

# Comprehensive evaluation of the water-energy-food nexus in the Tarim River Basin, northwest China

**Yaning Chen, Meiqing Feng, Yiding Wang and Weihong Li**

*State Key Laboratory of Desert and Oasis Ecology, Key Laboratory of Ecological Safety and Sustainable Development in Arid Lands, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi, China  
Email: chenyn@ms.xjb.ac.cn*

**Abstract:** Water, energy, and food are the basic factors of human survival and development, and their internal coupling contributes to the realization of regional sustainable development goals. The Tarim River Basin is located in the arid northwest China, with a drainage area of  $1.02 \times 10^6$  km<sup>2</sup>. The basin is featured with irrigated agriculture, and irrigation water in the TRB accounts for about 95% of the region's total water consumption.

This study investigated the agricultural water-energy-food nexus index in the Tarim River Basin, focusing on the water and energy consumption, water and energy productivity, and water footprint of food production of the main crops (rice, wheat, maize and cotton). The results indicated that different crops had significant differences in water and energy consumption. The blue water requirements of wheat, maize, rice, and cotton were  $3174.9 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ ,  $4271.8 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ ,  $7283.3 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$  and  $8769.3 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ , respectively. Of these crops, wheat had the lowest blue water requirements and cotton had the highest. During 2000-2019, the water footprint increased significantly from  $2.15 \text{ m}^3/\text{kg}$  to  $2.86 \text{ m}^3/\text{kg}$ , of which 93% is blue water and 7% is green water. At the same time, the planting area of the Tarim River Basin also increased by  $105 \times 10^4$  ha during 1990-2019 with cotton accounting for 45% of the total planting area. The expansion of the planting area led to a continuous improvement in cotton production income, leading to the highest energy economic productivity in cotton ( $0.065 \text{ \$/MJ}$ ). However, with the increase in total water and energy consumption, the water and energy mass productivity in cotton were lower than in the other three crops. A water-energy-food nexus index was constructed and calculated for the agriculture of the Tarim River Basin. The average water-energy-food nexus index of rice, wheat, maize and cotton was 0.40, 0.45, 0.43 and 0.35, respectively. This demonstrated that wheat had the highest resources utilization productivity in agricultural inputs, while cotton had the lowest.

These results can provide an important scientific basis for current and future agricultural management optimization in the arid regions to achieve the United Nations Sustainable Development Goals.

**Keywords:** *Water footprint, water-energy-food nexus, water consumption, Tarim River Basin*