Policy Brief

May 2019

# Agricultural Water Productivity

## Key Findings

The Agricultural Water Productivity Taskforce (TF-AWP) aimed at assessing the water status of the basin in the agricultural sector. It was one of six taskforces of the Collaborative Programme on the Euphrates and Tigris (CPET). The taskforce analysed the productivity of water used in the agricultural sector in the Turkish, Syrian, and Iraqi portions of the Euphrates and Tigris (Euphrates-Tigris) basin.

The findings of the taskforce suggest that most agricultural development in the basin prioritized land productivity and not water productivity, and thus there is much room for development in this regard. While much of the agricultural areas have low to medium water productivity, there are hot spots of high productivity, indicating that high water use efficiency is an attainable goal within the Euphrates-Tigris basin. The taskforce identified multiple cause for both the high- and low-productivity of water in the basin; understanding them will allow for further development and improvement in the agricultural sector of the riparian areas.

## Key Messages

**1. National policies**: Government policies on agricultural water use shift from providing enabling environments for increasing yield (biophysical return per hectare) to increasing water productivity (total benefits/cubic metre of water). Focusing on shifting the subsidization of water supply to areas associated with value added processes would bring more benefits from the water. Should cropping patterns change in the quest for higher water productivity, then this will require policies to improve market dynamics in favour of these crops.

**2. Transboundary cooperation**: The countries sharing the basin conduct a dialogue on Win-Win-Win-Win approaches to maximize basin agricultural water productivity. Discussions should focus on the comparative advantages of each in producing crops at higher water productivity. This could allow changes in cropping patterns and exchange of virtual water with lasting benefits.

**3. Technologies**: The taskforce identified systems of high- and low-water productivity in each country within the basin. Conditions and practices associated with these levels of productivity were also indicated. Countries should discuss how to share and transfer practices and technologies that could bring about these higher levels of productivity. Investments into technologies to modernize agriculture, building and maintaining drainage systems for salinity control in irrigated systems, and taking advantage of the advancements in germplasm improvements are some of the priority areas.

**4. Capacity building**: The capacity of agricultural practitioners working on ways to enhance water productivity vs. land productivity needs to be improved. Basin countries should include this material in university courses and conduct formal training for graduates and policy-making groups to encourage a scientific approach to it.

**5. Research**: It is recommended that further research be conducted to improve assessments of water productivity in agriculture in the basin. Areas of research include crop mapping with high resolution remote sensing, ground truthing at the crop level for yield and water use, tools to study water quality impacts, and an assessment of economic water productivity.

# AGRICULTRAL WATER PRODUCTIVITY

## INTRODUCTION

Over 60% of the available water resources of the Euphrates-Tigris basin (ET) are consumed by the agricultural sectors of the riparian countries of Iran, Iraq, Syria, and Turkey. Agriculture serves as an important source of income generation and employment, especially in rural areas, and has the potential to spur further economic growth in the basin. However, the agricultural water productivity of crops in the Euphrates-Tigris basin is much lower than world averages. The main reasons for the low yields include inadequate use of fertilizer, poor quality seeds, inadequate pest and other agronomic management, and lack of water demand management strategies. Water is becoming scarcer in both quantity and quality while the population is growing, and more food is needed using less water. Therefore, the focus on improving AWP is relevant, essential and timely.

It is essentiall to understand the efficiency of use of water in the agricultural sector in order to plan and implement feasible improvements. Increasing AWP should be regarded as a building block for achieving food security, economic growth, and environmental sustainability in the basin.

Agricultural water productivity (AWP) is defined as the mass of useful crop produced per volume of water used/depleted by the crop in its production (typically kg/m$^3$). This is also known as "crop per drop". Along with land-use patterns and biomass production, a major component for mapping water productivity is evapotranspiration. Actual evapotranspiration (AET) provides crop water requirements at the field and system levels.

