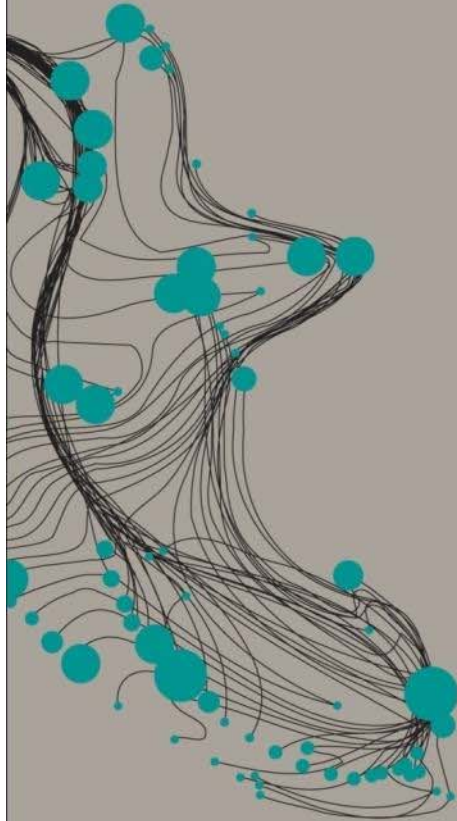


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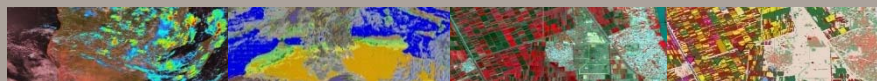


INTRODUCTION TO WATER PRODUCTIVITY & FAO - WAPOR

BEN MAATHUIS / CHRIS MANNAERTS
FACULTY ITC, UNIVERSITY TWENTE, THE NETHERLANDS

$$WP = \frac{\left(\begin{array}{c} \uparrow \\ \text{BIOMASS} \end{array} \right)}{\left(\begin{array}{c} \downarrow \\ \text{EVAPOTRANSPIRATION} \end{array} \right)}$$

WATER PRODUCTIVITY



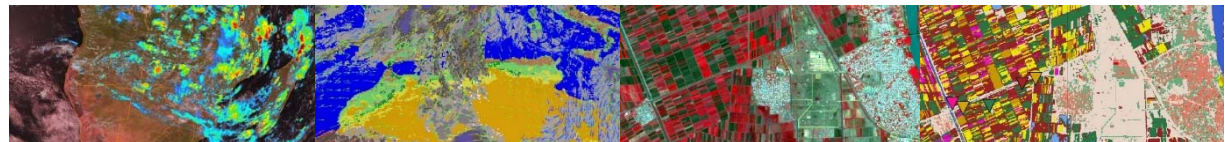
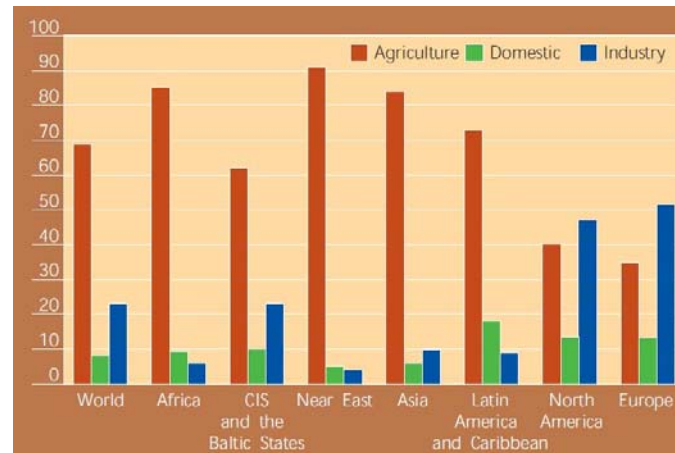
FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION





INTRODUCTION: “MORE WITH LESS”

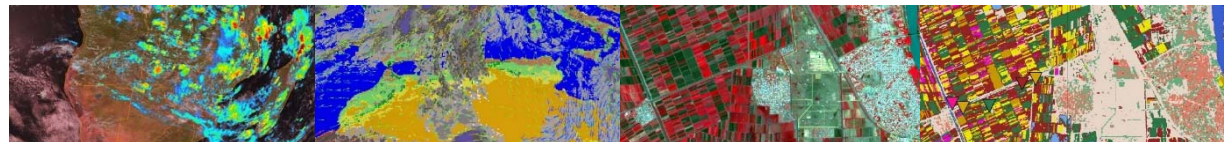
- Achieving food security in the future while using water resources in a sustainable manner is a major challenge;
- In 2050, food needs to be produced for an expected population of between 9 and 10 billion people;
- A lot of water is needed to produce food. Agriculture, as it is practiced today, is responsible for 70% of all freshwater withdrawals in the world.





MORE EFFICIENT USE OF WATER

- Increase in agricultural production required to meet demand in 2050 is 50% (48.6%), compared to 2013 baseline (FAO,2017) at a time of increasing pressure on water quantity and quality.
- Against this background, improved crop water productivity is needed.
- Production in agriculture should not only be considered per unit of land(kg/ha),but also expressed in the production per unit of water consumed, or in short Water Productivity (WP).
- Contribute directly to Sustainable Development Goal 6.4 on improved water use efficiency.



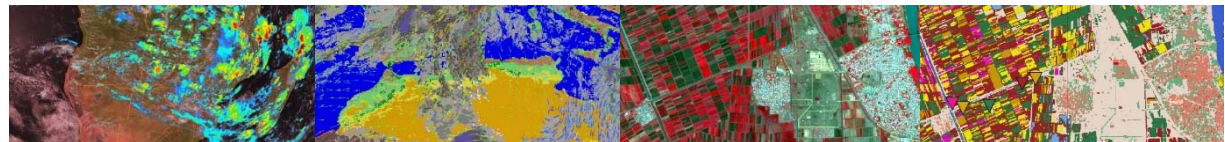


WATER PRODUCTIVITY

- Water productivity is defined as the quantity or value of output in relation to the quantity of water beneficially consumed to produce this output.
- Can be expressed as biomass, grain or money. For example, the so-called 'crop per drop' approach focuses on the amount of product per unit of water.
- Water productivity in agriculture can be expressed as amount of product per unit of water beneficially consumed by the crop.

$$WP = \frac{\left(\begin{array}{c} \text{↑} \\ \text{BIOMASS} \end{array} \right)}{\left(\begin{array}{c} \text{↓} \\ \text{EVAPOTRANSPIRATION} \end{array} \right)}$$

