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WATER PRODUCTIVITY IN CROP PRODUCTION AND ITS ASSESSMENT: A CASE STUDY OF TASHKENT REGION

Abstract: In the context of climate change, ensuring timely and adequate water supply for agricultural crops is becoming an increasingly pressing issue. Addressing this challenge can contribute to obtaining higher yields from the supplied water, which is of great importance for irrigated agriculture in the Tashkent region. This study examines the changes in water productivity for traditional crops such as rice, wheat, apricot, cherry, grapes, melon, onion, tomato, watermelon, potato, and carrot, using climate data from 2019 to 2021. The analysis, which was carried out in the context of the conditions in Tashkent, revealed that among vegetables, onions had the lowest water productivity, and among fruits, cherries had the lowest water productivity.

Keywords: Water Demand, Water Productivity, Climate Change, Vegetable Crops, and Orchards.

Introduction. In the context of climate change, ensuring a timely and adequate water supply for agricultural crops remains a critical issue. Addressing this challenge can enable higher yields from the supplied water [1-3]. Delivering water to farms in a timely and sufficient manner, especially in the lower reaches of river basins, is complex, necessitating accurate assessments of water demand across the river basin and efficient water allocation [4-5]. However, changes in river flow supply over many years, particularly due to climate change, introduce significant uncertainties into this process [2,3]. Therefore, this research is dedicated to determining the water demand of major food crops for the conditions of the Tashkent region and to assessing the water use productivity of these crops.

Research Methods. The study was conducted in three stages. In the first stage, reference evapotranspiration (ETo) was estimated. For this, the Penman-Monteith formula, recommended by FAO for wide use, and the Hargreaves-Samani formula, for situations with insufficient climate data, were used. In the second stage, crop evapotranspiration (ETc) was estimated using the FAO method. Daily climate data for the years 2019–2022 were used to estimate ETo. In the third stage, the water use productivity of the crops, or the yield per m^3 of water consumed, was calculated. Water productivity was assessed for traditional crops: rice, wheat, apricot, cherry, grapes, melon, onion, tomato, watermelon, potato, and carrot. In this study, water consumption was assumed to be equal to crop evapotranspiration. Planting dates, vegetation period lengths, and development phase durations were considered for the selected crops. This was achieved by ensuring consistency between planting/harvest dates and placing the growing season within appropriate parts of the year with sufficient temperature amounts for crop growth. The climate data set was obtained from the Center of Hydrometeorological Service of the Republic of Uzbekistan (Uzhydromet), and water productivity was determined based on this data.

Results and Discussion.

Figure 1 shows the results of the reference evapotranspiration estimation during the crop growing period.

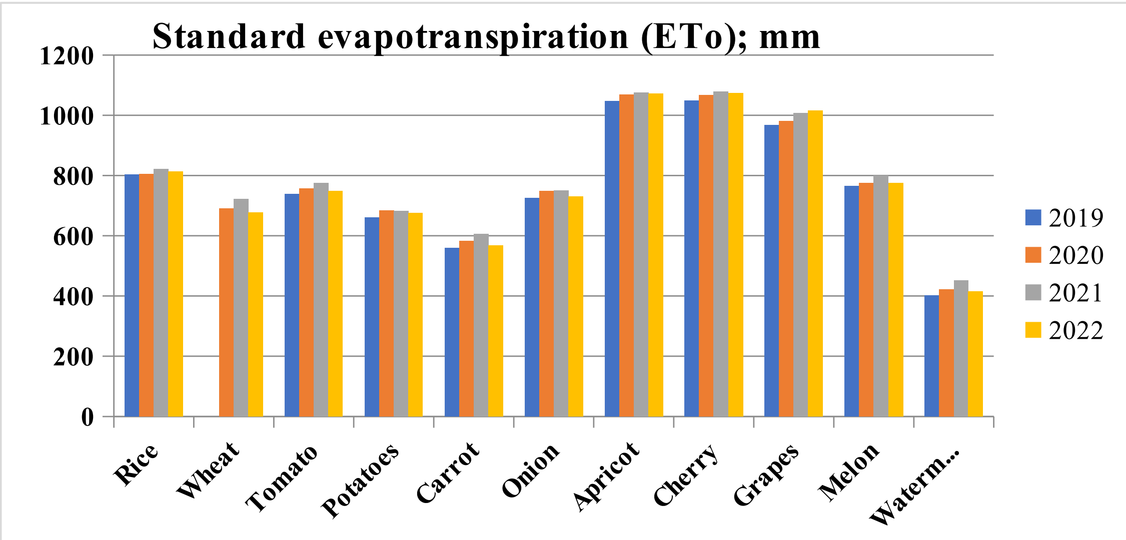

Figure 1. Reference evapotranspiration values during the crop growing season for the years 2019-2022.

