Economic Water Productivity of irrigated crops in Sirsa District, India
more cash per splash

Location	Sirsa district, Northwestern India
Contractor	Water for Food Programme
Period	2002 - 2003

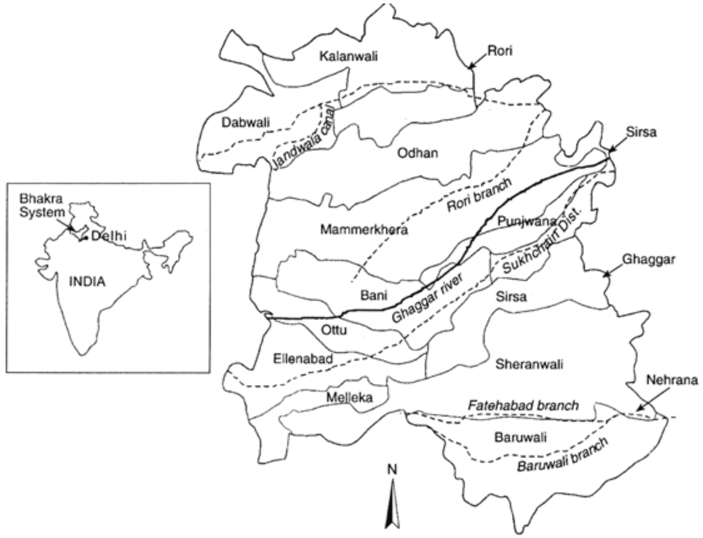
Scope of the project

Major issues with respect to water management in Sirsa district in northwestern India are waterlogging and salinization in areas with saline groundwater and over-exploitation of groundwater in areas with fresh groundwater. In order to identify the major agricultural water consumers and to estimate regional crop production, an extensive WATer PROductivity (WATPRO) project was performed. The project was funded by the Water for Food Pogramme of the Netherlands Ministry of Agriculture and Fisheries.

Study approach

The applied remote sensing methodology consists of three steps: first, a land cover classification was made for the 2001-02 Rabi and 2002 Kharif season. Secondly, the Surface Energy Balance Algorithm for Land (SEBAL) was applied to calculate yield and water use (actual evapotranspiration). For this purpose satellite images of the Landsat Enhanced Thematic Mapper (Landsat ETM) and the Advanced Very High Resolution Radiometer of the National Oceanic and Atmospheric Administration (NOAA-AVHHR) were acquired and processed. The third and final step is to integrate the monthly SEBAL results of NOAA with the daily Landsat results to obtain high resolution maps of water productivity.

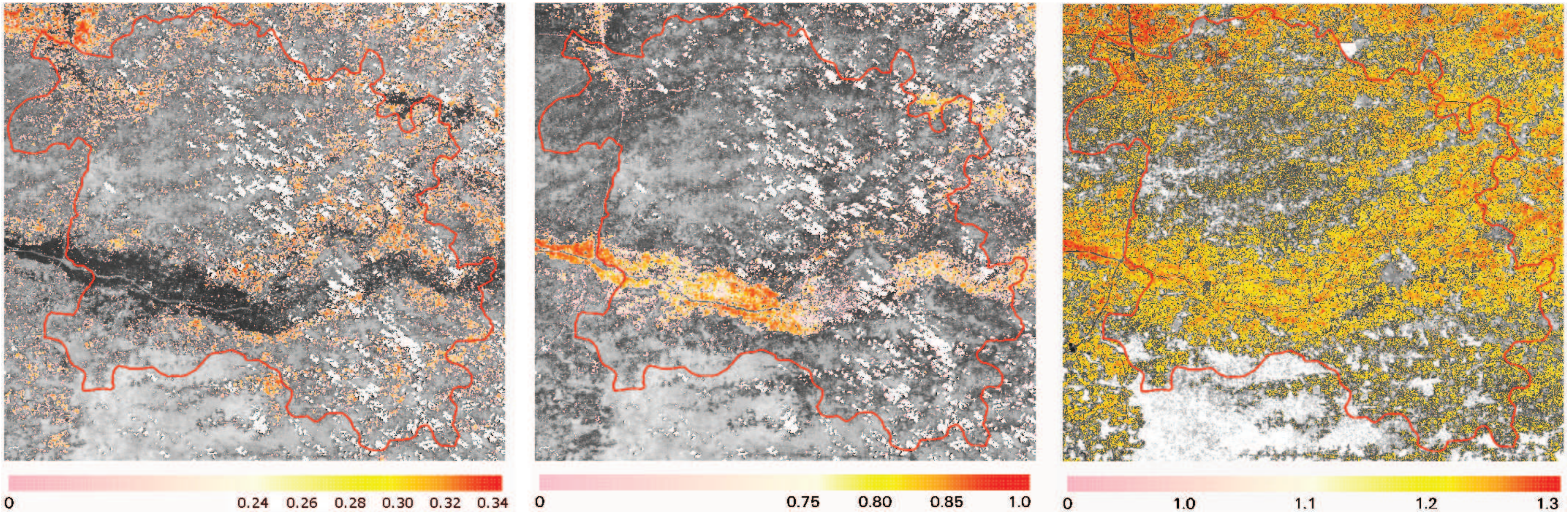
Agricultural productivity is usually expressed as production per unit of land (yield/ha). With water becoming the scarcer commodity, yield should be expressed per unit of water depleted (yield/m^3), i.e. *crop per drop*. This is useful in comparing the same crop over the same year, different years or between regions. To compare different crops in different regions and/or years, water productivity needs to be expressed as income per unit of water depleted ($/m^3), i.e. *cash per splash*. This indicator is a function of market prices and thus can differ between years and between regions. This WATPRO study is the first known application of SEBAL products to estimate spatially distributed economic water productivity.