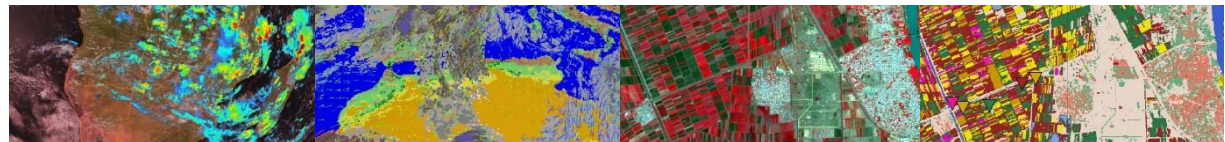
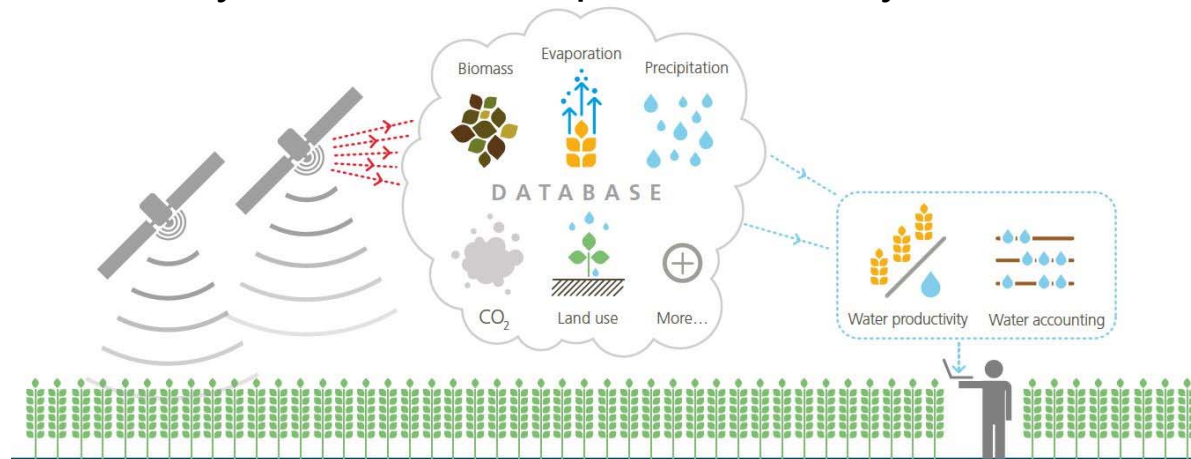
WATER PRODUCTIVITY





WAPOR: USE OF RS IN WP ASSESSMENT

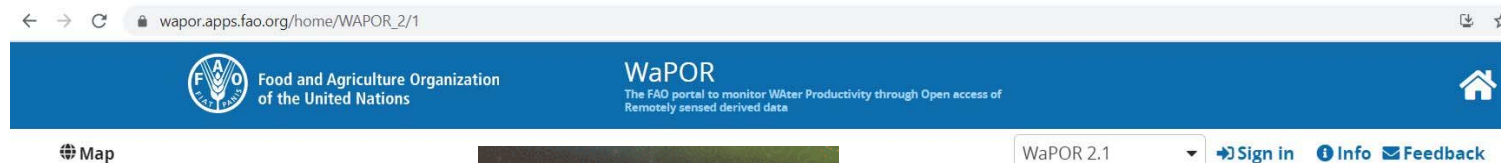
- Improving water productivity allows for better managing water demand in agriculture.
- Systematic monitoring helps to evaluate water productivity gaps and identify appropriate solutions for closing these gaps.
- Remote Sensing can help monitor water productivity in an objective and cost effective way and show the spatial variability.





WAPOR DATA BASE

- WaPOR is the FAO portal to monitor Water Productivity through Open access of Remotely sensed derived data. It monitors and reports on agriculture water productivity over Africa and the Near East and provides open access to the water productivity database and its thousands of underlying map layers. It allows for direct data queries, time series analyses, area statistics and data download of key variables associated to water and land productivity assessments.



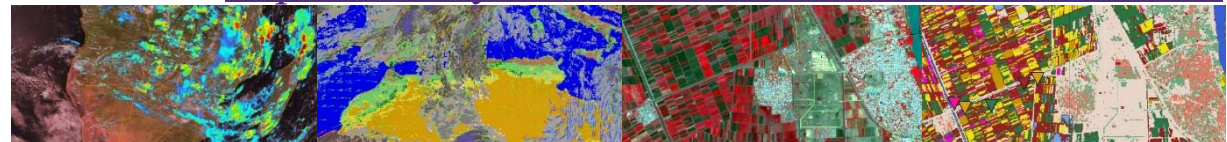
- Introduction WaPOR:



<https://www.youtube.com/watch?v=ZX7SOhk97hA>



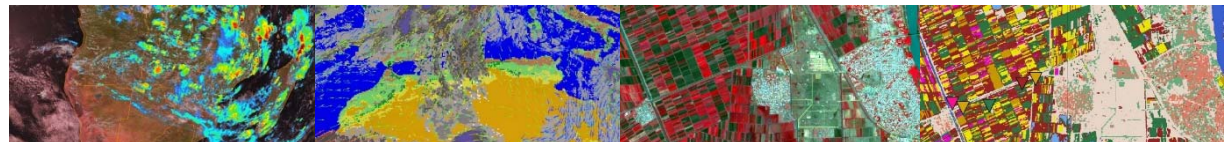
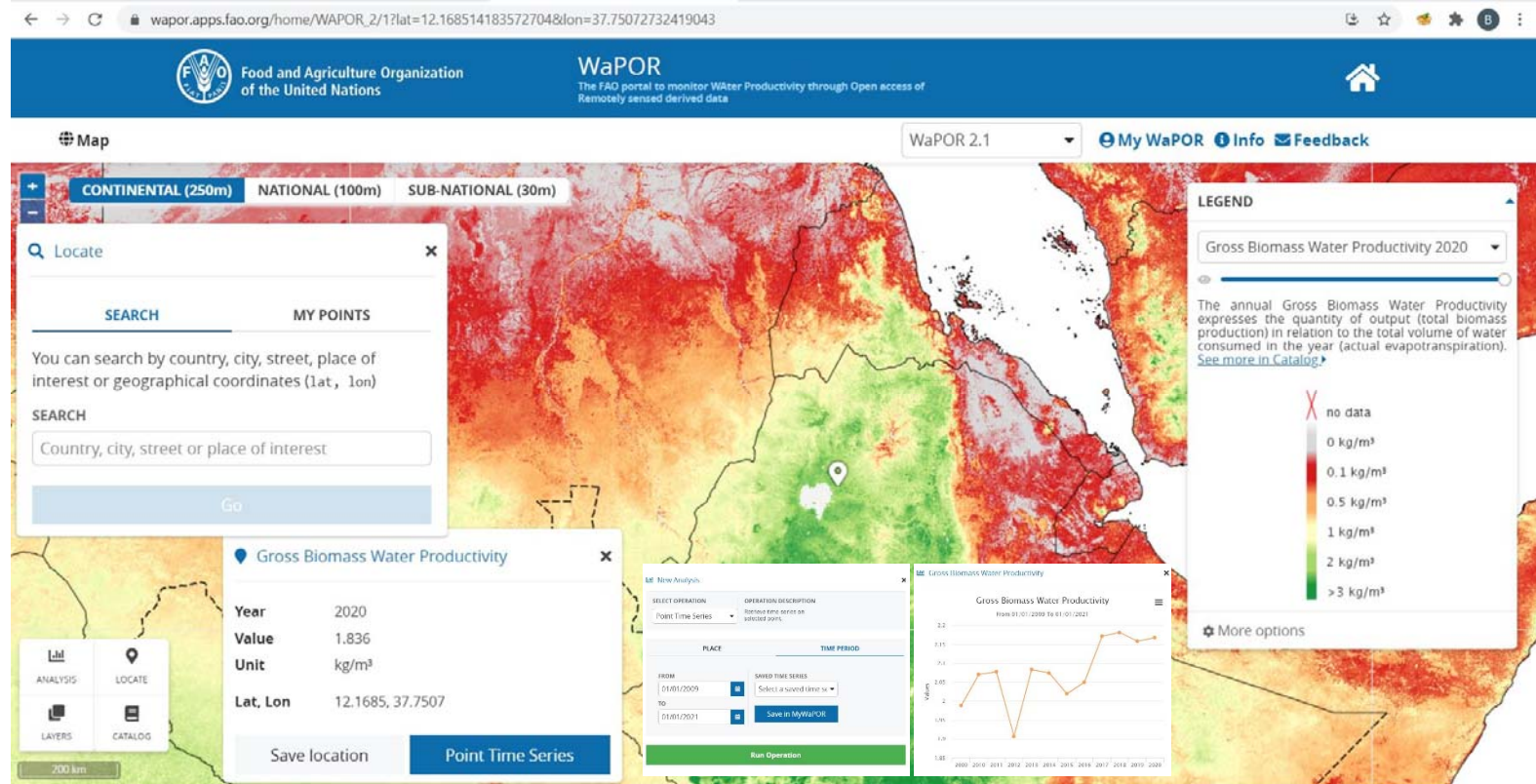
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WAPOR DATA BASE – VERSION 2