Figure 1 shows that reference evapotranspiration during the crop growing season varied as follows: rice, 1051 mm to 1079 mm; wheat, 677 mm to 722 mm; tomatoes, 738 mm to 774 mm; potatoes, 661 mm to 684 mm; carrots, 560 mm to 606 mm; onions, 726 mm to 750 mm; apricot orchards, 1047 mm to 1075 mm;

cherry orchards, 1048 mm to 1079 mm; grapevines, 968 mm to 1017 mm; melons, 765 mm to 800 mm; and watermelons, 402 mm to 451 mm. Figure 2 shows the results of crop evapotranspiration estimation.

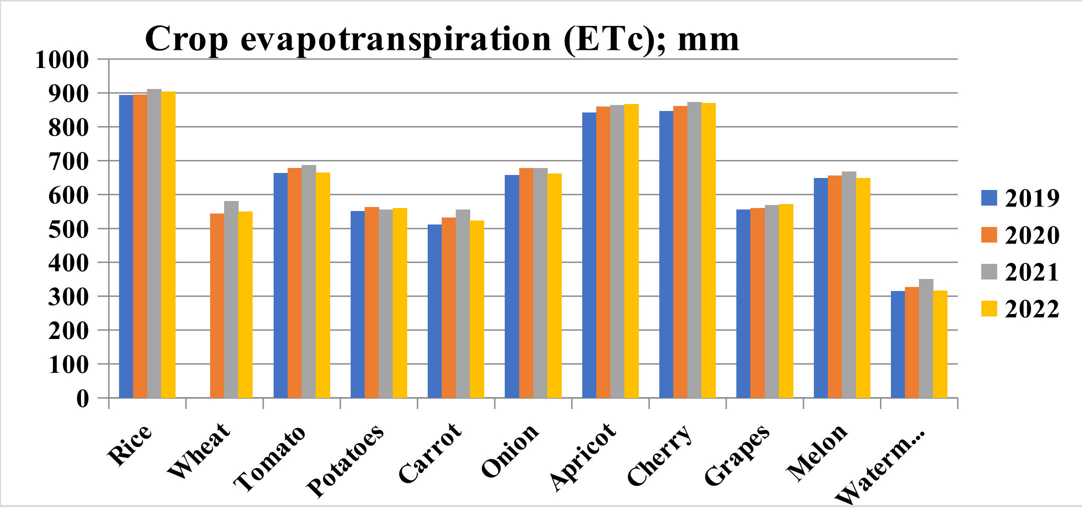

Figure 2. Results of crop evapotranspiration estimation for the years 2019-2022.

As can be seen in Figure 2, crop evapotranspiration during the crop growing season was found to be: 1027 mm to 1046 mm for rice; 543 mm to 581 mm for wheat; 664 mm to 688 mm for tomatoes; 550 mm to 563 mm for potatoes; 511 mm to 555 mm for carrots; 657 mm to 677 mm for onions; 842 mm to 866 mm for apricot orchards; 847 mm to 873 mm for cherry orchards; 555 mm to 572 mm for grapevines; 648 mm to 668 mm for melons; and 315 mm to 350 mm for watermelons. Table 1 presents the results of the water productivity change assessment for the 2019-2022 period, by crop type.