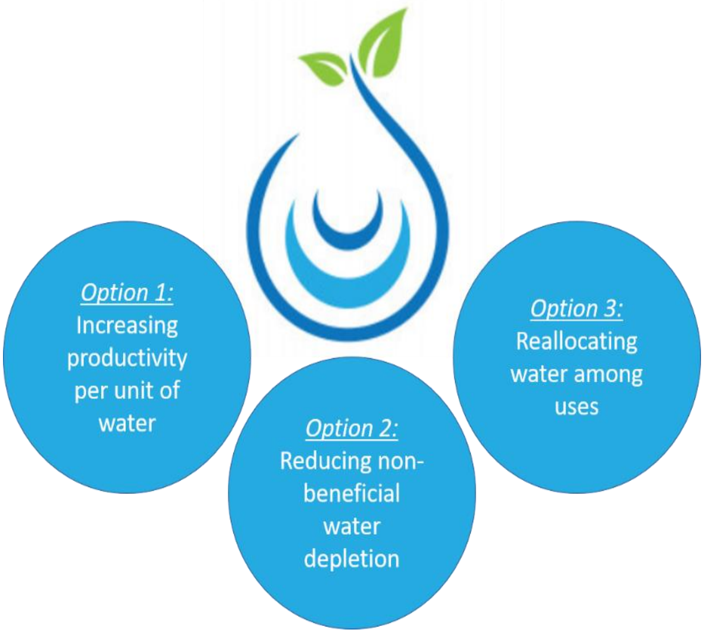
The main objective of the taskforce was to determine AWP at basin and temporal scales (wet to dry and normal climate years), and then use resultant maps and information to help quantify water use in the basin for improved water use scenarios. The key sub-components of the taskforce included:

1. Development of AWP maps using remote sensing data at landscape level
2. Identification of hotspots (low to high) in AWP across the basin
3. Development of scenarios for potential improvements of water productivity and water saving across the basin.

**Major outputs planned for this study included:**

- Methods for mapping AWP
- Quantification of AWP at temporal & spatial scales
- AWP scenario analysis
- Estimation and verification of crop water productivity for irrigated and rainfed agriculture
- Impacts of AWP improvement on regional cooperation and water use in the basin
- Support and inform climate change adaptation options and potential future investments.

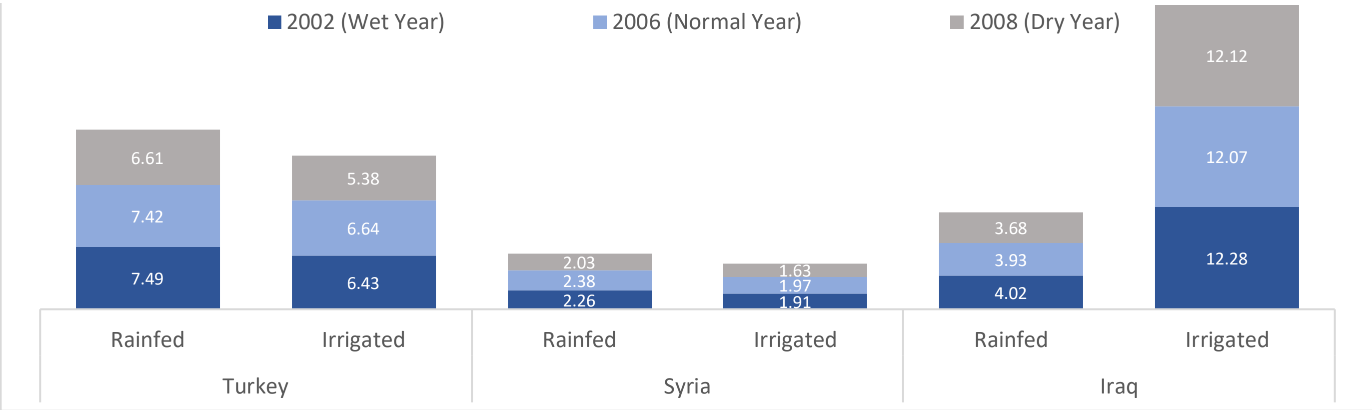
Options for Increasing Water Productivity




TF-AWP was led by the International Center for Agricultural Research in the Dry Areas (ICARDA) with full participation and contribution from the AWP Task Force members from CPET Country Partners. The final Agricultural Task Force report *(Agricultural Water Productivity, CPET 2018)* presents study findings and links them with the other five CPET taskforce reports and project components.

