Water Accounting (WA) Dashboard
A User Manual
October, 2024

1.What is a WA dashboard?

The water accounting dashboard provides detailed multi-year water accounts of a basin's water resources including inflows, outflows, water use patterns and availability, to establish baseline conditions. It can also compare baseline and future water accounts (where available), to provide stakeholders with an understanding of the current and potential future water resources status.

The platform leverages advanced data visualization tools to offer user-friendly access to complex information, empowering stakeholders to understand the dynamics between various water-balance parameters. In addition, the dashboard was designed to ensure that it caters to stakeholders of diverse backgrounds and expertise, from policymakers to scientists. Stakeholder feedback was incorporated to enrich the platform's accessibility and user experience to enable active participation and engagement.

This web-based dashboard represents one of the tools that could be used in promoting effective stakeholder deliberation of water balance information for sustainable water resource management.

2.Why do we need a WA dashboard?

Water resource management is an essential global challenge, necessitating a comprehensive and inclusive approach to address the diverse needs of the stakeholders involved. Stakeholder deliberation is crucial in fostering cooperation and informed decision-making for sustainable water management. However, lack of hydrometeorological observations often limits our understanding on the complex interlinkages between competing demands for water in the basin or a country. To overcome the challenges of water data scarcity in managing water resources, the International Water Management Institute is generating reliable and systematic analysis ready water data products on water use, demand, water availability and scarcity using water accounting plus (WA+) framework. The water accounting plus (WA+) approach (Karimi et al., 2013) derives basin scale water availability and scarcity indicators using earth observation data products and limited in situ observations. The WA+ framework is an open-source python programming-based model that uses a collection of remote sensing data products and in situ data to quantify water accounting indicators such as a) water yield, b) irrigation/rainfed water use, c) productive/unproductive water use, and other water availability indicators at river basin scale. Continental water accounting plus (CWA+) is a modified version of WA+ where the water accounting indicators can be generated for any given boundary (catchment, or a country or a county).

The suite of water data generated by water accounting studies provides several new insights into water availability and scarcity indicators at continental scale. The availability of open source codes enables repeatable and rapid water accounting assessments without much effort. IWMI's WA dashboard is a web-based dashboard built using Tableau technology to enhance stakeholder engagement and facilitate effective deliberation by summarizing and communicating the key water accounts basin.

3. Key Elements of the WA Dashboard

There are five key elements in a WA dashboard:
  i)   Basin overview
  ii)   Water availability
  iii)   Water balance
  iv)   Monthly water balance
  v)   WA indicators.

Mujib Basin

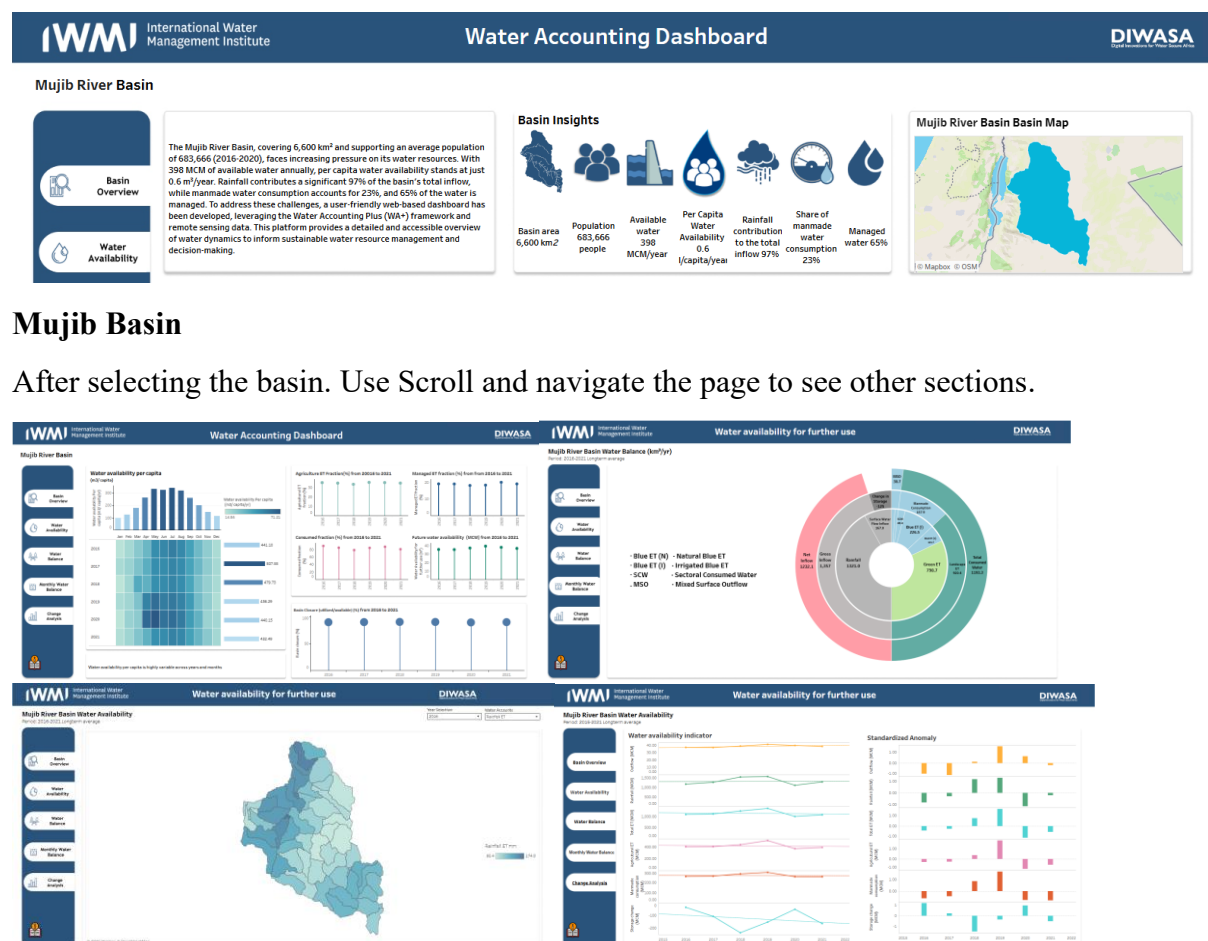After selecting the basin. Use Scroll and navigate the page to see other sections.

