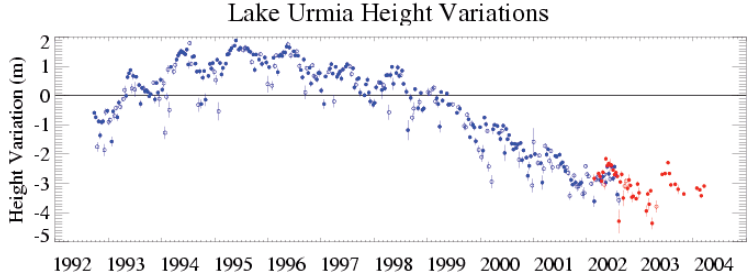
Location	Lake Uromiyeh, NW Iran
Contractor	ITC, the Netherlands
Period	2003

Scope of the project

The Lake Uromiyeh (Urmia) Basin in northwestern Iran is a classic closed drainage basin, where all precipitation and groundwater (except that which evaporates) drains to the central Lake Uromiyeh. Lake Uromiyeh is one of the most important and valuable aquatic ecosystems in Iran, and because of its unique natural features it has been declared a National Park, Ramsar site and UNESCO Biosphere Reserve.

Location of Lake Uromiyeh in northwestern Iran near the city of Tabriz

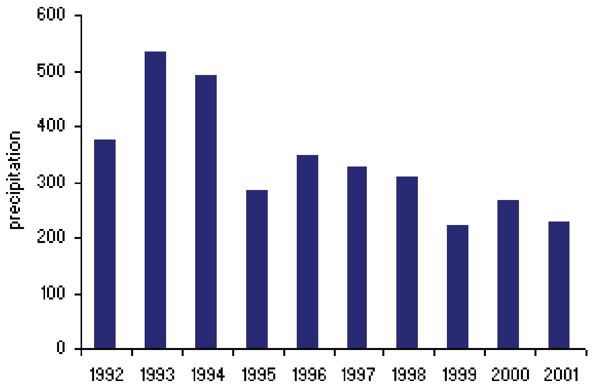


Relative lake height variations computed from TOPEX/POSEIDON (T/P) with respect to a 10 year mean level

During the last two decades, pressure on the natural resources of the Lake Uromiyeh Basin has grown as a result of non-sustainable human activities such as agricultural intensification and water resources developments. Moreover another 17 new reservoirs are planned in the basin. These pressures have been exacerbated by a recent period of severe drought, that caused the water level of the shallow lake to drop extremely. This has severely degraded the ecosystem, such that its capacity to deliver social, economic and environmental benefits is under threat. A strong conflict exists in the region on water requirements for ecosystems versus water for irrigated agriculture.

