Irrigation management and water use efficiency in cotton and wheat production
A case study from Fergana Valley, Uzbekistan

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Background & Scope

Cotton and wheat production in Fergana Valley (Uzbekistan) depend on irrigation as precipitation during the growing season does not suffice to cover the water demand of the crops. Irrigation, mainly fed from surface water bodies, covers about 90% of the water consumption of the crops. Water use efficiency is low due to poor maintenance of irrigation systems, little knowledge on water saving practices and a lack of economic incentives to implement water saving technologies.

Despite a general awareness of the problems in water management in agriculture in Uzbekistan, detailed studies on water use efficiency and the impact of irrigation management on water resources on a regional or field scale are scarce. This study aims to analyse the effect of current water management on water resources and water use efficiency in cotton and wheat production based on field experiments and modelling approaches.

Methods & Materials

Study area

We present results from a Water User Association (WUA) in the Fergana Valley, Uzbekistan. The study was done in the frame of the project CAWA ("Water in Central Asia", www.cawa-project.net).

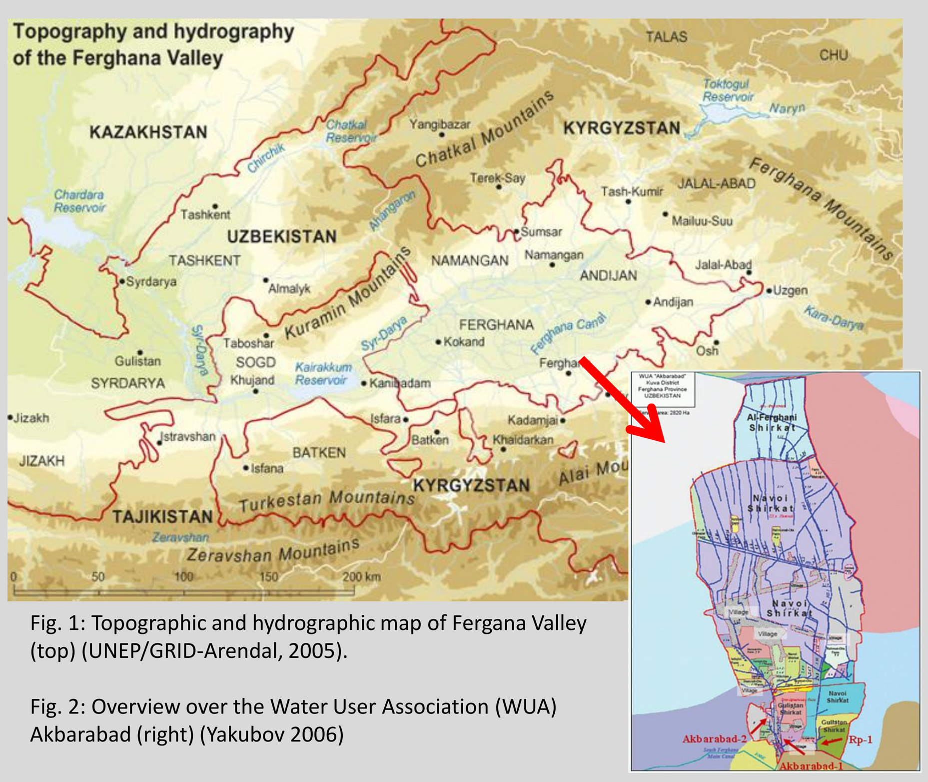
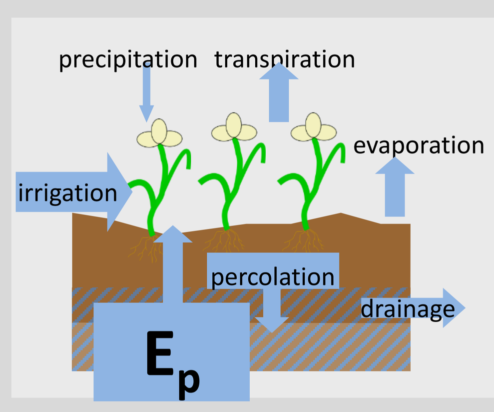


Fig. 1: Topographic and hydrographic map of Fergana Valley (top) (UNEP/GRID-Arendal, 2005).