Figure 1. Illustration of the water accounting dashboard for Basin.

The description of each element and the contents of water accounts displayed under each element are presented in detailed here.
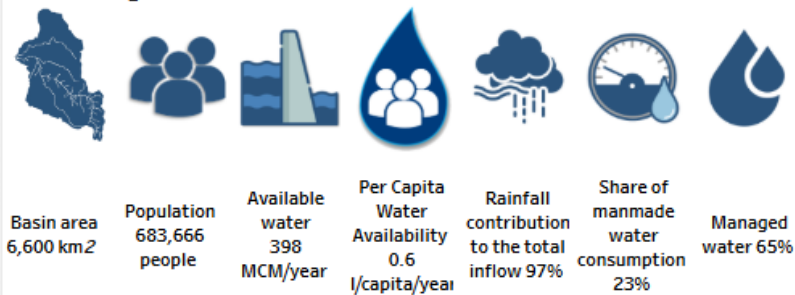
3.1 Basin Overview

The landing page of the dashboard provides the basin overview information. Several key baseline statistics on the river basin are provided on this page. The description of each section is provided here.

The Mujib River Basin, covering 6,600 km² and supporting an average population of 683,666 (2016-2020), faces increasing pressure on its water resources. With 398 MCM of available water annually, per capita water availability stands at just 0.6 m³/year. Rainfall contributes a significant 97% of the basin's total inflow, while manmade water consumption accounts for 23%, and 65% of the water is managed. To address these challenges, a user-friendly web-based dashboard has been developed, leveraging the Water Accounting Plus (WA+) framework and remote sensing data. This platform provides a detailed and accessible overview of water dynamics to inform sustainable water resource management and decision-making.

Basin description: The basin overview page provides a brief synopsis of the dashboard. A basin description is provided to give a brief account of the basin hydrology and highlights important hydrologic challenges in the basin.

Figure 2. The description of the basin provided on the basin overview page

Basin Insights

| Basin area 6,600 km2 | Population 683,666 people | Available water 398 MCM/year | Per Capita Water Availability 0.6 l/capita/year | Rainfall contribution to the total inflow 97% | Share of manmade water consumption 23% | Managed water 65% |

Basin Insights: The middle central portion of the basin overview page provides basic information on basin insights such as basin area, population, per-capita water availability etc.

Figure 3. The basic information on basin insights

Mujib River Basin Basin Map

© Mapbox © OSM

Basin Map: Here users can see an interactive map of the river basin. The users can zoom in and out of the basin area overlaid on the world map using the + and – symbols. The home icon on the map will reset the map to the full extent of the basin. The triangle icon offers additional features for interacting with the map.

