Location	Hai Basin, China
Contractor	WorldBank
Period	2002 – 2003

Scope of the project

The Global Environment Fund (GEF) project on Integrated Water and Environment Planning and Management presents a new approach to the chronically water short region and to the receiving environment of the Bohai Sea. The root cause of ecological decline in the shallow semi-enclosed Bohai Sea is the uncontrolled pollutant discharges from the main tributaries to the Bohai Sea and the reduction in total volume of freshwater reaching the Sea. The Hai River Basin is one of the seven river basins that flow into the Bohai Sea. A key element in the project is the establishment of real water savings program through an ET reduction strategy, which will enhance the streamflow and freshwater discharges into the Bohai Sea.

The objective of this remote sensing project is to generate the spatially distributed values of actual ET, biomass production and soil moisture.

Study approach

Data from the MODerate resolution Imaging Spectroradiometer (MODIS) satellite has been used to estimate the land surface energy balance at basin scale with use of SEBAL. The large MODIS swath width of 2330 km and its daily repetitive image acquisition, is suitable to cover large river basins such as the Hai Basin. The Landsat swath width is 185 km and it has pixel dimensions of 30 m which is not suitable to cover the Hai Basin. Landsat images have therefore only been used to survey the 15 counties (see Fig. 1) that were selected for demonstrating local solutions to ET reductions.

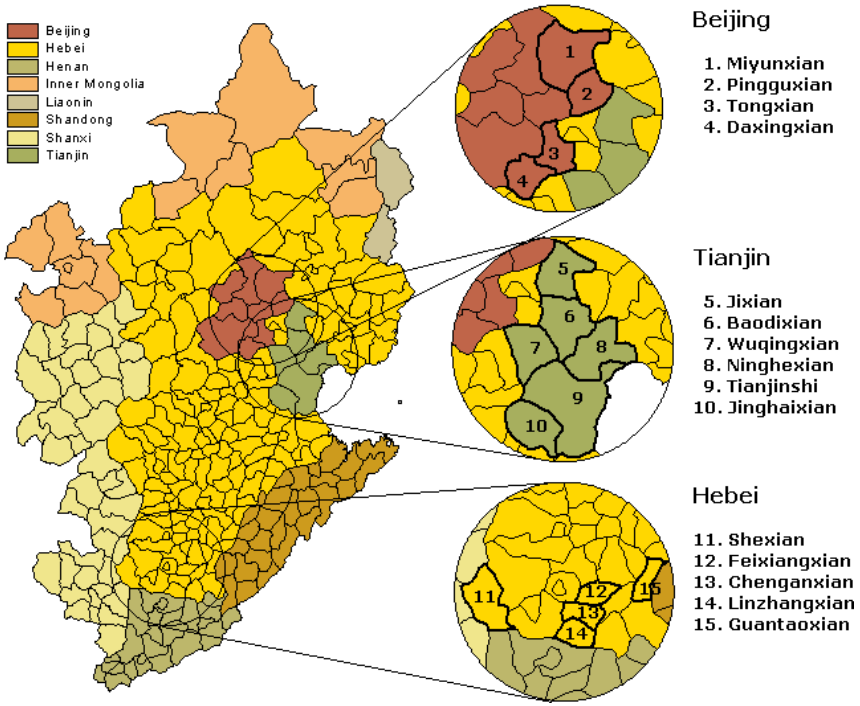

Figure 1: Location of the demonstration counties in the Hai Basin

Results

A map with the accumulated ET for 2002 is presented in Fig. 2. The mean ET is 714 mm/yr, which is above average due to the larger amount of solar radiation received in 2002 and the higher air temperatures that were prevalent as compared to an average year. Dacheng county in Hebei province has with 533 mm/yr the lowest ET. The county with the peak water consumption of 1010 mm/yr is Luanan (also Hebei province), being almost as twice as much as Dacheng county!

The irrigated areas with the highest consumptive use (ET is 850 to 1000 mm/yr) are found at the left bank of the Yellow river in Henan and Shandong provinces.