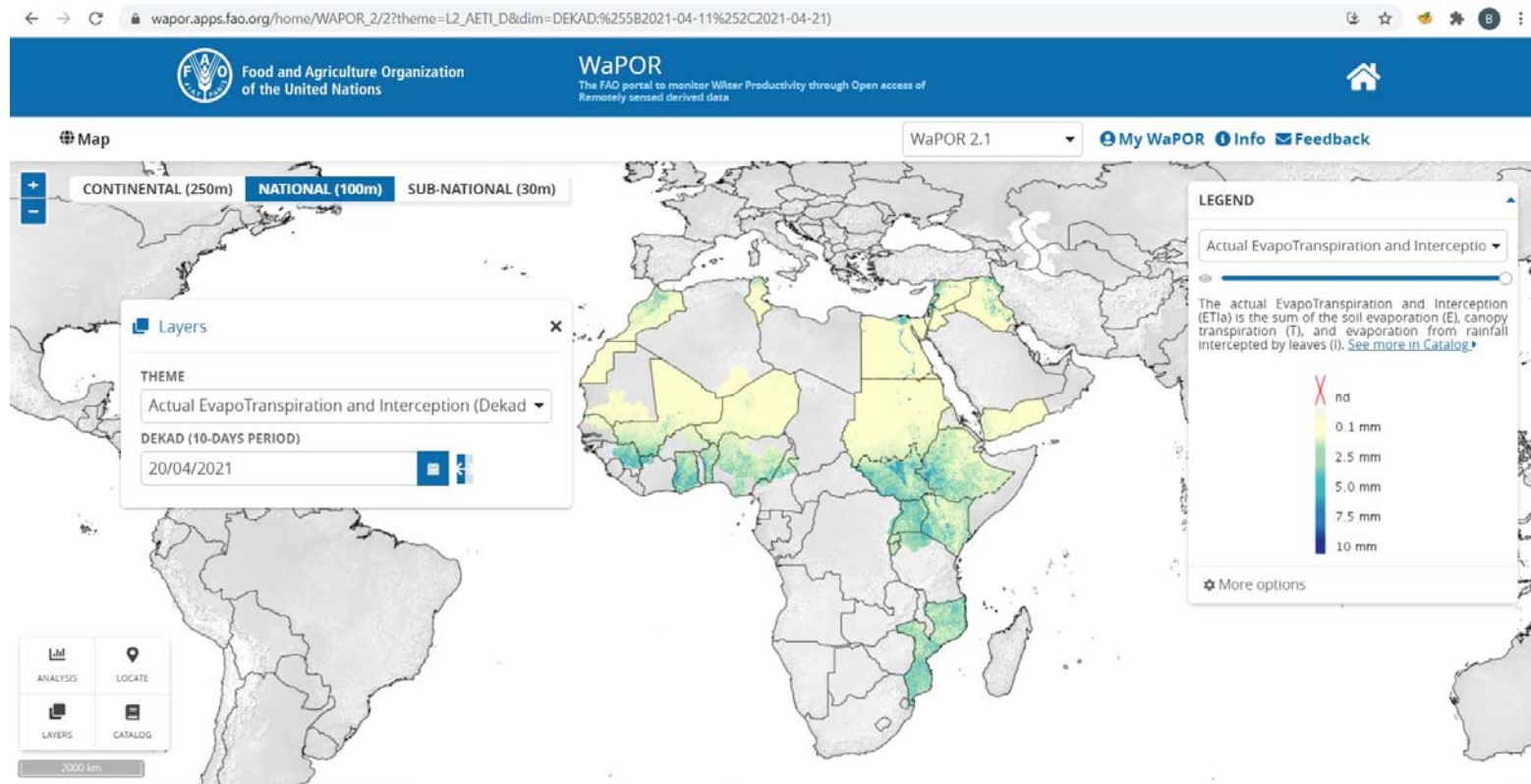
- 3 levels, online analysis – level 1 (Africa and MidEast)



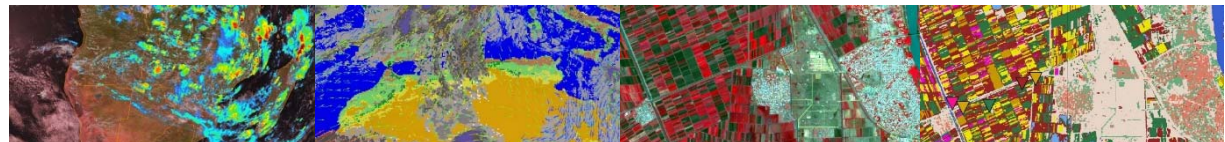


WAPOR DATA LAYERS

- Differs per level – level 2 (selected countries / basins)