Figure 4. Interactive map of the basin

Land Usage (km²)

Urban 1%
Agriculture 19%
Natural 80%

- Agriculture
- Natural
- Urban
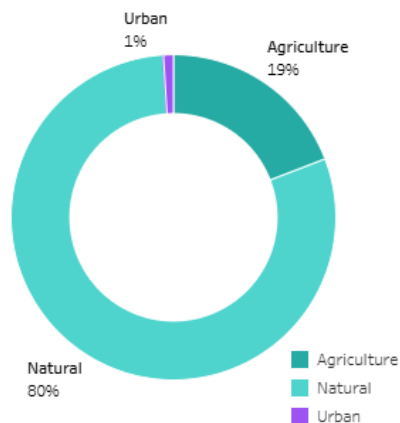
Land usage: The distribution of land use classes across the basin are provided in a double pie chart. In the outer pie chart, different landcover classes are reclassified into four broad classes of land use for water accounting (LUWA) classes. 1) The Utilized land represents natural landscapes that are utilized in their natural forms, without modifying or altering water and land resources. For example, humans utilize forests, grasslands, and shrub lands for grazing. 2) The Managed water class represents areas that are managed for agriculture where water is highly managed, such as irrigation. 3) The Modified land represents area where land is modified for
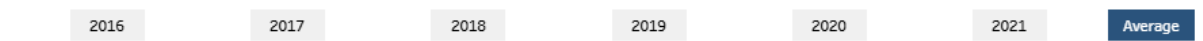
human use. For example, the natural landscapes are cleared/modified to grow crops under rainfed conditions. 4) Protected land use defines the area that is classified as protected such as national parks or other preserved areas.
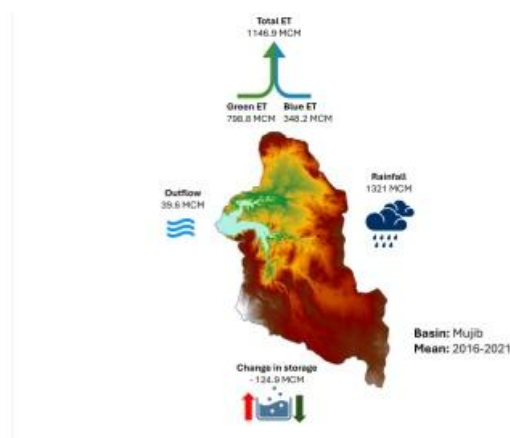
The inner pie chart shows the distribution of various classes that are classified/grouped into the board four categories.

Year Selection: The year selection tab helps users access overview of water balance and basin water yield information. The users can click and toggle between years to compare how water balance can changes over time.

Year selection

| 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | Average |

Mujib River Basin Water Balance

Total ET 1146.9 MCM
Green ET 798.8 MCM Blue ET 348.2 MCM
Outflow 39.6 MCM
Rainfall 1321 MCM
Basin: Mujib Mean: 2016-2021
Changes in storage -134.9 MCM

Water Balance: The water balance figure shows modeled estimates of key water balance terms. Each figure is specific to the year selected on the year selection tab. The dark blue colored downward arrow represents the total volumetric annual precipitation (P, in km3) received in the basin. The light green colored upward arrow represents total volumetric evapotranspiration (TotalET, in km3). The lighter blue upward arrow represents BlueET (Blue ET, in km3), a portion of total ET, occurring from the blue water sources (surface water bodies, river, lakes or shallow groundwater aquifers). The small dark green upward arrow represents, Rainfall ET or Green ET (in km3), a portion of total ET occurring from the green water sources (soil moisture replenished by the rainfall). The sum of Blue ET and Ranifall ET is equal to the total ET. The empty blue colored arrow represents basin

outflow (in km3) and the storage change denotes the changes in the basin storage due to either groundwater abstraction (+ve value) or groundwater recharge (-ve value).