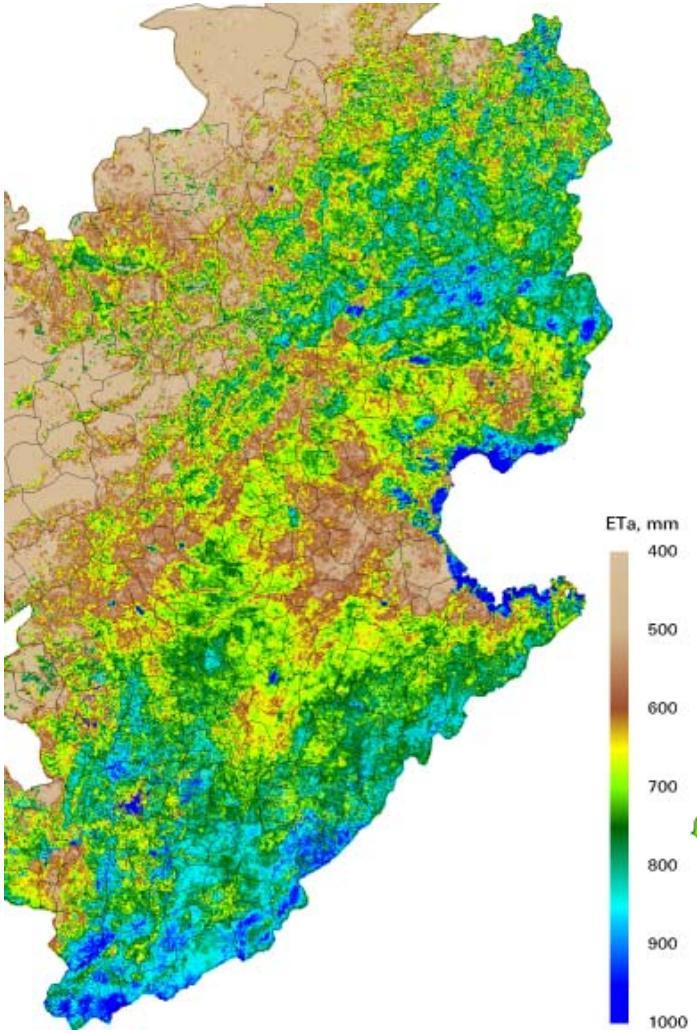

Figure 2: Annual actual evapotranspiration

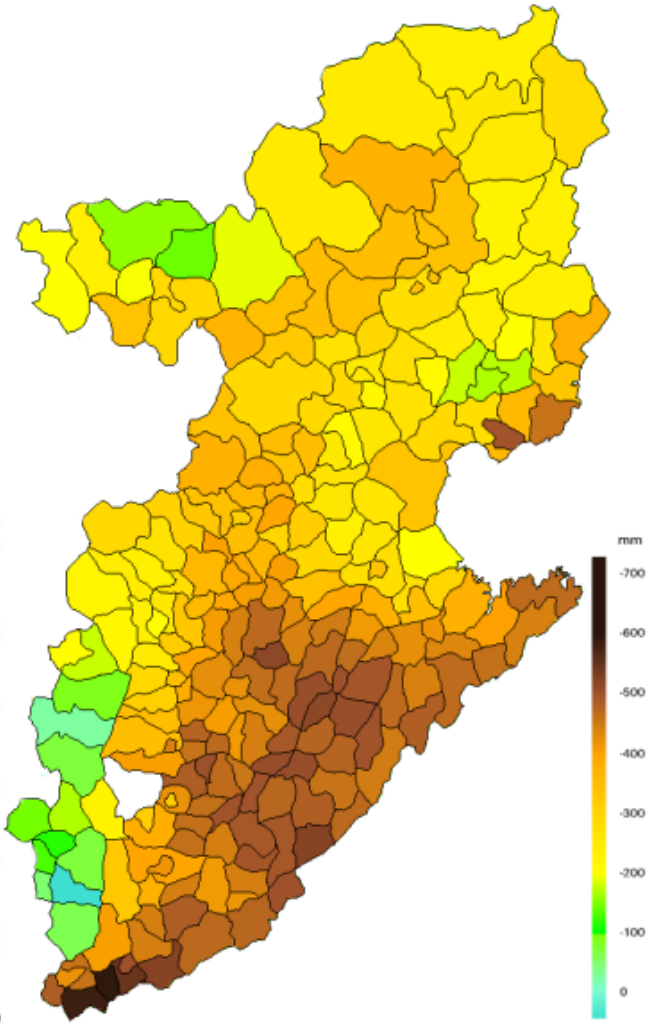

Figure 3: County-wise annual rainfall minus annual actual evapotranspiration

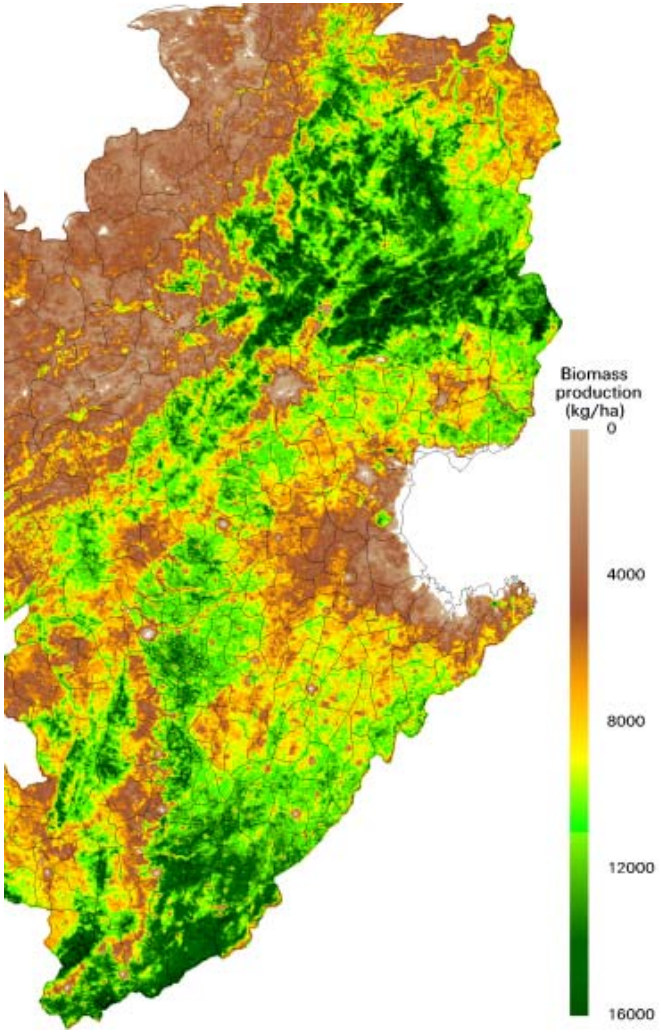

Figure 4: Annual Biomass production

These alluvial plains profit from the surface water diversions that convey Yellow river water into their region. Besides that, a significant inflow of groundwater seepage from the Yellow river occurs (some international groundwater studies estimate a seepage of 200 to 600 mm/yr). The access to these additional water resources yields into more ET and enhances the spatial heterogeneity in water consumption across the Hai Basin.

The high ET values in the northern part of Hebei (850 to 950 mm/yr) originate from the forests in the mountains. The downstream part of the Hai Basin South and Southwest of Tianjin exhibit a strongly reduced ET value (400 to 500 mm/yr), because surface water resources dry up at the tail end of canal systems, and groundwater is of poor quality and not suitable for exploitation. The land cover types are bottom land and saline-alkali land. The ET in these systems is approximately similar to the rainfall.