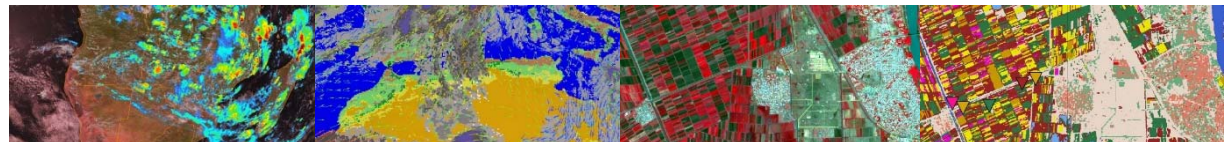
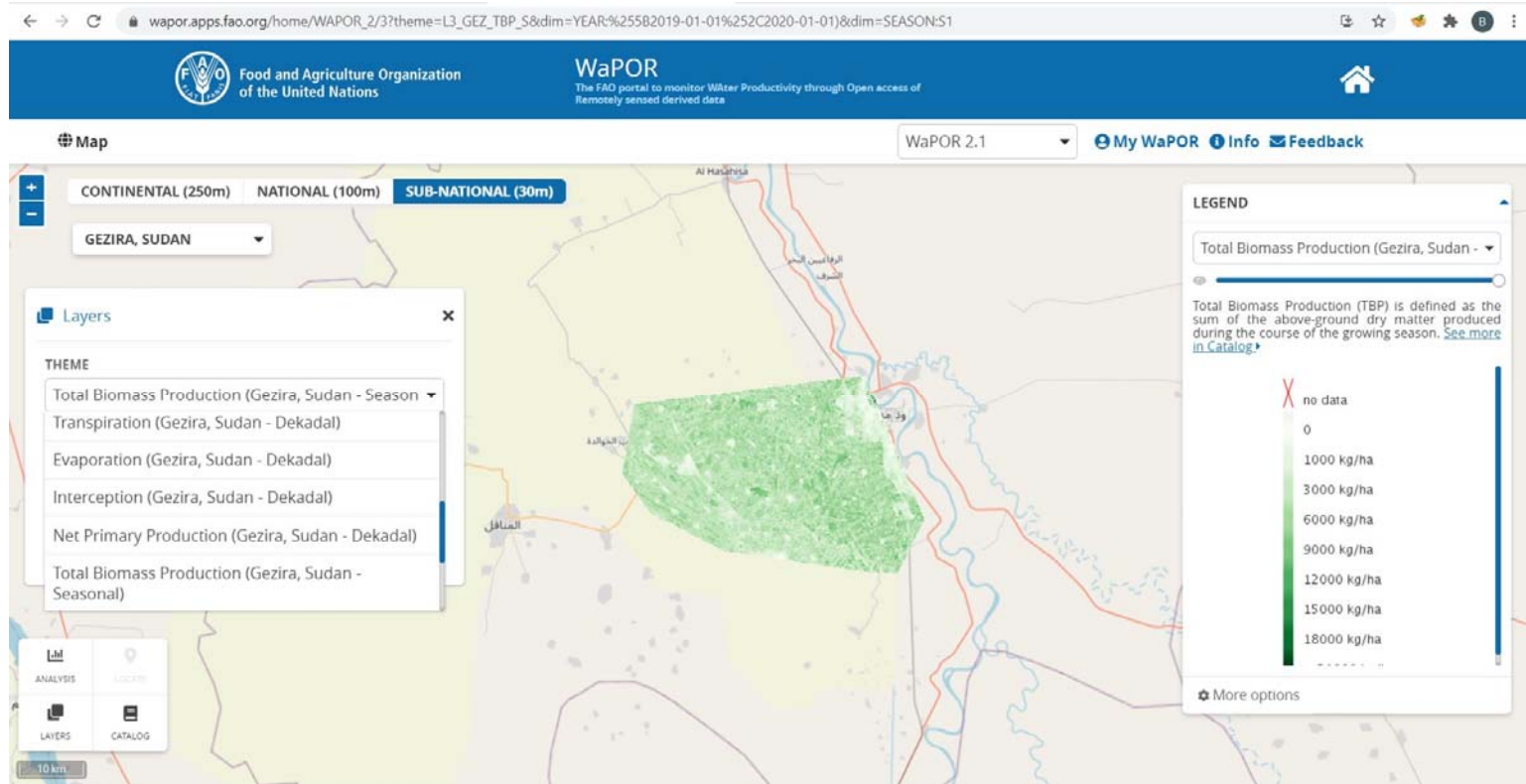
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WAPOR DATA LAYERS

- Differs per level – here level 3 (selected areas)





WAPOR DATA CATALOG

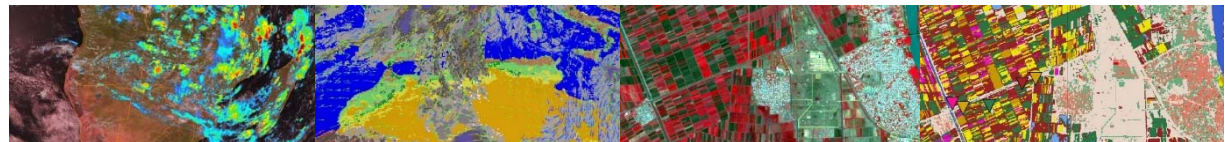
- All data (per level) is well documented

The screenshot displays the WAPOR Data Catalog interface. At the top, the FAO logo and 'Food and Agriculture Organization of the United Nations' are visible, along with the 'WaPOR' title and its mission: 'The FAO portal to monitor Water Productivity through Open access of Remotely sensed derived data'. The interface includes navigation links like 'Back to map' and 'Catalog', and a dropdown menu for 'WaPOR 2.1'. Below this, there are filters for 'CONTINENTAL (250m)', 'NATIONAL (100m)', and 'SUB-NATIONAL (30m)', with 'SUB-NATIONAL (30m)' selected. A dropdown menu shows 'GEZIRA, SUDAN'. On the right, there are checkboxes for 'Water', 'Land', and 'Ancillary', all of which are checked. The main content area features six data layer cards, each with a map thumbnail and a 'WATER' label:

- Actual EvapoTranspiration and Interception (Gezira, Sudan - Annual)**: The actual EvapoTranspiration and Interception (ETIa) is the sum of the soil evaporation (E), canopy transpiration (T), and evaporation from rainfall intercepted by leaves (I).
- Actual EvapoTranspiration and Interception (Gezira, Sudan - Monthly)**: The actual EvapoTranspiration and Interception (ETIa) is the sum of the soil evaporation (E), canopy transpiration (T), and evaporation from rainfall intercepted by leaves (I).
- Actual EvapoTranspiration and Interception (Gezira, Sudan - Dekadal)**: The actual EvapoTranspiration and Interception (ETIa) is the sum of the soil evaporation (E), canopy transpiration (T), and evaporation from rainfall intercepted by leaves (I).
- Transpiration (Gezira, Sudan - Annual)**: The Transpiration (T) data component is the actual transpiration of the vegetation canopy.
- Evaporation (Gezira, Sudan - Annual)**: The Evaporation (E) data component is the actual evaporation of the soil surface.
- Interception (Gezira, Sudan - Annual)**: Interception is the process where rainfall is captured by the leaves.



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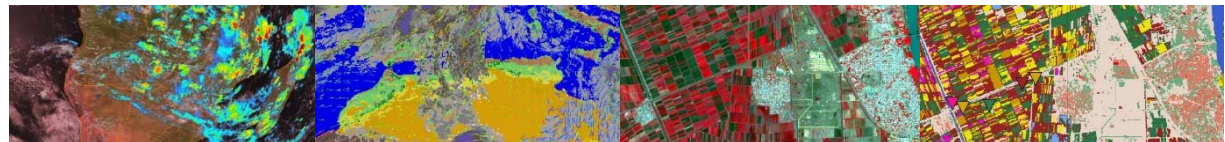


WAPOR DATA DOWNLOAD

- Allows for data download (if signed in) – geotif format

The screenshot shows the WAPOR data catalog interface. At the top, there is a blue header with the FAO logo and the text 'Food and Agriculture Organization of the United Nations' and 'WaPOR The FAO portal to monitor Water Productivity through Open access of Remotely sensed derived data'. Below the header, there is a navigation bar with 'Back to map', 'Catalog', and 'Actual EvapoTranspiration and Interception (Gezira, Sudan - Annual)'. The main content area is titled 'Description' and contains the following text: 'The actual EvapoTranspiration and Interception (ETIa) is the sum of the soil evaporation (E), canopy transpiration (T), and evaporation from rainfall intercepted by leaves (I). The value of each pixel represents the ETIa in a given year.' Below this is the 'Additional Information' section, which lists the following details: Format: Raster Dataset; Unit: mm; Data type: Int32 (32bit Integer); Conversion factor: the pixel value in the downloaded data must be multiplied by 0.1; No data value: -9999; Spatial resolution: 30m; Spatial extent: Gezira, Sudan; Spatial Reference System (SRS): EPSG:32636 - WGS 84 / UTM zone 36N; Temporal resolution: from January 2009 to present; Temporal extent: Annual; Methodology: See ETIa by dekad for further information. The annual total is obtained by taking the ETIa in mm/day, multiplying by the number of days in a dekad, and summing the dekads of each year. Below the description is a table with a 'Year' column and a 'Download' button for each year. The table shows the year 2020 with a corresponding map thumbnail and a 'Download' button. The year 2010 is also visible with a 'Download' button.