Mujib River Basin Water Yield (mm/year)
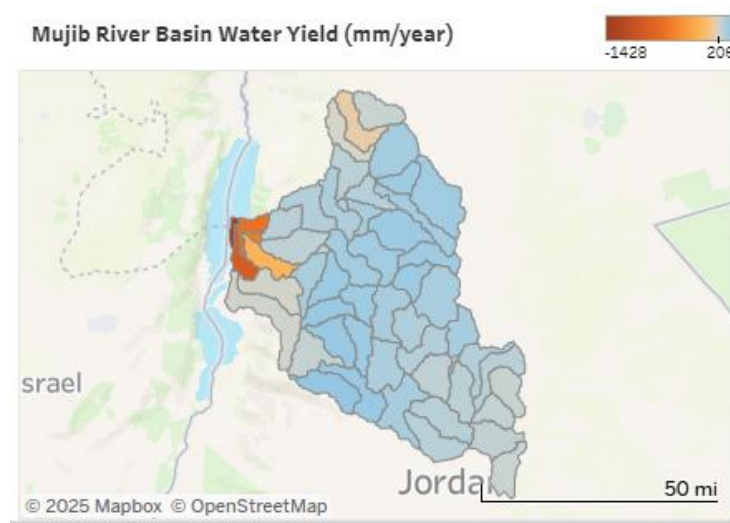
Water Yield: The map shows the water yield obtained from the water accounting analysis. The water yield is defined as water that is available after meeting landscape water requirement (landscape ET). This is the amount of water that can be exploitable for human needs. The map shows water yield for administrative regions within the basin. Some regions shows negative values (shades of red), which indicate that at annual time scales there is not water available. Other regions show positive values (shades of blue) which indicate that at annual time scale, water availability for human needs is not a problem. Such information is important to understand spatial variability of water availability within the basin. The blue areas are also called water towers of the basin are the regions that provide most water to the river and where future activities such as irrigation development or canals for diverting water can be constructed.

3.2 Water Availability

Information on water availability in a river basin is crucial for understanding various aspects of human, environmental, and economic well-being. Through this dashboard, water availability in a river basin is summarized using indicators of water availability for a) humans b) environment c) agriculture and d) other uses.
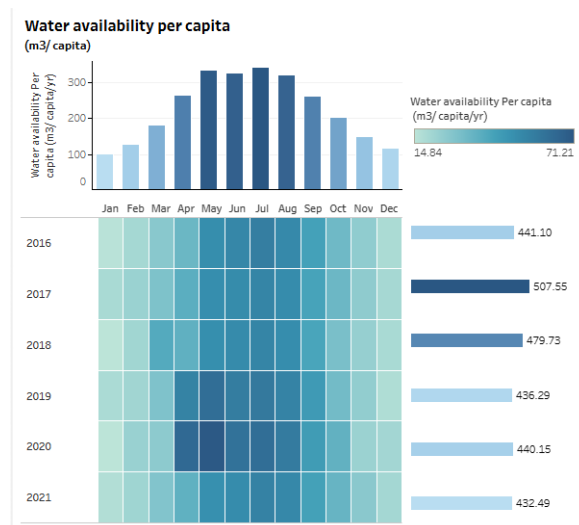
Water availability per capita is highly variable across years and months

Water Availability Per Capita (m3/per capita): Water availability per capita refers to the amount of freshwater resources available for each person in a specific region or country. It is typically measured in cubic meters (m³) per person per year and is an important indicator of a region's or country's ability to meet the water needs of its population while also supporting economic and environmental demands. Calculating water availability per capita involves dividing the total annual freshwater resources of a region or country by its population. Within water accounting, we derive water availability per capita as

$$\text{Water Availability Per Capita} = \frac{available\ water}{Population}$$

The water availability per capita is estimated is presented at monthly and annual timescales from 2009 to 2018.

The annual total per capita water availability is presented to the right side as horizontal bar plots. The monthly average per capita water availability is presented on the top as the vertical bar plots.

*Water Availability for further use (MCM)*

Future water availablility (MCM) from 2016 to 2021
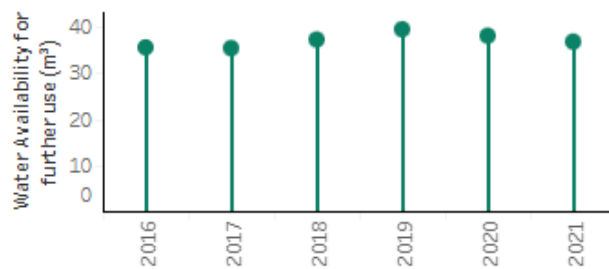
The water available for further water resources development highlights the water scarcity in the basin. The estimates presented in the figure quantifies the amount of water available after meeting all the basin demands of nature via landscape evapotranspiration, rainfed agriculture, domestic and industrial demand and irrigated water use. This is the volume of water that can be used for planning any basin developmental activities such as additional diversion for domestic and industrial water use, additional irrigation development etc.