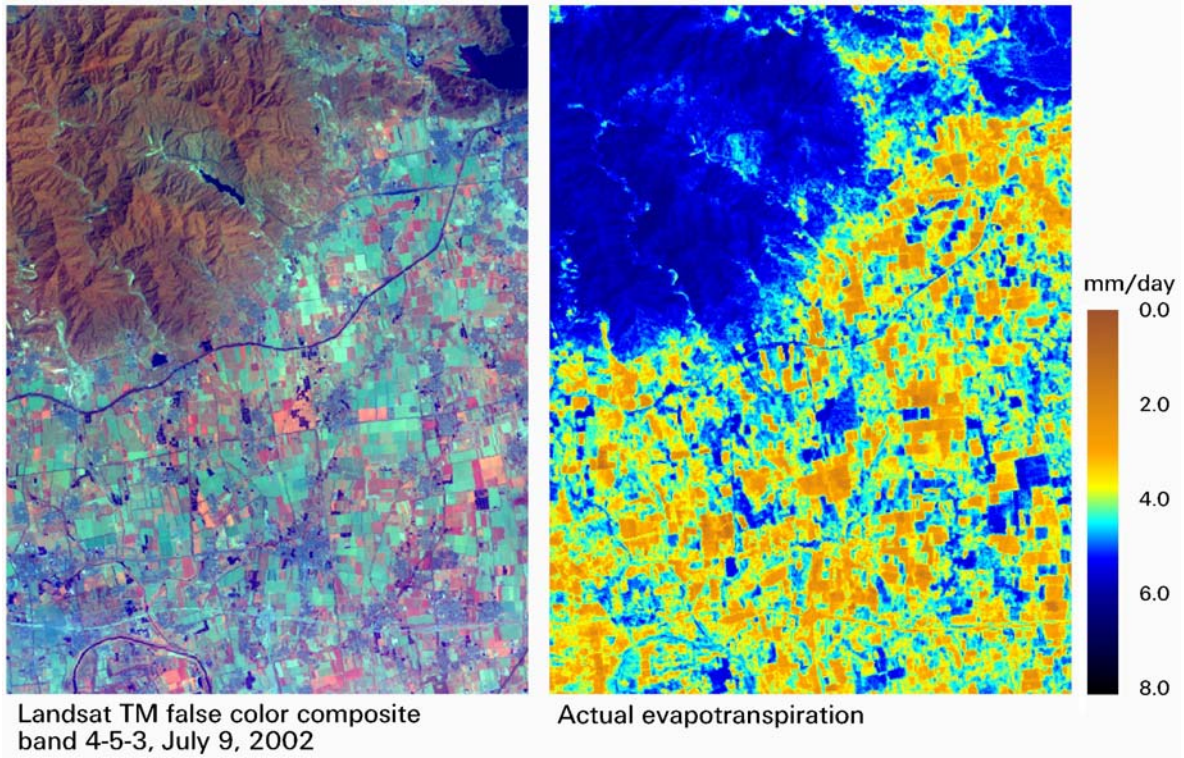

Figure 5: Example of a raw Landsat image (false color composite) and the actual evapotranspiration (ET_{act}) in the Huairouxian, Changpingxian and Shunyixian countyies, Being Province, 9 July 2002. The spatial resolution is 30 m.

The southern part of the Hai Basin that borders to the Yellow river shows up with very high biomass production values (Fig. 4), which is consistent with the high ET values noted in Fig. 2. If the average dry matter production value for a 1 km pixel is 16 ton/ha, the local value on a particular field can exceed 20 to 25 ton/ha, which at a harvest index of say 0.5 (being common for wheat and maize), is equivalent to a physical yield of 12 ton product for two growing seasons can be harvested. The approximately yield is than 6 ton/ha for each individual season, which is also shown by the example provided for summer wheat (see Fig. 7). A crop yield of 12 ton/yr should at a crop water productivity of 1.2 kg/m^3 (which is measured for wheat in the North China Plain), coincide with an ET of 1000 mm/yr. Hence, the results for biomass production and ET are consistent, and the ET can from a bio-physical point of view not be much lower.