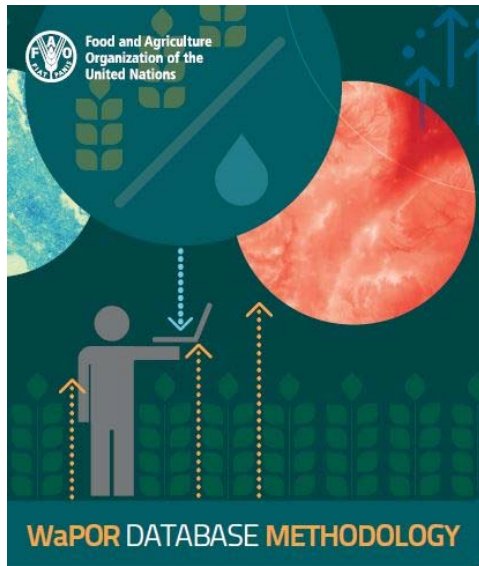
Year	Download
2020	Download
2010	Download





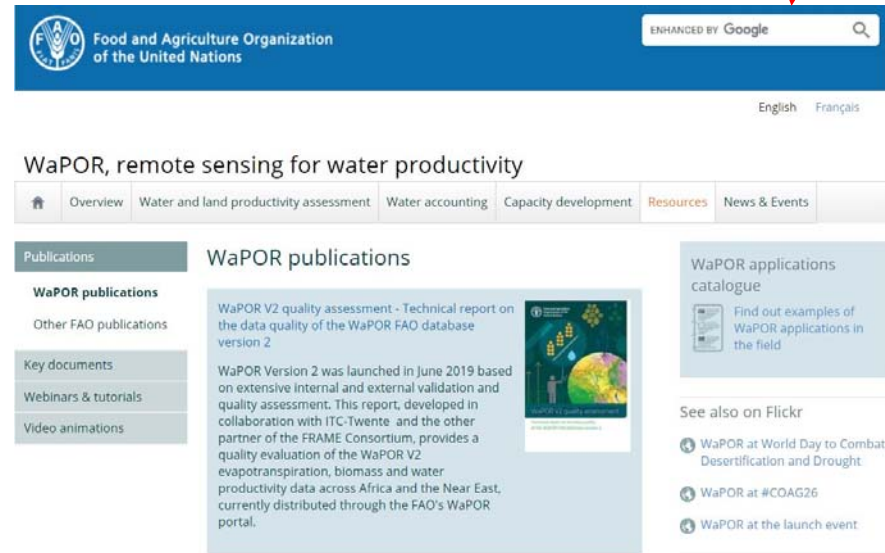
WAPOR DATA BASE METHODOLOGY

- Calculation procedures to derive WP and other data layers

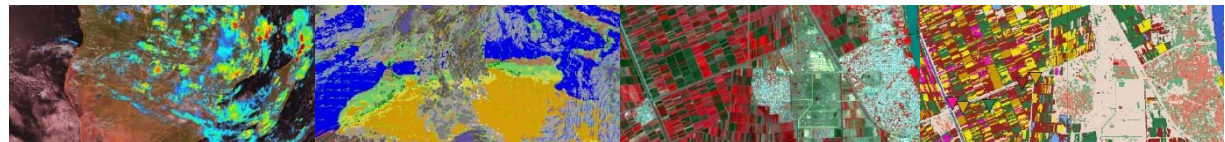


Version 2 release

April 2020

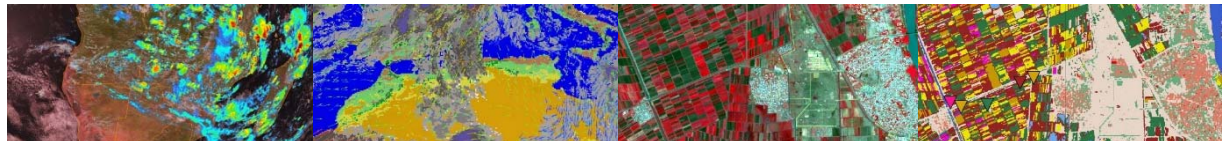
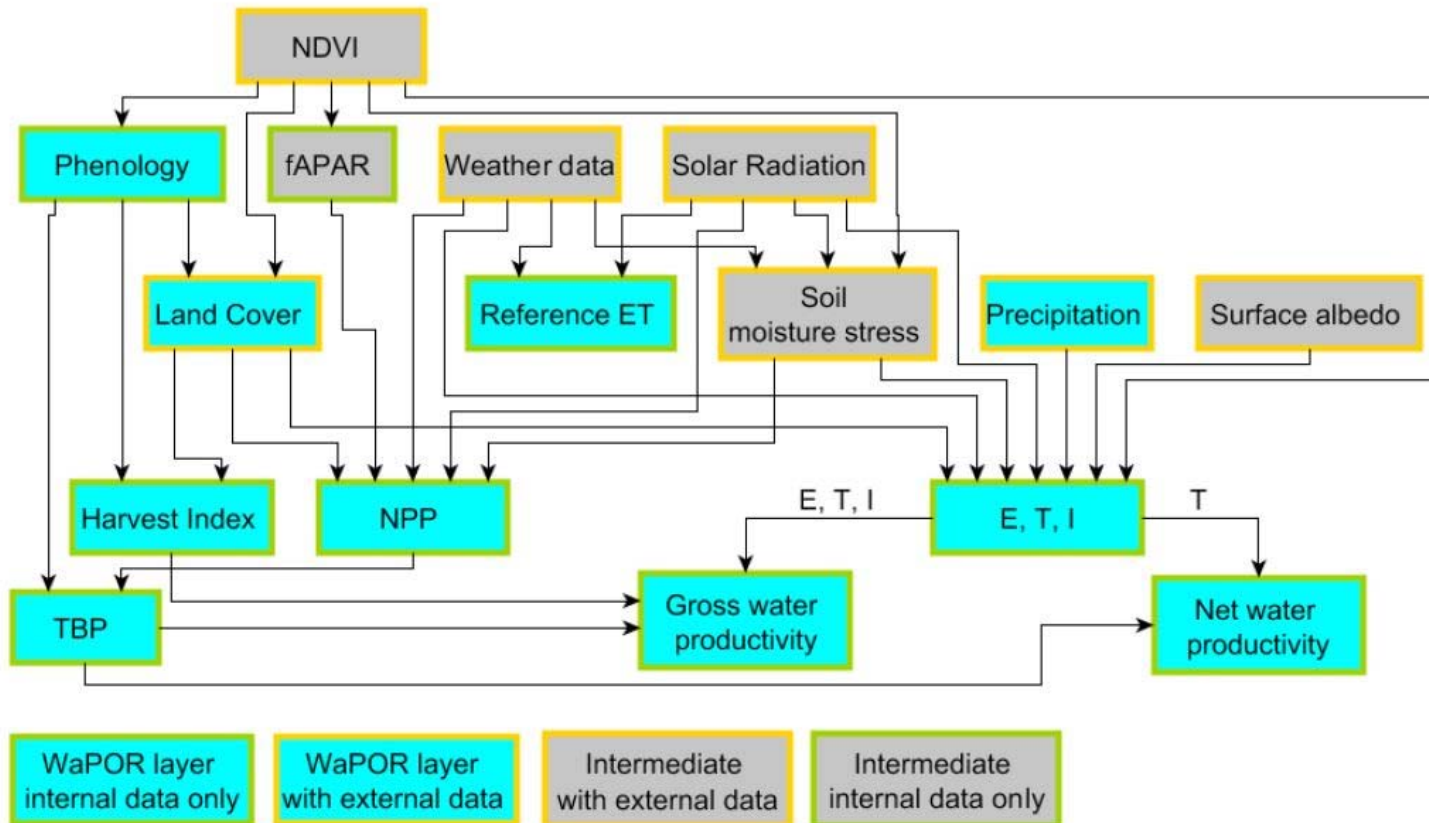