Managed ET fraction (%) from from 2016 to 2021
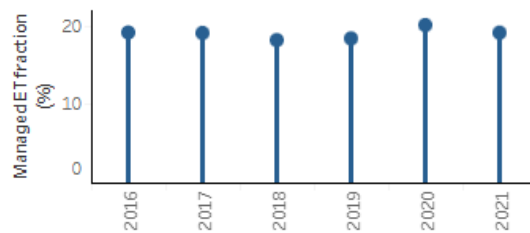
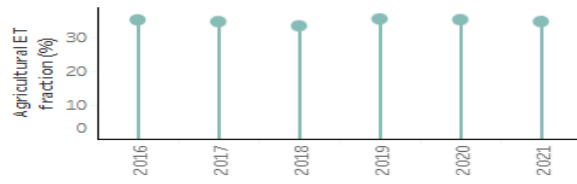*Managed Evapotranspiration Fraction*

The ET processes in a basin that could be manipulated by land use, cultivation practices and water withdrawals. This allows for more effective water management and conservation strategies in agricultural and land management practices
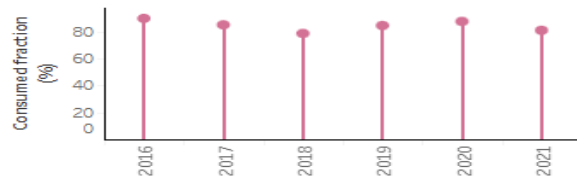
$$\text{Managed ET Fraction} = \frac{ET\ Managed}{ET}$$

Agricultural Evapotranspiration Fraction

Agriculture ET Fraction(%) from 20016 to 2021

Consumed fraction (%) from 2016 to 2021

The part of ET that is attributed to agriculture production. The Agricultural ET Fraction highlights the proportion of evapotranspiration specifically from agricultural activities, emphasizing the water consumption in farming. This helps in planning sustainable water management strategies.
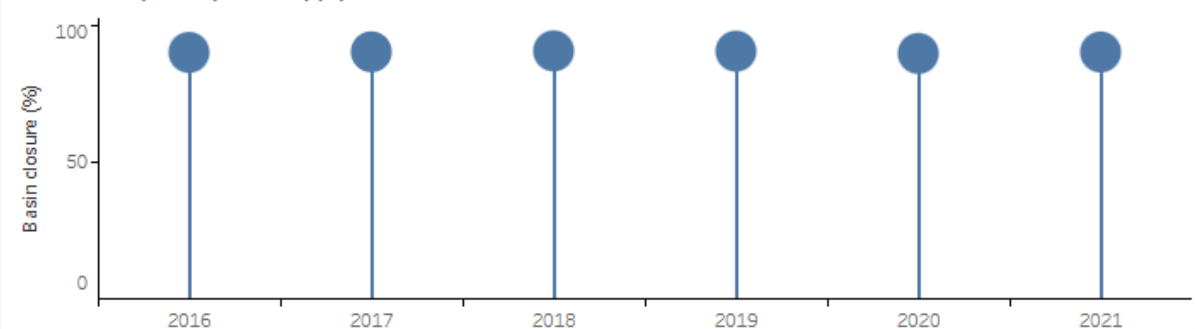
Agricultural ET Fraction

$$= \frac{Agricultureal\ ET}{ET}$$

Basin closure (%)

The basin closure is calculated as total amount of water available that is utilized within a basin.

$$Basin\ closure = \frac{utilized}{available\ water}$$

Basin Closure (utilized/available) (%) from 2016 to 2021

Any basin with estimates closer to 100% indicate basin closure – indicating most to all water availability in the basin is currently consumed with in the basin. A smaller value indicates that water is available in the basin.

3.3 Water Balance
The Water balance, also known as the hydrologic balance or water budget, is a fundamental concept in hydrology. It refers to the equilibrium or accounting of water inputs, outputs, and storage within a defined area, such as a watershed, catchment, or region. The water balance equation helps quantify the movement and distribution of water in various forms through the Earth's hydrological cycle.

Within the water accounting framework, water balance of a river basin is quantified and presented using a number of hydrologic variables. Unlike most hydrologic studies where the water balance is mostly represented by the key hydrologic variables such as Precipitation, evapotranspiration, discharge and change in storage, the water accounting framework derives a variety of hydrologic parameters. A full list of water balance indicators quantified in the water accounting framework are presented in Table 1.