Results

Crop water productivity

The values of water productivity of <u>wheat</u> are between 1.0 to 1.4 kg/m^3 per unit of water consumed (see Fig. 2c). Molden et al. (2000) compared the water productivity of irrigated wheat systems in Pakistan and India. They found a value of 1.1 kg/m^3 as an average for the Bhakra system. According to Fig. 2c, the average water productivity for wheat is 1.22 kg/m^3. The areas with higher water productive wheat systems are located outside the Sirsa Circle in the Punjab and in



a) cotton (Kharif) *b) rice (Kharif)* *c) wheat (Rabi)*

***Figure 1**: Water productivity of cotton, rice and wheat (yield divided by the amount of water depleted, kg/m^3)*

Rajasthan. The highest productivity found is 1.61 kg/m^3.

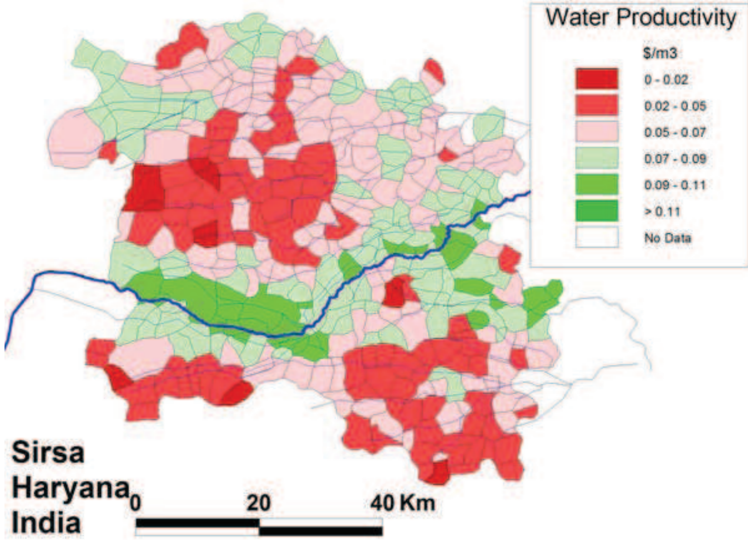
The average water productivity for rice per unit of water consumed is 0.72 kg/m^3. The maximum value is 0.98 kg/m^3. Using field data from Northwestern India, Tuong and Bouman (2003) concluded that the water productivity was between 0.5 and 1.1 kg/m^3, revealing a significant scatter in the farmer practices and management of the irrigation system. This comparison with other data sources suggest that the values obtained are reasonable and that the crop water productivity for rice in Sirsa Circle is a kind of average value for the climate and growing conditions in India.

The average crop water productivity for cotton (based on lint yield) is 0.31 kg/m^3 and the maximum value found is 0.42 kg/m^3 (Fig. 4a). These levels are comparable to what has been measured elsewhere in the region.