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DATA COMPONENT FLOW CHART

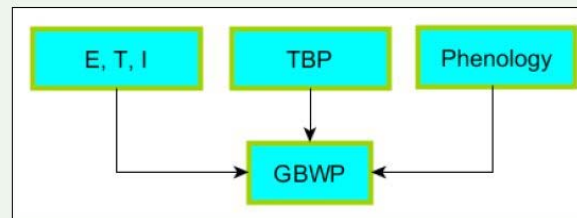


$$GBWP = \frac{TBP}{E + T + I}$$

GROSS BIOMASS WATER PRODUCTIVITY

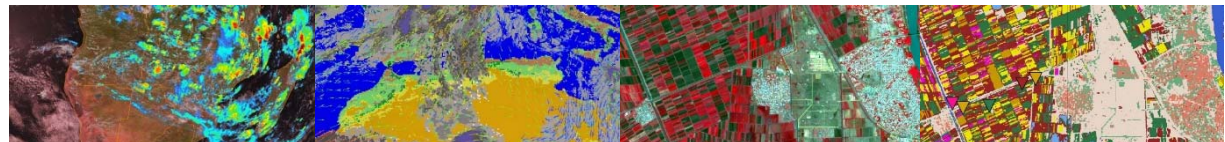
- The Gross Biomass Water Productivity (GBWP) expresses the quantity of output (biomass production) in relation to the total volume of water consumed in a given period

Gross biomass water productivity in relation to other data components



- Calculating GBWP requires input from total biomass production, evaporation, transpiration and interception, and phenology if calculated on seasonal time step.
- No external data source is required to calculate GBWP.
- The output is not used in any other data component.

Where TBP is total biomass production in kgDM/ha, E is evaporation, T is transpiration and I is interception, all in mm. The following data is used for calculating GBWP: TBP, E, T, I, and phenology if calculated on seasonal time step.

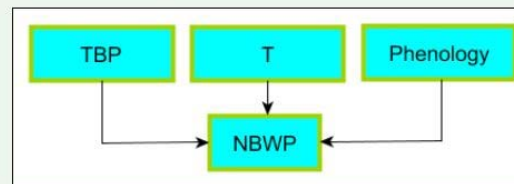


$$NBWP = \frac{TBP}{T}$$

NET BIOMASS WATER PRODUCTIVITY

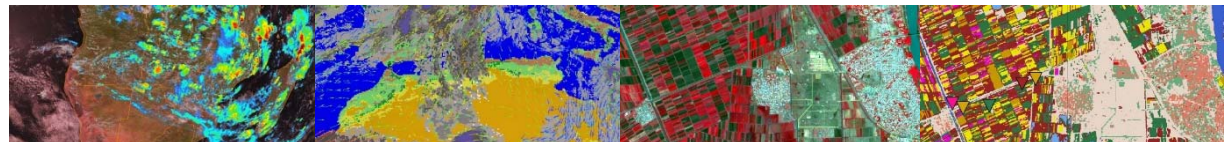
- The Net Biomass Water Productivity (NBWP) expresses the quantity of output (total biomass production) in relation to the volume of water beneficially consumed (through canopy transpiration) in the year, and thus net of soil evaporation.

Net biomass water productivity in relation to other data components



- Calculating NBWP requires input from total biomass production, transpiration, and phenology if calculated on seasonal time-step.
- No external data source is required to calculate NBWP.
- The output is not used in any other data component.

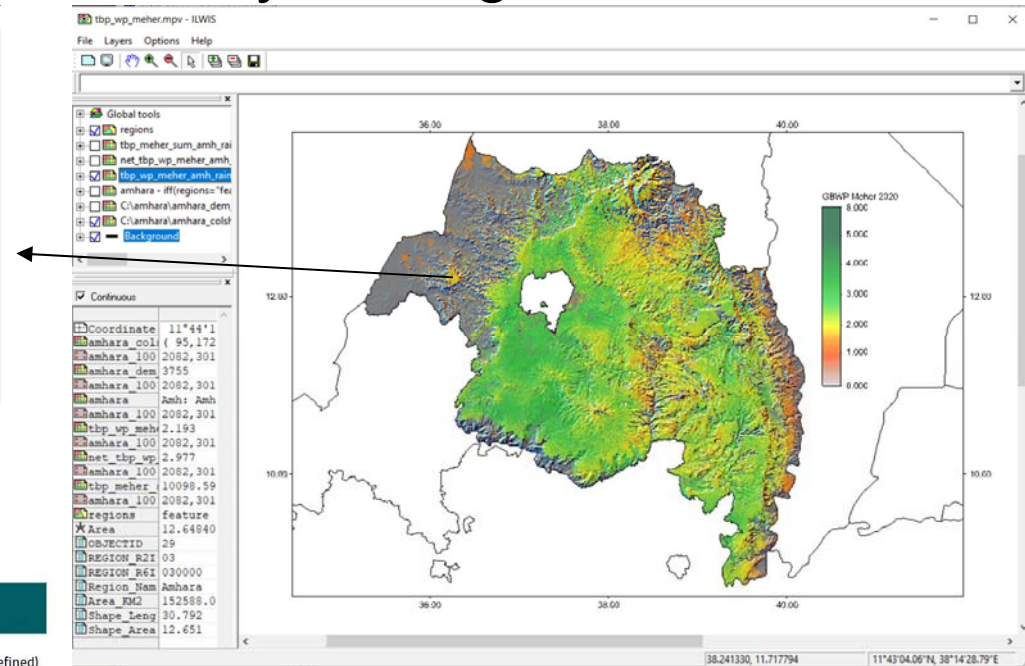
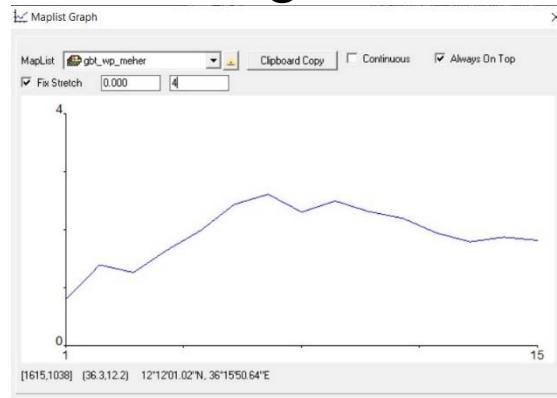
Where TBP is total biomass production in kgDM/ha and T is transpiration in mm. The following data is used for calculating NBWP: TBP, T, and phenology if calculated on seasonal time-step.