Table 1. Water Productivity Values for the 2019-2022 Period kg/m^3

Water Productivity	2019	2020	2021	2022
	0.34	0.26	0.30	0.38
Rice		0.67	0.51	0.52
Wheat	5.93	4.54	4.77	4.68
Tomato	6.05	5.84	5.54	4.93
Potato	6.35	6.49	6.44	7.27
Carrot	4.56	4.36	4.55	5.33
Onion	0.46	0.57	0.60	0.75

Apricot	0.37	0.63	0.50	0.56
Cherry	0.74	0.62	0.67	0.66
Grape	4.57	3.55	4.38	4.52
Melon	6.53	6.79	3.45	3.48

As can be seen from Table 1, in the conditions of the Tashkent region, the crops are ranked in the following order according to their increase in water productivity (kg/m³): rice > cherry > wheat > apricot > grape > melon > onion > tomato > watermelon > potato > carrot.

The results of assessing the water use productivity of crops (sum/m³), taking into account the prices of agricultural products in the markets of the Tashkent region, are presented in Figure 3.

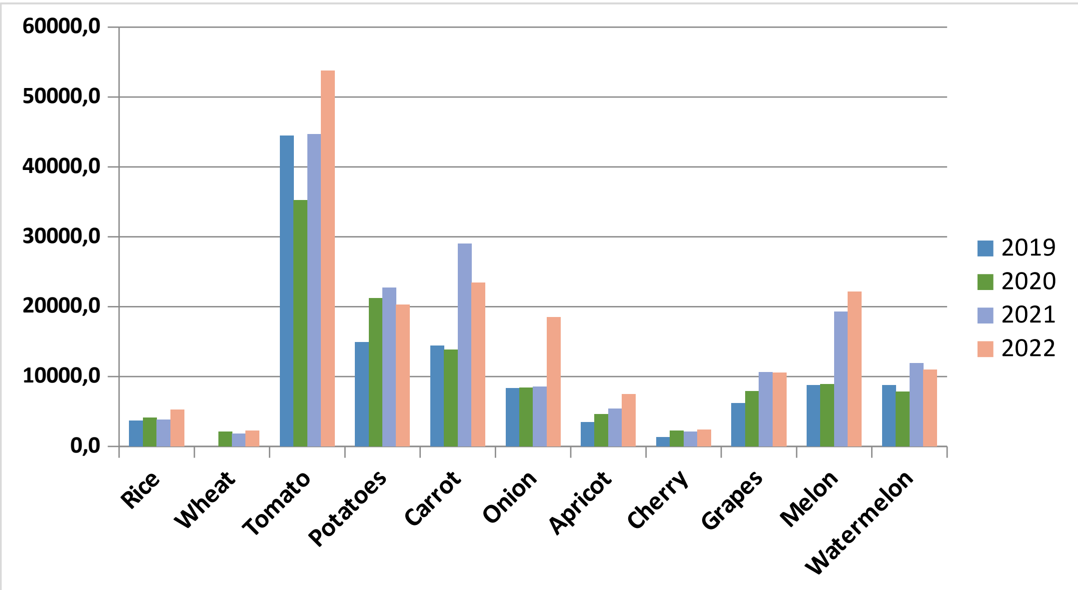

Figure 3. Price graph based on water productivity.

Based on the increase in price, the crops were ranked in the following order according to their water use productivity: cherry > wheat > rice > apricot > grape > watermelon > onion > melon > potato > carrot > tomato.

Under the conditions of the Tashkent region, the following are recommended:

- Achieving water savings by replacing water-intensive crops with less water-intensive crops.
- Planting more crops with high water productivity and less crops with low water productivity in water-scarce conditions.

- Planning crop areas by taking water productivity into account when scheduling crop placement.
- Using a water consumption assessment method for predicting crop water requirements.

Summary. The results showed variations in ETo and ETc across the studied crops, with rice, apricot, and cherry exhibiting higher values. When ranked by water productivity (kg/m³), the crops were in the order: rice > cherry > wheat > apricot > grape > melon > onion > tomato > watermelon > potato > carrot. However, when considering market prices (sum/m³), the ranking changed to: cherry > wheat > rice > apricot > grape > watermelon > onion > melon > potato > carrot > tomato, indicating that crops like cherry and wheat offer better returns considering both yield and market value relative to their water use. Based on these findings, the study recommends several strategies for improving water management in the Tashkent region: replacing water-intensive crops with less water-intensive ones, prioritizing crops with higher water productivity during water scarcity, integrating water productivity into crop planning, and using water consumption assessment methods for better forecasting of crop water requirements. These recommendations aim to enhance water use efficiency and optimize agricultural production in the region.

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