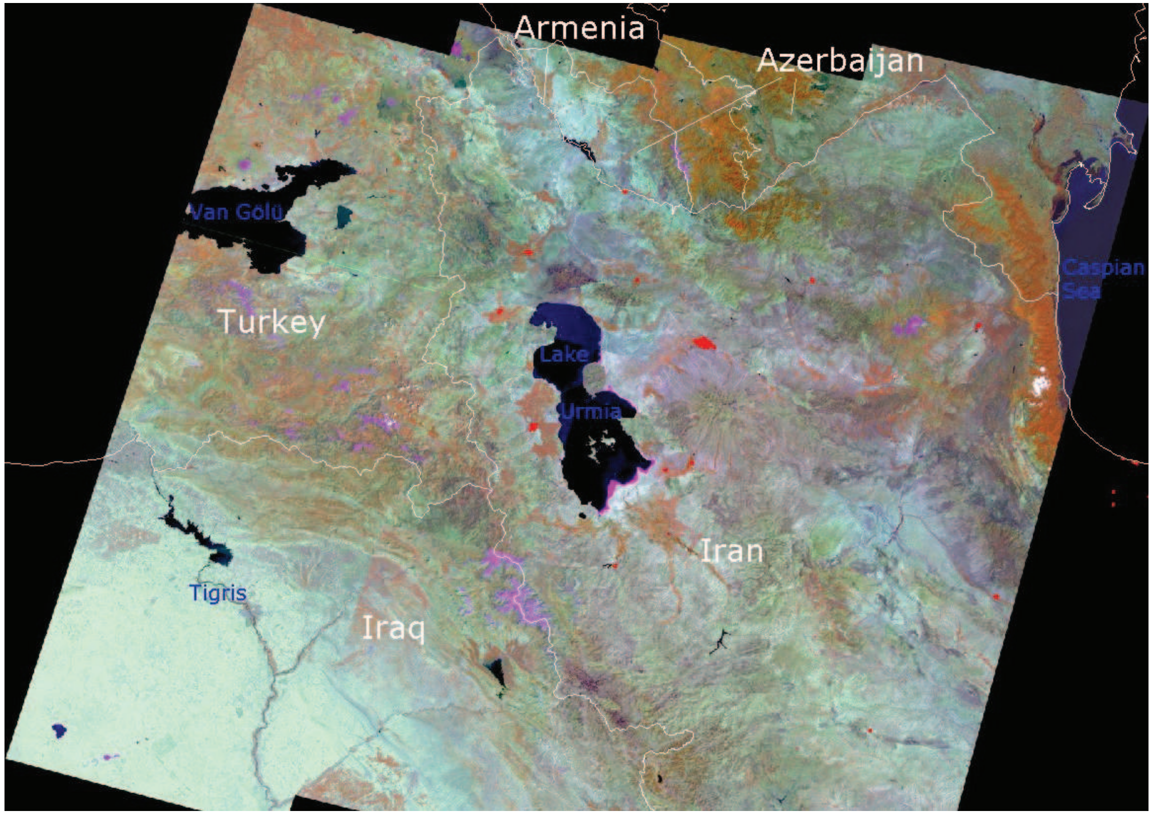
Study approach

The basis of the Remote Sensing component of this project was to assess the water balance for two hydrological years in 1993-1994 and 1999-2000, starting in the third decade of September



Average annual precipitation (mm) of six meteorological stations in the Uromiyeh basin and ending in the second decade of september of the following year. Climatic conditions for both years differed extremely. For some meotorological stations in the basin, precipitation was found to be more than two times lower in the 1999-2000 hydrological year. More sunshine hours and a lower relative humidity were measured in most stations as a result.

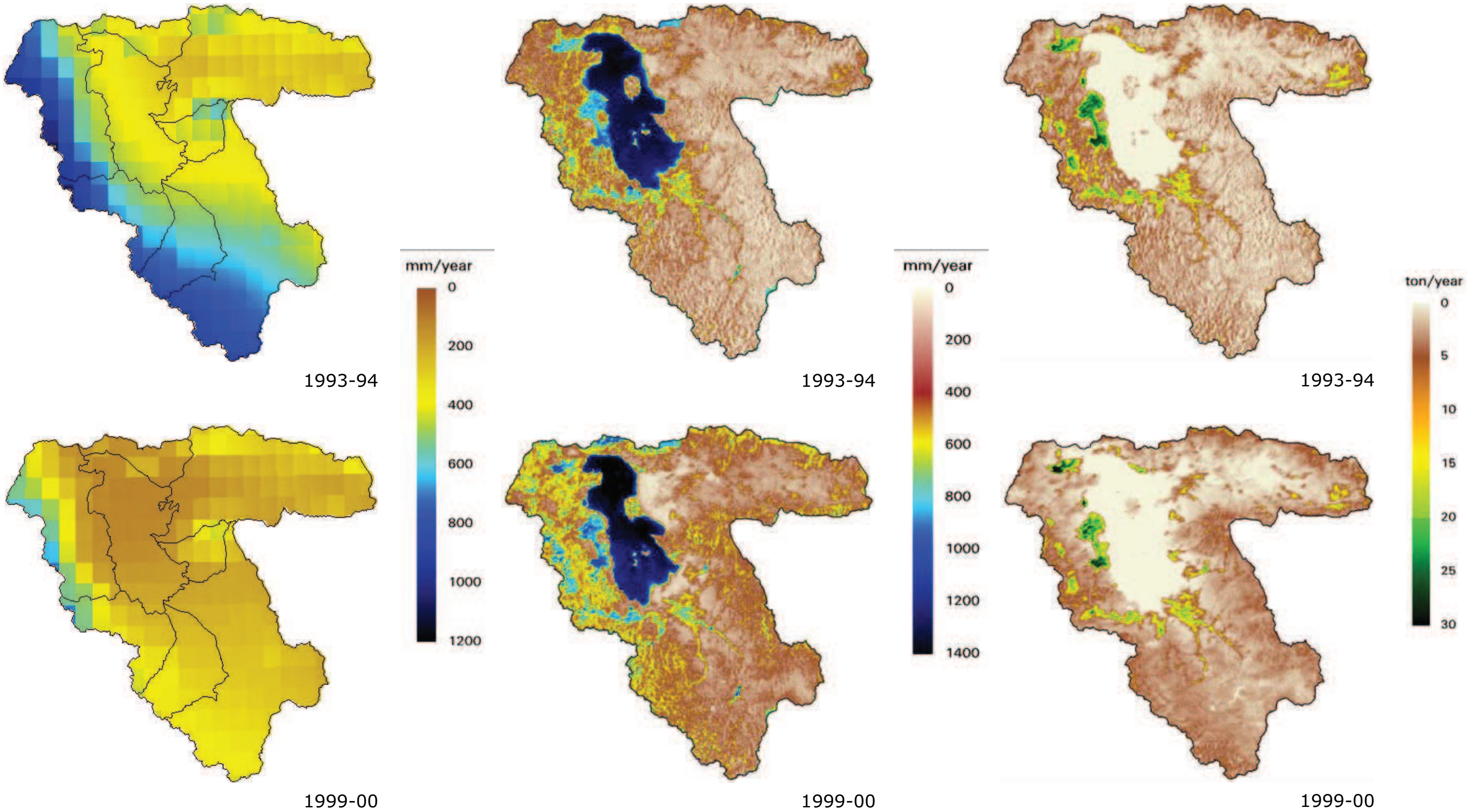
The first step in assessing the water balance, is to spatially calculate the actual evapotranspiration by using the SEBAL technology. SEBAL was applied to satellite images of the Advanced Very High Resolution Radiometer (AVHRR) sensor. All recordings of this sensor are archived since 1978 and available freely for download from the NOAA website (www.saa.noaa.gov), thus offerening great opportunities for historic analysis. The hydrological year starts in the third decade of September and lasts 36 decades. It was aimed to acquire at least one image for each decade. During the winter, however, availability was restricted due to clouded conditions. For the 1993-94 hydrological year, a total of 24 NOAA-11 images was selected, vs. 27