Fross farm income

The gross return (see Fig. 4) was calculated using the crop yield maps of SEBAL multiplied by fixed market prices given by (Hellegers, 2003):

rice	5.8 Rs/kg	0.123 $/kg
wheat	6.4 Rs/kg	0.136 $/kg
cotton	21.5 Rs/kg	0.457 $/kg



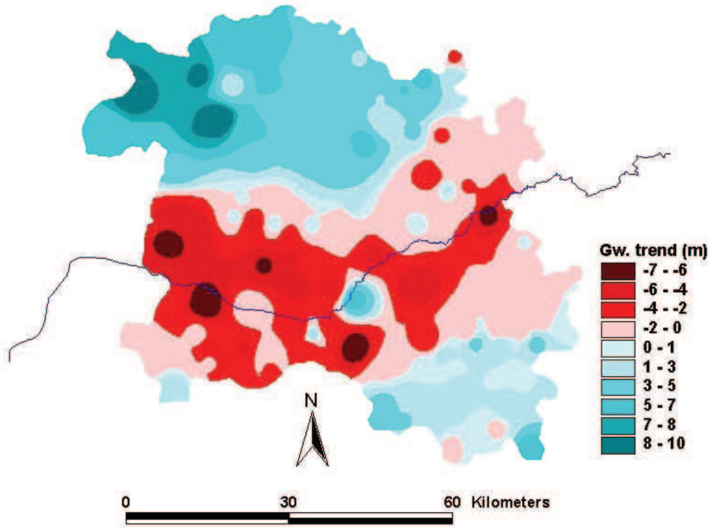


***Figure 3**: Groundwater trend (m / 10 year) of Sirsa district, calculated over the period 1990 to 2000 in meters (negative value is declining groundwater level).*

The rice-wheat areas located in the southern part of the district on the alluvial plains of the Ghaggar river have the highest yearly gross farm income (> 1000$/ha). Figure 3 presents the changes in groundwater during the last 10 years and a strong relation between groundwater decline (i.e. use pumpstations for irrigation) and gross farm income can be noticed. Although the gross return for farmers is the highest in those areas, the net farm income may much lower due to pumping costs. Moreover this way of practicing agriculture is not sustainable as they drain the Ghaggar plain.

Economic water productivity

By dividing the gross return with the consumed water (m^3 evapotranspired), the economic water productivity is calculated (see Fig. 2). For both seasons combined, the total water productivity was 0.15 US$ per cubic meter. In

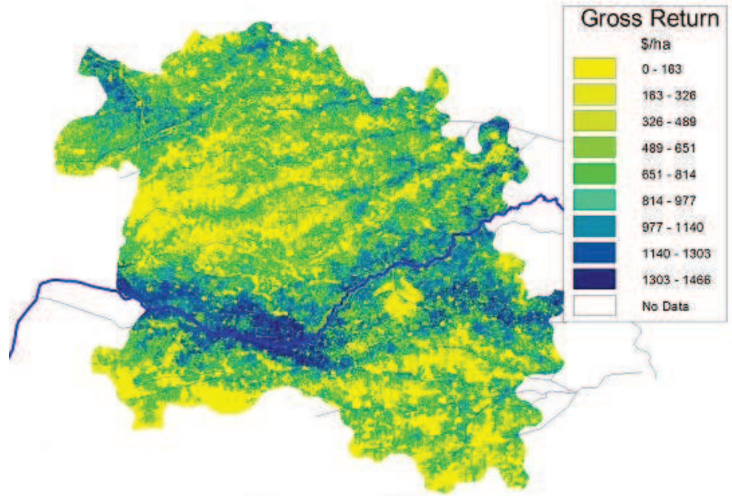


***Figure 4**: Gross return based on crop production and crop market prices. Period included is Rabi and Kharif 2001-2002.*

other words: every cubic meter of water evapotranspired generates 0.15 US$ to the agricultural sector. Differences exist however between the two seasons and between different crops. The average economic water productivity in the *Rabi* season is 0.11 $\$/m^3$ and is much lower in the *Kahrif* season (0.04 $\$/m^3$). Wheat has the highest economic water productivity (0.14 $\$/m^3$), followed by rice and cotton (0.07 and 0.04 $\$/m^3$ resp.). The farmers in the >0.10$\$/m^3$ per year range are found in the rice-wheat systems along the Ghaggar river. So again, farmers with the highest productivity ruin the longer term environmental conditions.

The SEBAL products were the basis for spatial analysis of economic water productivity. This type of analysis can be used to monitor and/or evaluate the economic performance of for example irrigation schemes by integrating operation and maintenance costs of the system and by including water pricing to farmers. Instead of considering the gross returns, the net return can be assessed, thus giving (spatial) insight in the profitability of farming in the region.

Rural development programs should focus on the underlying social-physical reasons for inducing differences in income and sustainability. The total value of water productivity (both in kg/m^3 and $\$/m^3$) in Sirsa District can increase if farmers with low water productivity adjust their current practices.

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