The taskforce determined AWP using remote sensing data and models, and then verified the results with national and open source secondary data. The multi-temporal images from the Moderate Resolution Imaging Spectroradiometer (MODIS) from 2002 to 2010 were used to assess wet, dry and normal years. These images are available for free from the US Geological Survey (USGS) EROS Data Center (http://edc.usgs.gov). In consultation with other CPET components and based on average climate data trends in the basin, the taskforce selected three years to represent the water status in the basin: 2002 as a wet year, 2006 as a normal year, and 2008 as a dry year. The selection was done mainly on the average rainfall occurring during the rainfed growing season that ended in that year. The taskforce then delineated rainfed and irrigated areas based on the International Water Management Institute's (IWMI) mapping procedures. Evapotranspiration was determined using the methodology proposed by USGS's Simplified Surface Energy Balance.

Crop yield was determined using the gross primary productivity (GPP) approach. National agricultural census data provided district-level actual reported yields of major crops in each CPET country. Comparing the actual crop yields with the results obtained using remote sensing confirmed the reasonable accuracy of the remote sensing models used. Biophysical water productivity (kg/m$^3$) was determined for each pixel by dividing crop yield by evapotranspiration (kg/m$^2$ /m).




Actual evapotranspiration (AET) in the agricultural areas of the riparian countries during the wet, normal, and dry years (2002, 2006, 2008).

## STUDY FINDINGS

Actual evapotranspiration (AET) values generated for both rainfed and irrigated croplands across the basin showed that the total regional (areas in Turkey, Iraq and Syria only) agricultural consumptive use to be 34.4, 34.4, and 31.5 billion cubic metres (km$^3$) for the wet, normal, and dry years assessed. Of this, about 40% was in Turkey, 12% in Syria, and 48% in Iraq for the wet year of 2002; for the normal year of 2006, consumption was 41% is in Turkey, 13% in Syria, and 46% in Iraq; while for the dry year of 2008 water use was 38% in Turkey, 12% in Syria, and 50% in Iraq. The chart above indicates the consumptive use of water for rainfed and irrigated systems in wet, normal and dry years for the three basin countries. The values of AET reflect the consumptive use of water by agriculture in the basin and do not include recycled water, water stored in aquifers, or surface flows into reservoirs. The results show that the water consumed by agriculture is about 60% of the total renewable water resource pool of the basin. This percentage may become higher if one adds the drainage water joining salt sinks downstream of the basin.

Country-level Agricultural Water Productivity (AWP) for key crops.

| Turkey | | Iraq | | Syria | |
|---|---|---|---|---|---|
| **Crop** | **AWP** | **Crop** | **AWP** | **Crop** | **AWP** |
| Wheat | 0.42-1.5 | Wheat | 0.2-0.4 | Wheat | 0.1-0.5 |
| Cotton | 0.16-1.54 | Rice | 0.5 | Beef | 0.09 |
| Maize | 0.75-2.86 | | | Olives | 1.6 |
| Soybean | 0.26-1.07 | | | | |
| Sunflower | 0.17-0.82 | | | | |

AWP is generally low in the Euphrates-Tigris basin, being a consequence of the low crop yields described above. The overall average of rainfed AWP is 0.53 kg/m$^3$, while irrigated AWP is 0.54 kg/m$^3$. This shows that irrigation water is inefficiently managed. However, exceptions exist in certain hotspots, where the water productivity is found to be as high as 0.8 to 1.0 kg/m$^3$, a sign that higher efficiency performances can be achieved. The table above provides AWP values for selected crops in Turkey, Iraq and Syria. Both Iraq and Syria use more water to produce one kilogram of wheat than Turkey does, and this requires further in-depth analyses. Climate undoubtedly plays a role in this, but the best performing areas in these countries should not be comparable to the lowest performing areas in Turkey.

