumed through evapotranspiration (ET), with between 2 percent (in 2010) to 3.6 percent (in 2006) available as runoff (blue water) for allocation. An important advantage in using Earth Observation data as input is the spatially discrete nature of the indicators. The maps in Figure 2 shows the rainfall surplus and provide an indication of the areas that are important for generating runoff (and thus supporting water availability for downstream users) and those that support natural processes and have a high ET. The Ethiopian highlands, for example, have a high rainfall surplus each year, while the numerous lakes and wetlands across the basin (such as Lake Victoria and the Sudd wetland) have a high annual ET.

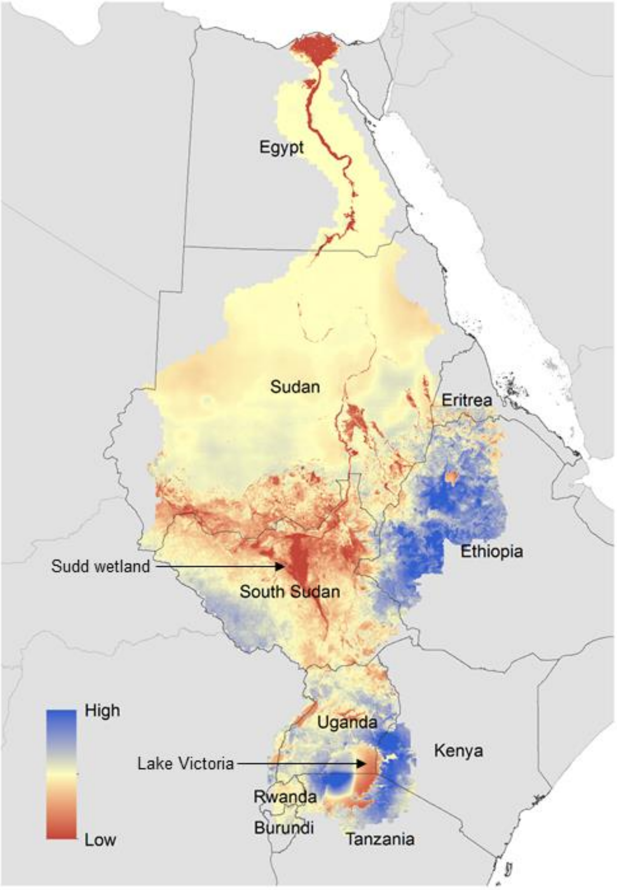

Figure 2: Precipitation surplus in the Nile basin, 2005-2010

Of the available water, 76 percent is used for irrigated agriculture. The majority of the ET (around 93 percent) supports natural processes (savanna and wetland ecosystems), with about 7 percent used in rainfed cultivation. Irrigated agriculture uses a large proportion of the available (blue) water, ranging from 65 percent in 2006 (a wet year), to over 100 percent[1] in 2010 (a dry year). In 2006 there is a large outflow to the Mediterranean, and a large increase in storage (e.g. Lake Victoria and Lake Nasser). In contrast in 2010 outflow is negligible and a decline in storage occurs.

Further analysis of the spatial data enables the derivation of additional key indicators, which allow for assessments of crop water use. Within the agricultural services component (see table 1) land[2] and water[3] productivity (WP) are important indicators to assess agricultural productivity and water use in agricultural production, and to determine whether is it possible to increase the agricultural production per unit of water. Within the Nile basin countries, the WP of irrigated crops is only marginally higher than that of rainfed crops, leaving room for improvement. Within the evaporation component of the framework (see Table 1) the ET for each land use type is further separated into two metrics; evaporation[4] and transpiration[5]. The ratio of these provides important information on agricultural water use, and can be used to identify options for management interventions when analyzed for individual crop types in different locations. Across the Nile the ratio of transpiration to evaporation is similar for both rainfed and irrigated crops – targeting the application of irrigation water would improve this and could result in water savings.

As the water accounts are produced in a consistent format on an annual basis with input data available from circa 2000, national baselines can be determined from this point and annual changes can be assessed against these. The indicators derived from Earth Observation datasets of precipitation, evapotranspiration and biomass growth are key to identifying options for improved land and water management while maintaining ecosystem services. Agricultural productivity and water productivity are used here as an example, as they are integrative indicators for several of the SDGs and associated targets. In particular, water productivity improvements can effectively address food insecurity, secure water resources for other landscape uses including ecosystem services (Molden et al. 2010).