The figure below shows basin input parameters on the left side and basin output parameters on the right side. The WA+ framework tracks both the flow and consumption (depletion) that occur within the basin as water moves from the inlet to the outlet of the basin. The depletion accounting is used to estimate how much of water us consumed over different landscapes. This is summarized under four broad categories of land cover/land use – Protected-conservation areas with minimal changes in land and/or water management, Utilized- are areas with limited human influence and can include forest, natural pastures, savannahs and deserts, Modified- areas that are significantly modified by human activities usually for rainfed agriculture and Managed water use- are land use classes that are significantly modified for agriculture and include water purposefully withdrawn from the surface or groundwater sources for use The flow accounting derives a bunch of parameters such as exploitable water, available water, managed water use, utilizable flows, non-utilizable outflows, reserved outflows, and non-consumed water.
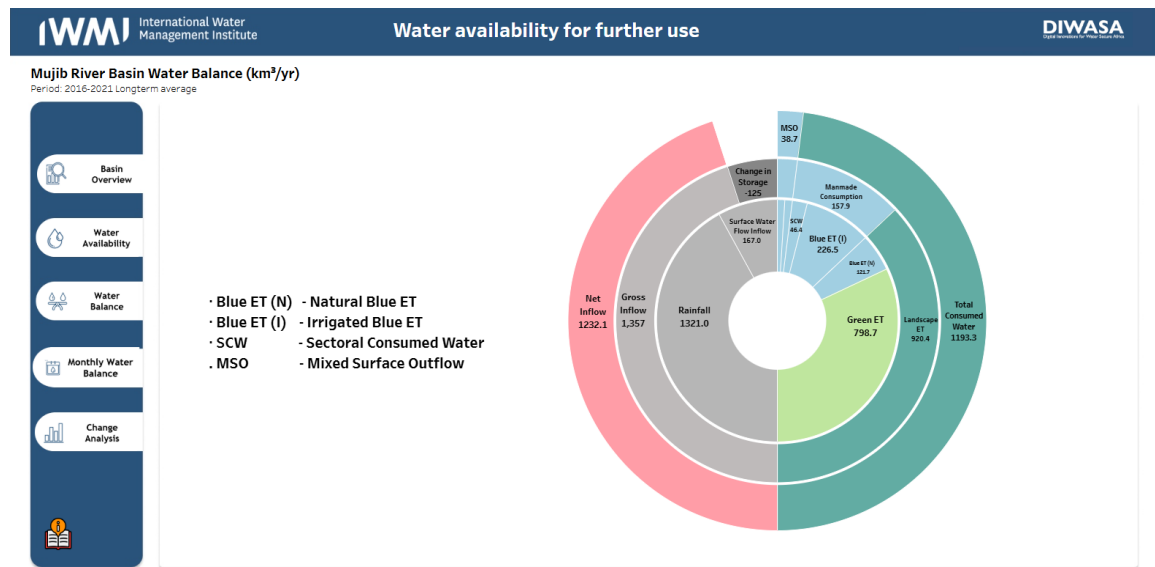

Table 1. List of hydrological variables and indicators quantified in the water accounting framework.

| No	Flux/Indicators	Description	Equation
1	P advection	Precipitation received in the basin, aggregated over the hydrologic year	$\sum_{i=1}^{12} P$
2	Basin inflow (interbasin transfer)	Surface water or groundwater diverted into the basin	Q_{in}^{sw} and Q_{in}^{gw} (Measured estimates)
3	Gross Inflow, GI	Total inflow from all sources	$P + Q_{in}^{sw} + Q_{in}^{gw}$
4	Change in the soil moisture, ΔSM	See equation 2.	See equation 2.
5	Net Inflow, NI	The gross inflow plus the change in soil moisture	$GI \pm \Delta SM$

6	ET rainfall, ET_{rain}	ETa that occurs from effective precipitation and canopy interception, summarized for all land cover classes (1 to n classes).	$\sum_{i=1}^{n} ET_{rain}$
7	ET incremental, ET_{incr}	ETa that occurs from other sources except effective precipitation and interception. Includes ET from irrigation water, groundwater abstraction, open water sources, summarized for all land cover classes (1 to n classes).	$\sum_{i=1}^{n} ET_{incr}$
8	Landscape ET, ETa_{land}	ETa from natural landscapes (protected, utilized and modified land use classes); not due to water management.	$ET_{rain} + ET_{incr}$
9	Consumed water, C_{water}	Total ETa that occurs from all landscapes over all months	$\sum_{i=1}^{12} ET_a$
10	Utilized flow, $Uzed_{flow}$	ETa from managed water use (irrigated crops, managed reservoirs).	ET_{incr} from the managed water use class
11	Exploitable water, EX_{water}	The exploitable water is the amount of water that can potentially be used within the basin	$NI - ET_{landscape}$
12	Available water, AW	The water that is left after meeting ET and reserve flow requirements	$GI - ETa_{land} - Reserve\ Flows$
13	Utilizable outflow, $Uzble_{flow}$	The water that can be reallocated for further uses after accounting for reserved flows and utilized flows.	$EX_{water} - ER_{flow} - Uzed_{flow}$
14	Qsw outlet	The river outflow at the outlet of the basin	Q_{outlet}^{sw}
15	Basin outflow (interbasin transfer)	Surface water or groundwater diverted to areas outside the basin	Q_{out}^{sw} and Q_{out}^{gw}
16	Non-consumed water, NC_{water}	Total outflow	$Q_{outlet}^{sw} + Q_{out}^{sw} + Q_{out}^{gw}$