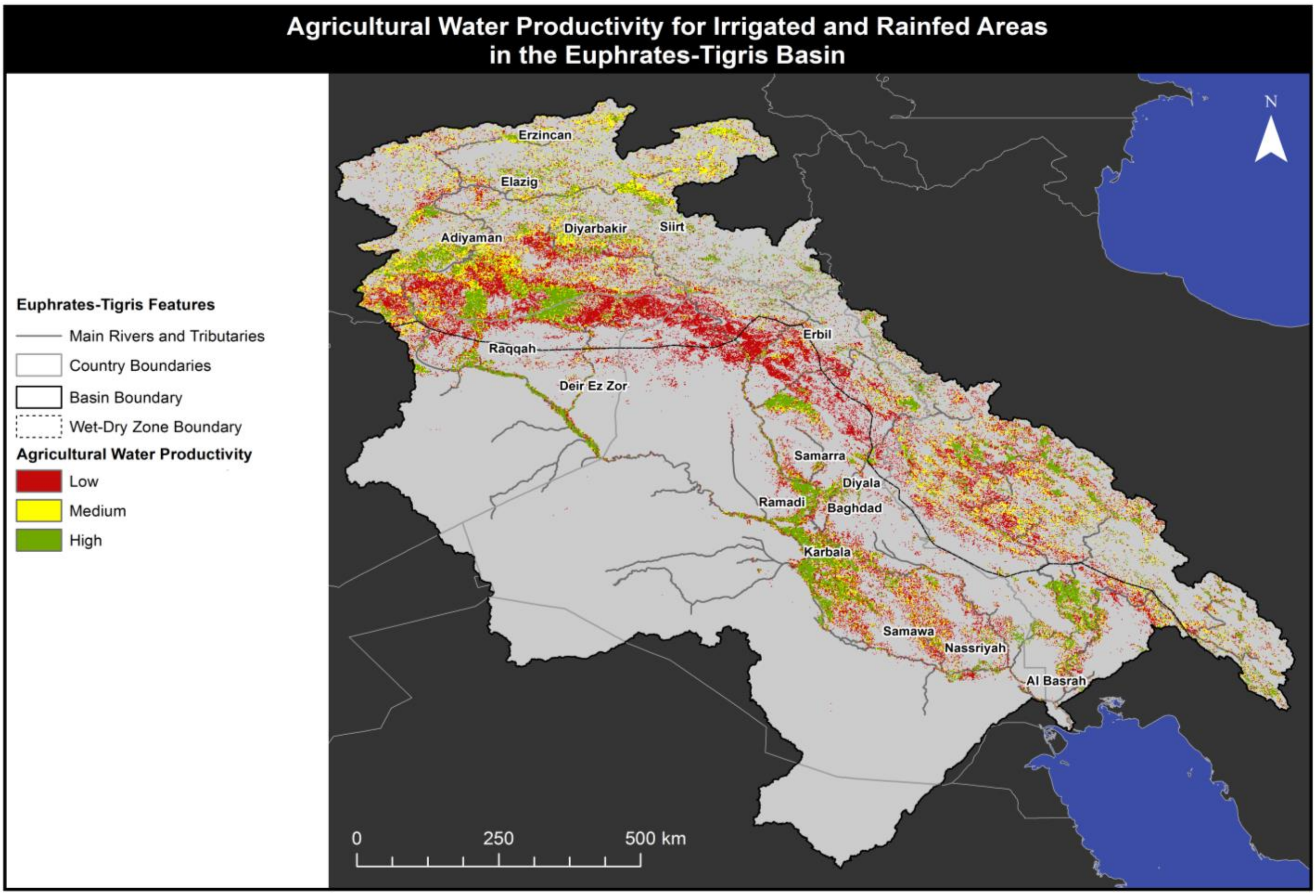
**Scenario Analysis**: A three-scenario analysis (S1: conservative, S2: recommended and S3: optimistic) was conducted to determine water savings or gains in production with improving AWP to 0.75, 1.0 and 1.25 kg/m$^3$, respectively. At the basin level in the normal year of 2006, raising AWP according to scenarios 1, 2, and 3 would have saved up to 13.0, 16.7 and 19.0 km$^3$ of water, respectively.