GBWP EXAMPLE AMHARA REGION ETHIOPIA

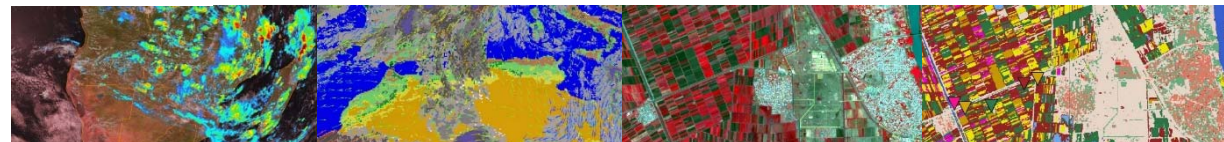
- For the Meher (rainy) season (dekad 16 – dekad 30), rainfed agricultural areas only – using level 2 data



Overview of biomass water Productivity data components

Data component	Unit	Range	Use	Temporal resolution
GBWP	kg/m ³	0 to 6 ¹	Measures quantity of dry biomass output in relation to consumptive water use	Seasonal (further aggregated to user-defined)
NBWP	kg/m ³	0 to 6	Measures quantity of dry biomass output in relation to transpiration (or beneficial water consumption)	Seasonal (further aggregated to user-defined)

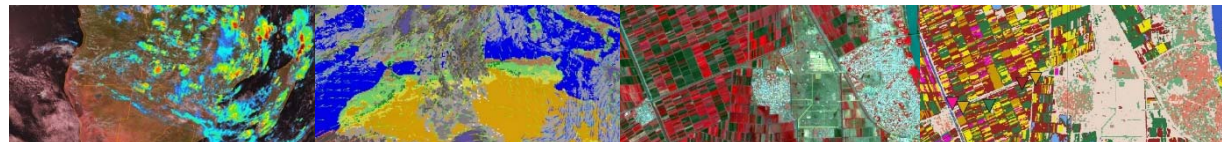
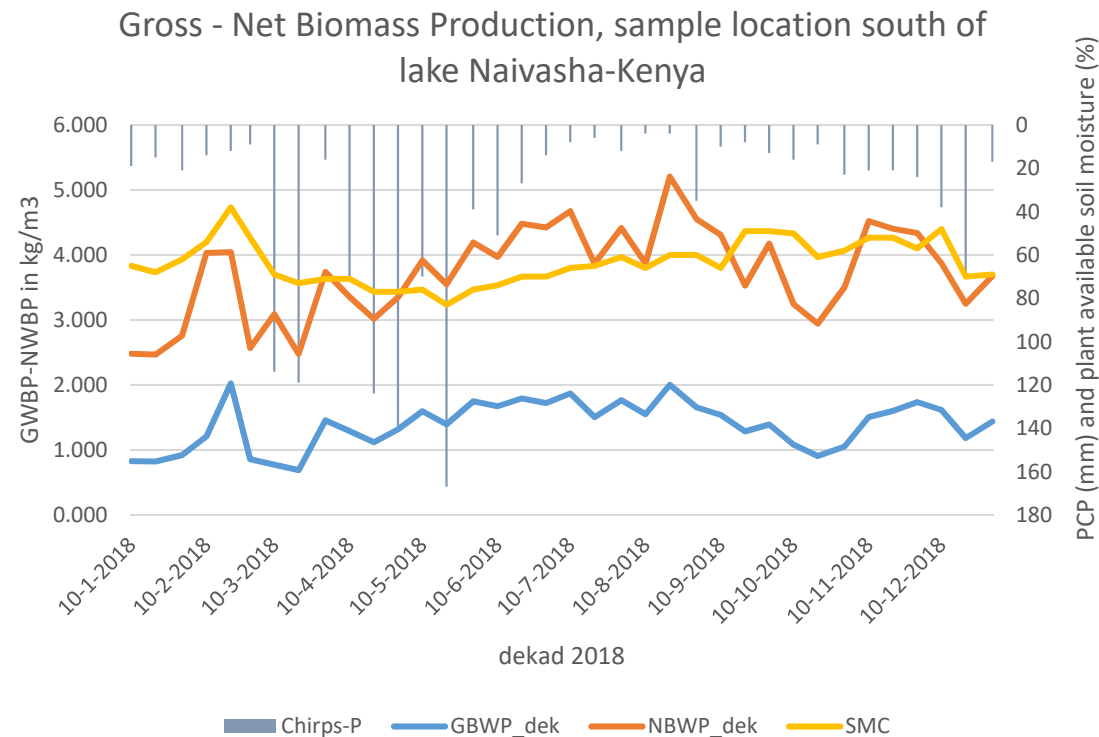
¹ Range observed in WaPOR area, but theoretical range could go up to 25.





EXAMPLE CALCULATION (EXCEL)

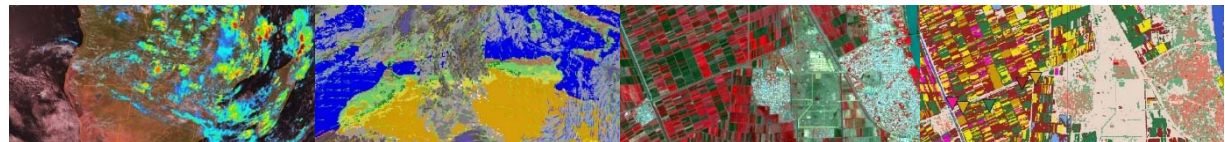
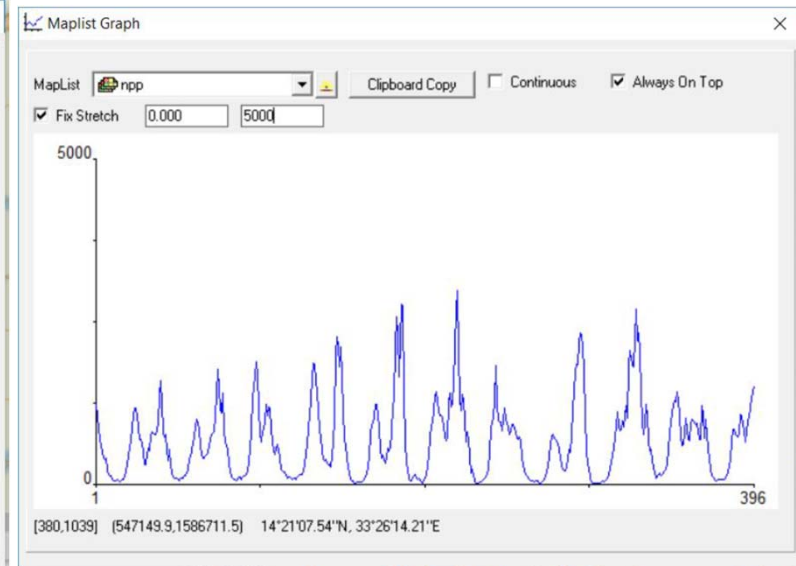
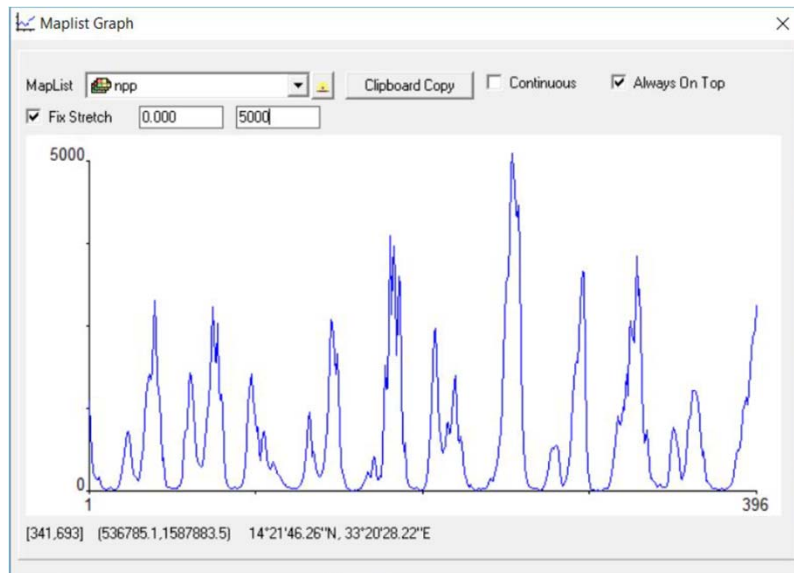
- Calculation procedure to derive GBWP / NBWP
- See: WP_Calc_manual.xlsx





