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Virtual water concept for enhancing water-saving options

Most people in the Aral Sea basin (ASB) in Central Asia do not realize that for producing one T-shirt, about 2,860 liters of regional water are being used. Moreover, it takes e.g. 2,070 liters of water to produce 1 kg of their daily bread. The ZEF/UNESCO project in Khorezm, Uzbekistan, has combined the concepts of value chain (see ZUR 2) and of virtual water to examine the virtual water content of cotton, wheat, and their subsequent products. The goal was to identify high water consuming products and sectors as well as water-saving options both for decision makers and water consumers in the region.

Water in the ASB has become scarce due to decreasing availability of fresh water resources and an increasing water demand by households and agricultural producers. In addition, deteriorating irrigation and drainage networks cause high water losses (see ZUR 14). The increasing water demand in combination with an expected reduction in water supply is aggravating local agricultural production and the livelihoods of the population. It is therefore necessary to improve the technology of water distribution and use and to raise awareness among agricultural producers and other water users regarding water value and scarcity.

The ZEF/UNESCO project used the concept of virtual water, which has become an important indicator of sustainable water use and water management for water scarce regions worldwide. Virtual water stands for the total volume of water being used to produce a commodity (Allan 1998). The adjective 'virtual' explains that water used to manufacture a product is not directly contained in it, but has been used at all production stages. The real-water content therefore often is generally negligible as compared to the virtual water content.

Research on virtual water conducted in the ZEF/UNESCO project estimated how much water is being used along the cotton and wheat value chains (Figure). In total eleven types of cotton and five types of wheat products have been analyzed for virtual water content.

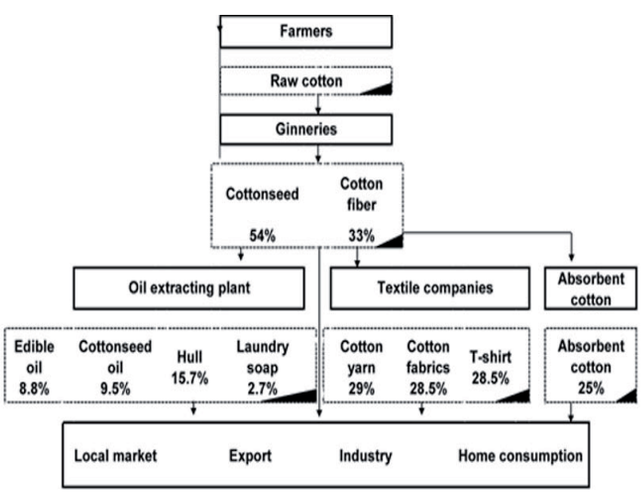

Figure 1: Cotton and its products.

To calculate virtual water we therefore added all water used along all production stages. Thus, the total virtual water of any product is the sum of agricultural water use and water use at several industrial stages and is being calculated as:

Total virtual water = Agricultural water use (AWU) + Industrial water use (IWU)

Water use at each industrial stage for cotton products includes water for cotton processing (bleaching, dyeing, etc.), whereas agricultural water use includes water for leaching, irrigating fields during the vegetation season, the amount of water lost in the irrigation canals and also grey water, which is the water virtually needed to dilute the pollutants caused by pesticide and fertilizer seepage. This is estimated as:

Agricultural water use = leaching + vegetation + losses + grey water

For all analyzed products (see Table) the estimates show that agriculture is the major contributor to the total virtual water content, including water losses caused by the inefficient irrigation and drainage networks. It takes roughly 6,820 liters of water to grow one kg of raw cotton and about 2,300 liters to grow one kg of wheat.

Water use at each industrial stage compared to agriculture is less significant with around 1 liter of water per kg of cotton or wheat processed products. The exception is the weaving industry in the cotton chain, which along with cotton fabrics produces 789 liters of polluted (waste) water from the bleaching and dyeing processes. Producing T-shirts for instance from colored fabrics requires a high industrial water use and causes a lot of waste water.

Table 1: Virtual water estimates for cotton and wheat products in the study region

	AWU	IWU (cumulative)	TVW
Cotton and cotton products			
1 kg Raw cotton	6,819	0	6,819
1 kg Fiber	6,819	1	6,820
1 kg Yarn	7,759	(1)+0.7	7,761
1 kg Fabrics	7,895	(1+0.7)+789	8,686
1 T-shirt (330 g)	2,074	(1+0.7+789)+0	2,865
1 kg Cottonseed	6,819	0	6,819
1 l Edible oil	6,821	(0)+3.2	6,824
1 kg Cottonseed meal and cake	6,819	(0)+0.3	6,819
1 kg Soap	6,821	(0)+11.8	6,833
1 kg Absorbent cotton	9,001	(1)+43.7	9,046
Wheat and wheat products			
1 kg Wheat	2,302	0	2,302
1 kg Flour	2,302	0.3	2,302.3
1 kg Pasta	2,302.45	(0.3)+1.15	2,303.9
1 kg Loaf of bread	2,072.7	(0.3)+1	2,074
1 kg Fodder	2,032.68	0.22	2,032.9

TVW = Total virtual water (TVW); AWU = Agricultural water use (AWU): IWU = Water use at industrial stage (IWU)

Conclusions and recommendations

Decision makers and end users alike are usually astonished when they realize how much virtual water is included in cotton and wheat products. Furthermore, research revealed that water users (households, farmers, industries, etc.) lack the stimulus and the knowledge on water saving options and thus sustainable water use. The analysis showed that huge amounts of water are lost during field level agricultural production, whereas much polluted water is generated during the processing of cotton fabrics or absorbent cotton - thus deteriorating the environmental problems in the region.

Two options to help reducing the current high and unsustainable water use in the region seem feasible: First is to reduce agricultural water use through upgrading irrigation and drainage networks and introducing efficient water use technologies in the field. However, this would require considerable capital investments. Secondly, water use can be shifted from the agricultural sector to the more water-balanced processing sector with a focus on non-polluting industries. For instance, a stronger focus on manufacturing cotton yarn rather than on manufacturing of complete cotton garments is favorable, as long as the 'grey' (waste) water generated by the textile industry cannot be reduced.

Water tanks for manufacturing absorbent (medicine) cotton at a cotton factory in Khorezm, Uzbekistan.

Reference

Allan, J.A., 1998. Virtual water: a strategic resource, global solutions to regional deficits. Groundwater 36 (4), 545–546.

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