Hotspots of low (<0.5 kg/m$^3$) and high (>1.0 kg/m$^3$) AWP in each country were identified for rainfed and irrigated agriculture. The taskforce received data related to hotspots and were given the chance to investigate the reasons behind the status in each hotspot and the means to improve these swathes of land from low or medium to high AWP. It is recommended to further analyse these hotspots of high-water productivity to better understand the best practices adopted by these farmers. These practices can then be scaled up and disseminated in order to close the yield gap and reduce the consumptive use of crops.

**The Role of Women in Agriculture:** Gender plays important role in improving agricultural AWP. Women in the Euphrates-Tigris basin share most of the operations in the field with men; in addition, they take greater responsibility for raising children at home. There remains a great need for empowering women in agricultural areas and for better defining the roles of men and women in improving water productivity in agriculture.

## CONCLUDING REMARKS

AWP is a relatively new concept in the Euphrates-Tigris basin. With water as the limiting resource, efforts to increase crop water productivity should be prioritized. The trade-offs between water and land productivity need to be determined at local scale based on the scarcity of the resource proportional to net returns from economic, ecological and sustainability standpoints. The methods used for assessing AWP, both using remote sensing and collecting ground data, are sound and produced useful results. The data on crop yields obtained through remote




Agricultural Water Productivity (AWP) of Rainfed and Irrigated areas in the basin in the normal year (2006).

sensing was compared and verified with national data. Water productivity relates to water actually consumed (depleted) in the production process, and not to all water diverted or applied to the fields. Lost water is not necessarily an absolute loss; farmers downstream can use return (drainage) flows. This is not considered in calculating AWP, as it would lead to double accounting. In 2002, 2006, and 2008 total AET in the basin, excluding Iran, was calculated at 34.4, 34.41, 31.45 km$^3$, respectively. Biophysical AWP is low or medium in most of the rainfed and irrigated systems. However, there are spots of high productivity that can serve as examples when seeking to improve water efficiencies in low AWP areas.

It is within reach to at least double water productivity in the basin. This will require investment in agricultural inputs, improved irrigation practices and management, conservation of soil and water, using improved varieties and minimizing losses of water in evaporation. In some areas, modifying cropping patterns to grow more water efficient crops may be required. Substantial amounts of water would be saved if higher levels of water productivity could be achieved. For example, in 2006 (normal year) similar crop yields could have been achieved with a saving of 19 km$^3$ if anticipated higher productivities had been realised. Alternatively, with higher levels of productivity, production could have been boosted by nearly 24 million tons using the same volume of water.

Regional cooperation could bring about an increase in water productivity in each country and at the basin level. Controlling water quality, coordinating cropping patterns based on comparative advantage, and trading virtual water, are some of the potential win-win options. Exchanging experience and capacity building would also support improvements. Despite the challenges brought about by conflicts and local politics it is very encouraging to see that at the technical level people from all basin countries are cooperative and willing to accommodate each other.

## Recommendations

**1.** There is a lot of scope for raising agricultural water productivity and reducing water demand in the Euphrates-Tigris Basin. This high-level assessment needs to be absorbed and practices implemented at a practical and realistic scale.

**2.** Existing examples of successes should be studied and implemented without delay.

**3.** Further research into improvements in Agricultural Water Productivity, with consideration of possible unintended consequences, should be undertaken by all the Basin countries.

**4.** The role of the Agricultural Task Force under CPET was limited in scope to this broad-scale review of agricultural water productivity. There are many other aspects to agricultural productivity, and especially to agriculture as the major user of water in the Euphrates-Tigris Basin that require study with a view to reducing demands and improving efficiencies; this in order to achieve a more equitable allocation of resources both across sectors and the basin.