3.4 Monthly water balance

The monthly WA indicator tab on the dashboard presents the key indicator parameters variables in Rainfall, ET, Water yield and its temporal change. A total of five parameters are presented on the dashboard – Rainfall, Blue ET, Rainfall ET, Total ET and water yield. The units are km3/year
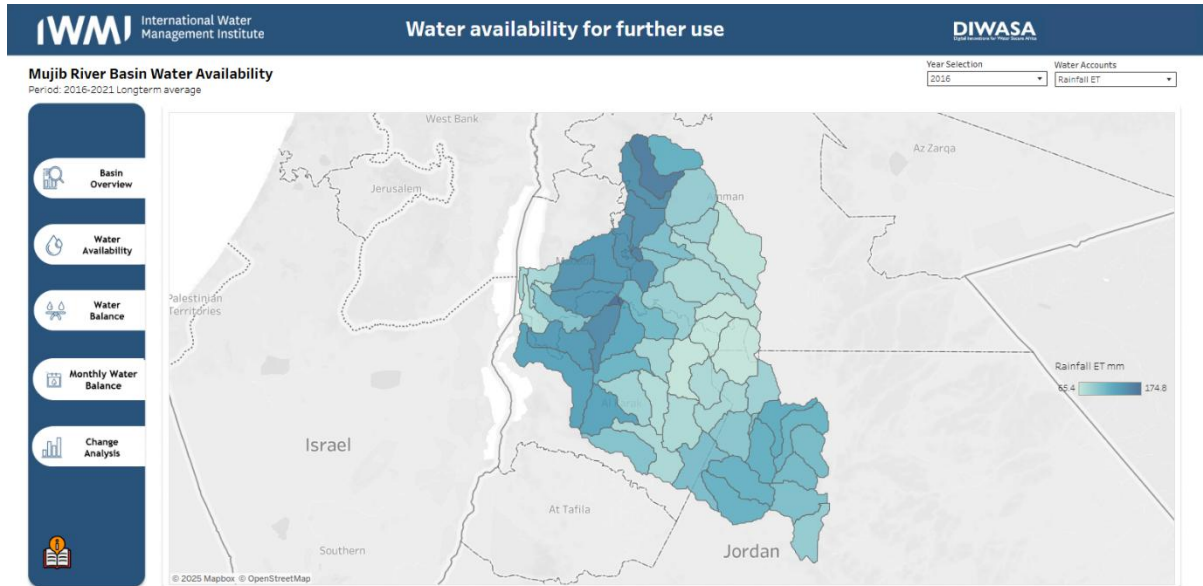
The spatial variation of the basin's water accounts is presented as monthly maps. The maps display the monthly spatial variation of rainfall, Total evapotranspiration (ET), Rainfall(P), Blue ET, Green ET and water yield by selecting relevant parameters.
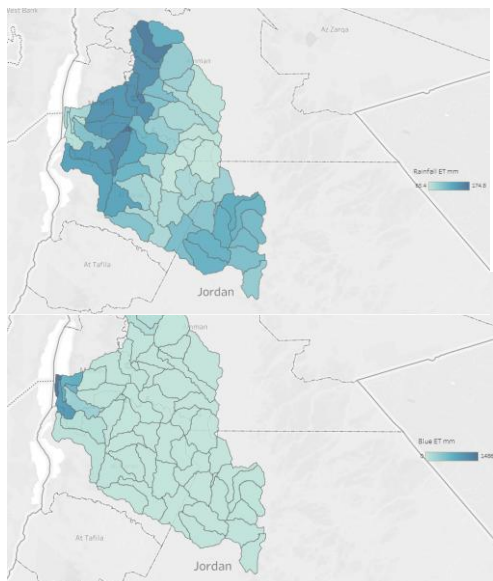

Rainfall ET

Rainfall ET refers to crop or vegetation evapotranspiration (ET) comes from the water consumed by the vegetation from the root zone soil moisture and soil evaporation from the unsaturated soil surface.