TIME SERIES ASSESSMENT, EXAMPLE NPP

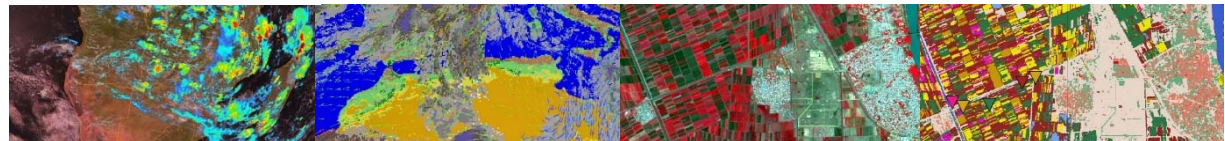
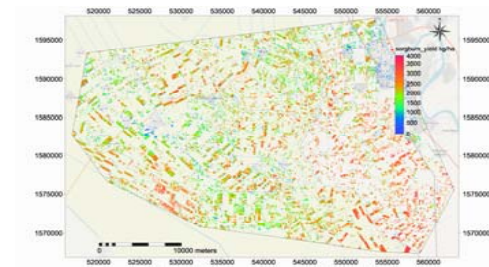
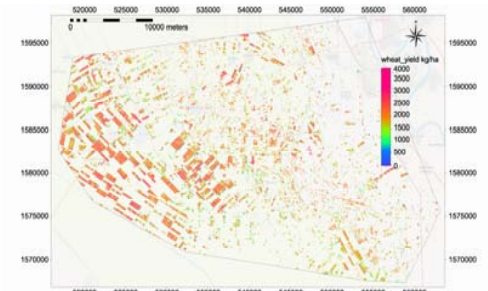
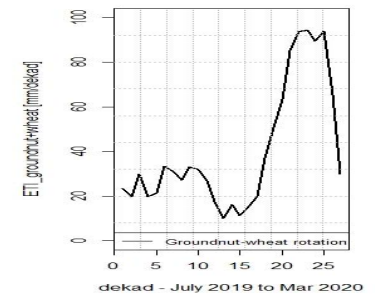
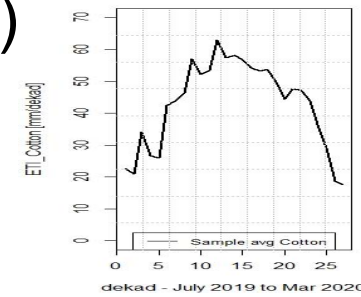
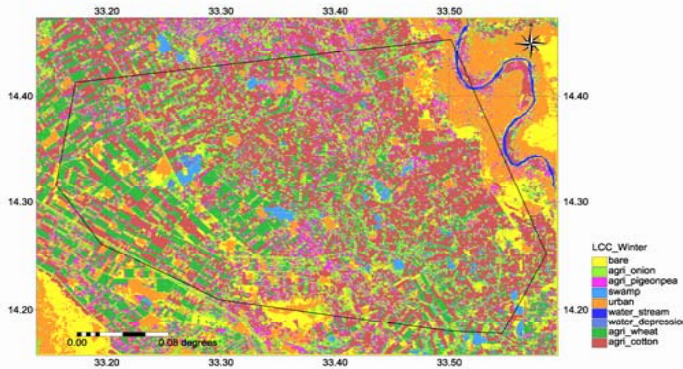
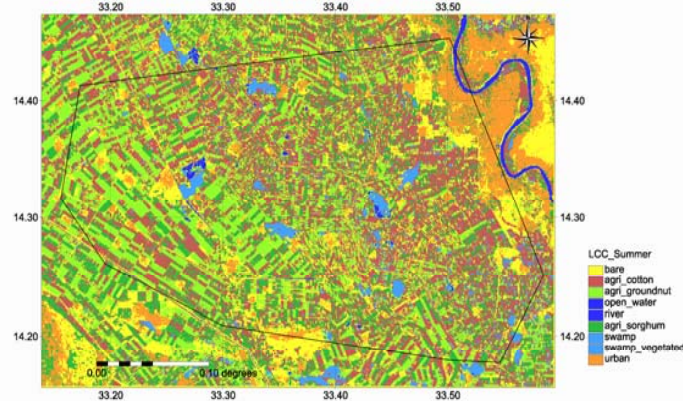
- NPP profiles (2009-2020) Gezira – left profile having cotton and right profile having onions during the Nov 2019 survey. The variations may be due to crop rotations, weather, climate and irrigation and field practices, a/o other influences.





CROP WATER PRODUCTIVITY / YIELD

Example Gezira study (level 3)





IMPORT DATA AND CALCULATION IN ILWIS

■ FAO-Frame toolbox

The screenshot displays the ILWIS Open interface with the FAO-Frame toolbox selected in the Operation-Tree. A script window titled "Script 'ET1a_dek_calc' - ILWIS" is open, showing the following description and code:

```
Description
Script Parameters Default Values

rem calculate sum ET1a map for a given dekad
rem input maps expected have average ET1 in mm/day
rem calculate sum T map for given dekad
rem input map expected has average T in mm/day

rem units in mm and m3/ha are used for the output maps

rem note length of dekad for last dekad of month changes
rem dekad defined as:
rem first dekad month = days 1-10, total 10 days
rem second dekad month = days 11-20, total 10 days
rem last dekad month = day 21 to last day of month, e.g. 8, 9 (leap year) for February or 10,11 days otherwise

rem calculate ET1a in mm - apply scaling of 10
%5_mm=(%1+%2+%3)/10*%4;
```