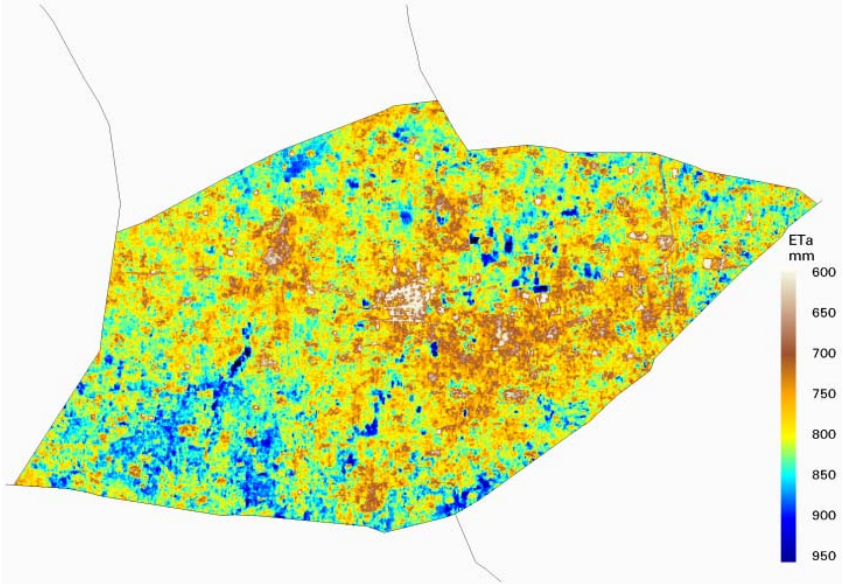

Figure 6: Example of an annual ET map for Feixiang district in Hebei province with a 30 m spatial resolution during 2002 based on 24 MODIS images and 3 Landsat images. The minimum, mean and maximum values are 300,794 and 974 mm/yr respectively

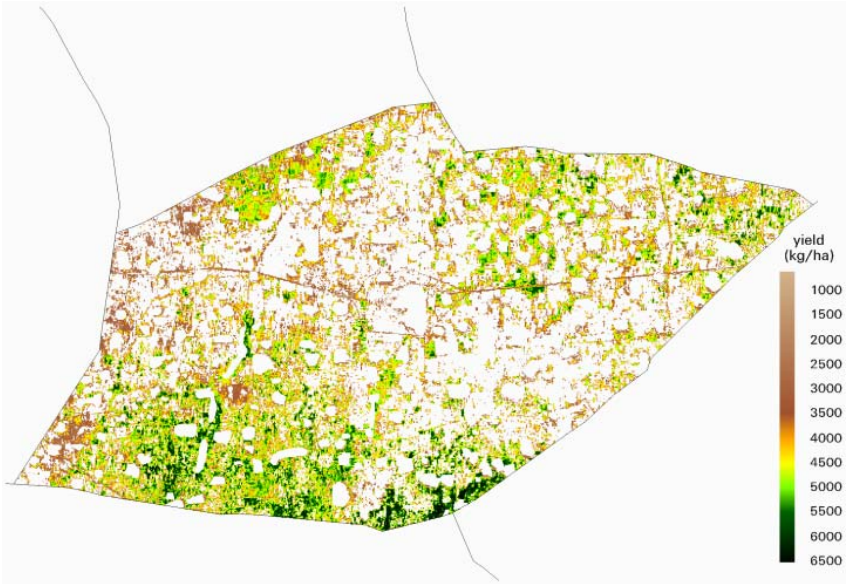

Figure 7: Crop yield map for summer wheat (2002) based on a combination of Landsat and MODIS images (Feixiang district) This figure is prepared from the combination of the summer wheat map produced by IRSA and the biomass production map from the Landsat image and several biomass production maps based on MODIS.

For demonstration counties, ET values have been broken down into a 30 m grid. Highly detailed ET values have been provided for Feixiang district in Hebei Province (Fig. 6). The mean value for the Feixiang district exceeds with 794 mm/yr the Hai Basin average ET value of 714 mm because of the large scale groundwater extractions prevailing in the south.

The 2000 statistical data for Shandong is taken for the sake of comparison because this should match with the higher end of the crop yields. This secondary statistical data reveals for paddy (6.7 ton/ha), summer grain (4.7 ton/ha), wheat (4.9 ton/ha) and corn (6.2 ton/ha). These values are in a good agreement with the SEBAL-based yield estimations shown in Fig. 7.

Conclusions

The evaporative depletion of 2002 exceeds the rainfall for almost all counties due to over-exploration of groundwater resources. Although, the drier than average year 2002 will over-estimate the utilization of the groundwater resources, it indicates the need for introducing a *real* water savings program, that tempers the evaporative depletion. The next step is to prepare jointly with the Chinese Ministry of Water Resources the (i) distributed water balance and (ii) to define target levels of evaporative depletion.

WaterWatch
Generaal Foulkesweg 28
6703 BS Wageningen
The Netherlands

Tel: +31 (0)317 423 401
Fax: +31 (0)344 693 827
Web: www.WaterWatch.nl
E-mail: info@WaterWatch.nl