Conclusion

Achieving the water related SDG targets will require establishing baselines, identifying intervention options, and monitoring progress towards goals. Access to accurate and up to date information continues to be a serious constraint for integrated water management, and national level water resource monitoring and reporting systems providing consistent data are typically unavailable in the areas where the development challenges are greatest. There is therefore an urgent need for national (and transboundary) water information systems which describe water resources in a standard context using clear terminology and in a framework that is internationally recognized and accepted. The WA+ framework presented in this paper has been designed to address this gap and to provide a national level monitoring and annual reporting system. Key features of the framework include the use of open source data of consistent, uniform quality; standard and verifiable data

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[1] Can exceed 100% because of inter-annual water storage in the basin (reservoirs and aquifers)

[2] Biomass production is used here to calculate yield equivalent of crops (kg per ha)

[3] Defined here as physical mass of production per unit volume of water consumed (kg per m^3)

[4] Evaporation is the process whereby liquid water is converted to water vapour and removed from the evaporating surface. Water evaporates from a variety of surfaces, such as lakes, rivers, soils and wet vegetation (FAO 2016).

[5] Transpiration consists of the vaporization of liquid water contained in plant tissues and removal of the vapour to the atmosphere (FAO 2016).

acquisition methodologies; standard reporting formats and indicators which are understandable for managers and policy makers across different sectors. Importantly, the framework is not costly to implement and is thus affordable for developing countries. One of the main challenges in developing these new sources of information will be to ensure their ownership and full integration within any national water monitoring and reporting mechanisms.

A major challenge in progressing towards the water-related SDGs targets will be to ensure that a balance is achieved between the competing uses and users of water for various purposes, meeting both human needs while maintaining ecosystem health. Mobilizing the water resources needed to achieve various SDGs will require informed decisions within the water sector and in related sectors in order to balance water use and requirements among sectors (Rebelo et al. 2014). The central focus of the framework described in this paper is the determination of water balances at a range of scales (from national to transboundary basin) in order to identify water withdrawals, depletions and productivity (Molden and Sakthivadivel 1999; Karimi et al. 2012) as well as hydrological ecosystem services. Understanding of these water resources parameters and their interactions is fundamental to the development of effective and sustainable water management pathways.

Bibliography

Clark, D.J, Bastiaanssen, W.G.M., Smithers, J.C. and Jewitt, G.P.W., 2015. A Review of Water Accounting Frameworks for Potential Application in South Africa, South African Water (*under review)*

Bastiaanssen, W.G.M., Karimi, P., Rebelo, L-M., Duan, Z., Senay, G., Muttuwatte, L. and Smakhtin, V. 2014. Earth Observation-based Assessment of the Water Production and Water Consumption of Nile Basin Agro-ecosystems, Remote Sensing, 6:10306-10334, doi:10.3390/rs611103

FAO 2014: AQUASTAT database, Food and Agriculture Organization of the United Nations.

FAO 2016: Introduction to Evaporation, http://www.fao.org/docrep/x0490e/x0490e04.htm

Karimi, P., Molden, D., Bastiaanssen, W.G.M. and Cai, X. 2012. Water accounting to assess use and productivity of water – evolution of the concept and new frontiers. In Water accounting: International approaches to policy and decision-making, Chalmers, K., Godfrey, J., Eds. Edgar Elger: Cheltenham, UK, pp 76-88

Karimi, P., Bastiaanssen, W. G. M. and Molden, D. 2013. Water Accounting Plus (WA+) – a water accounting procedure for complex river basins based on satellite measurements, Hydrology and Earth System Sciences, 17:2459-2472

Rebelo, L.-M., Johnston, R., Karimi, P. and McCornick, P.G. 2014. Determining the dynamics of agricultural water use: Cases from Asia and Africa. Journal of Contemporary Water Research and Education, 153:79-90

Molden, D. and Sakthivadivel, R. 1999. Water Accounting to Assess Use and Productivity of Water, International Journal of Water Resources Development, 15:55–71, doi:10.1080/07900629948934

Molden, D., Oweis, T., Steduto, P., Bindraban, P., Hanjra, M. A., Kijne, J. 2010. Improving agricultural water productivity: between optimism and caution. Agricultural Water Management, 97:528-535

UN Water 2016. A Dedicated Water Goal, http://www.unwater.org/sdgs/a-dedicated-water-goal/en/