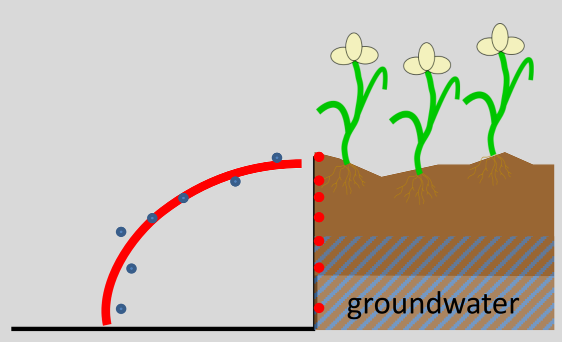
Fig. 2: Overview over the Water User Association (WUA) Akbarabad (right) (Yakubov 2006)

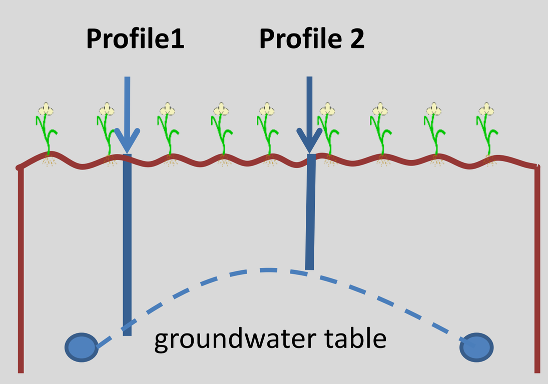
Field scale (< 1 km²)

The evaporative loss of groundwater was quantified using isotopic signatures of soil water. Profiles with different depth to groundwater were compared. High evaporative losses indicate that a large amount of irrigation water is not used for biomass production and accounts for unproductive water losses.



? How much water is evaporating from groundwater ?





Scale of Water User Association (28 km²)

The CROPWAT and DRAINMOD models were applied to calculate the water footprint of cotton and wheat production. Land use, irrigation and harvest data from the Water User Association were used to calculate the amount of virtual water stored in the harvested commodity and the water use efficiency related to crop production.

$$VWC = \frac{CWR}{CY}$$

VWC = virtual water content [m³/t]
CWR = crop water requirement [m³/ha]
CY = crop yield [t/ha]

Management and climate change scenarios (i.e. temperature increase) were applied 1) to assess the effect of alternative irrigation strategies on water use efficiency and 2) to assess future water demand in agricultural production.

Management and climate change scenarios		
Irrigation management	Change in irrigation scheduling/volume	Change in cropping system
Climate change scenarios	Temperature increase (+2 °C)	Water limitation (-5%)

Results

Evaporative losses from groundwater

Phreatic evaporation at different depths to groundwater		
Depth to groundwater	2.4 m	1.8 m
Evaporation from groundwater [m a^{-1}]	0.14	0.6

On the field scale, evaporation from groundwater ranges between 0.14 – 0.6 m per year. The values show that evaporative losses depend largely on depth to groundwater.

Effect of irrigation management

Virtual Water Content of cotton in WUA Akbarabad under current irrigation management and with management scenarios (calculated with CROPWAT)

	Current irrigation	Optimised irrigation	Deficit irrigation
VWC [m³/t]	4932	3069	2386
Reduction of irrigation		38 %	52 %
Yield loss		-	~ 7 %

Effect of temperature increase and water limitation

Effect of climate change scenario on cotton production (calculated with DRAINMOD)

	Current	+2°C	+2°C -5 % water
Crop yield [t/ha]	2.25	2.09	2.07
Number of water stress days	42	52	54

Conclusions

The results show that agicultural production in the study region is marked by poor water use efficiency and high water losses. On the field scale, isotope profiles indicate that unproductive evporative losses from groundwater largely depend on the depth to groundwater. Drainage pipes in the fields influence the groundwater surface and hence cause a high in-field variation of evaporation from groundwater. The amount of phreatic evaporation is expected to increase under elevated groundwater levels.
Alternative management scenarios on the WUA scale show that the volume of irrigation can be reduced without yield losses.

Hence, water use efficiency can be increased even with simple measures, such as a change in timing and volume of irrigation. Given climate change predictions, adaptive measures are required to sustain agricultural production in the study area, e.g.:

- Change of irrigation management (improved scheduling, driven by water demand)
- Introduction of less water demanding crops
- Introduction of incentives for improved water management

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