Blue ET

Blue ET comes from the water that is stored in the rivers, streams, surface-water bodies and groundwater resources.

Water Yield

Water yield defined as difference between P and ET(P-ET)
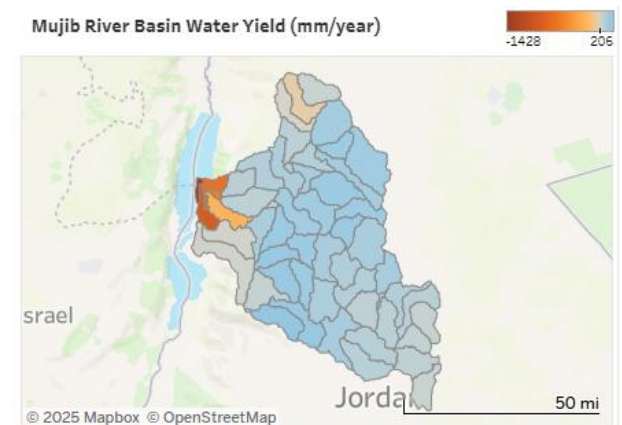
3.5 WA Indicators

Long-term changes in hydrology refer to significant and persistent alteration in the water cycle and the distribution of water resources (both temporal and spatial) over extended periods of time. On the dashboard, we present to charts. On the left side, we present long-term changes in hydrology with a focus on demonstrating increasing or declining trend in the parameter and on the right side, we present insights in to quantifying the change for 2003 - 2021.
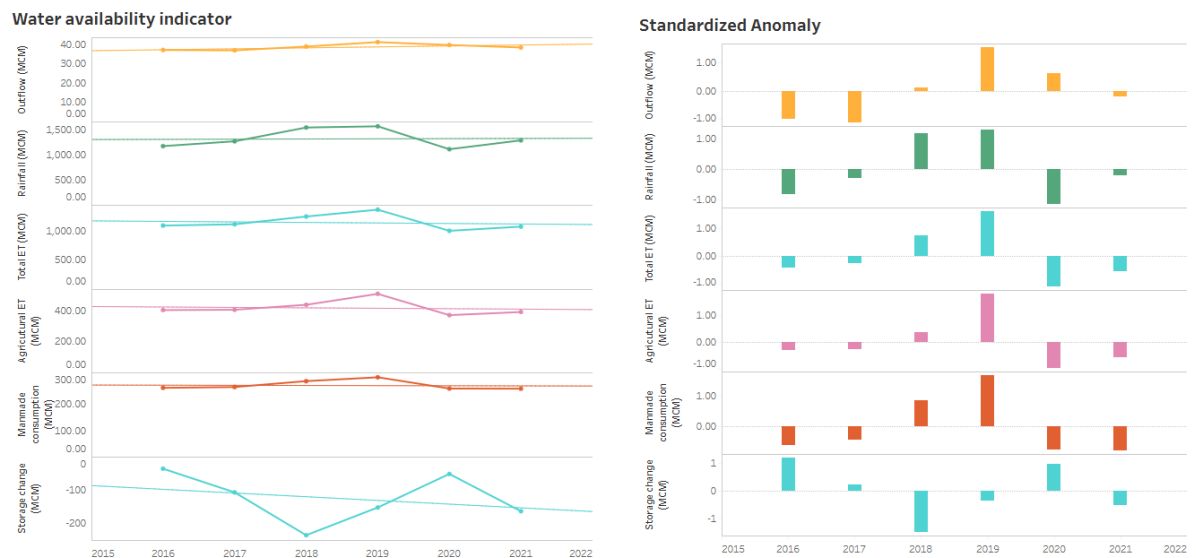
Additional features on the dashboard:

There are several additional features available on the dashboard. A brief description and purpose of each of the icons located on the lower right corner are presented here.

Contact: The contact icon is located on the lower right corner of the dashboard and it would provide email information on whom to contact in case you have any questions on the dashboard.

About: The about icon provides more info on the project.

Printing options: The dashboard can be printed or saved using three options. The current view of the dashboard can be saved to the local computer in three different formats – PDF, JPG or PPT. Please use appropriate icon as per your need.