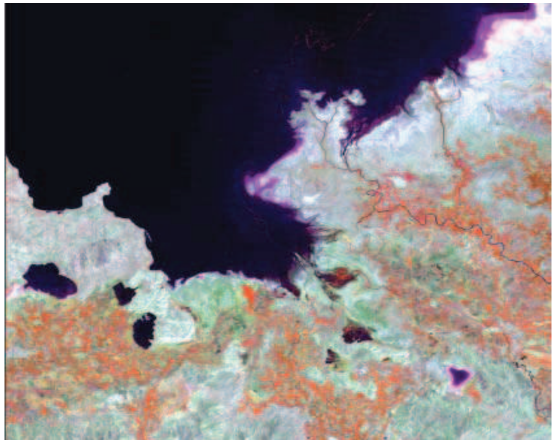
The Uromiyeh basin located in NW Iran; red colors represent green vegetation such as (irrigated) agriculture, wetlands and forests. The yellow-green colors are bare soils, rock and deserts. Bright pink and purple colors are areas with high reflectance such as snow or salt planes.

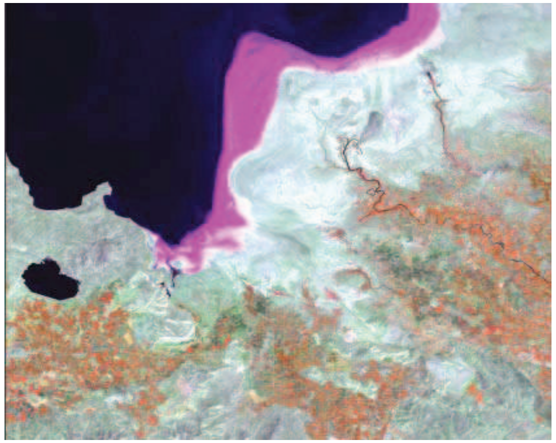
NOAA-14 images for 1999-2000 year. NOAA-AVHRR images have a spatial resolution of approximately 1.1 kilometer. Daily meteorological data from six different stations in the basin has been used.

precipitation **actual evapotranspiration** **biomass production**



basin wide annual averages		
	93-94	99-00
precipitation	501	259
actual evapotranspiration (mm)	399	408
potential evapotranspiration (mm)	540	519
reference evapotranspiration (mm)	1173	1193
biomass production (kg year^{-1})	5144	4408





1989 2000

Two Landsat images depicting the dramatic changes in Lake Uromiyeh's ecosystem. Lake levels have dropped sincerely since 1989 leaving behind salty plains (bright pink color). Small inland lakes, home to flamingo colonies, have disappeared due to the construction of dams and canals for irrigated agriculture.

Results

The average annual actual ET is similar for both years (399 and 408 mm). A detailed look on the spatial ET gives a different view. The hilly and mountaineous areas in the western part of the basin have a considerably higher ET in the 1999-2000 season than in the 1993-1994 season. This is largely compensated by a lower ET in the lake and a smaller lake area. The table right gives average ET in cubic meters for major land use classes. Range land classes have a higher ET in the dry year (1999-2000), which may be explained from a higher evaporative demand during the pre-summer decades when water was still sufficiently available for evapotranspiration. The marshland and wetlands classes exhibit a strong decrease in ET, indicating severe water shortages. This may indicate a loss and severe degradation of natural wetland habitats that surround the lake. Also, the biomass maps depict a decrease in biomass production in all irrigated areas. According to these initial results, orchards in the basin appear not to suffer from droughts. ET as well as biomass production for this class is constant between the two years analysed. The highest water depletion stems from the lake surface (30-33%).

actual ET by Land Use class (10^8 m^3 / year)				
	93/94 10^8m^3	99/00 10^8m^3	93/94 %	99/00 %
Range land dense	11.8	16.9	7.6	10.5
Range land medium dense	20.0	24.7	12.8	15.4
Range land low density	28.6	30.4	18.3	19.0
Range land / agriculture	13.8	15.8	8.9	9.9
Agriculture irrigated	10.7	9.3	6.9	5.8
Agriculture irrigated / Orchards	2.6	2.6	1.7	1.6
Orchard	5.2	5.4	3.3	3.4
Forest medium dense	0.3	0.5	0.2	0.3
Forest low density	0.2	0.2	0.1	0.1
Marsh land	0.6	0.3	0.4	0.2
Salty wetlands	4.0	0.9	2.5	0.5
Lake	51.8	49.0	33.2	30.6
total	149.6	156.0	100	100

annual water balance

	93-94	99-00	
runoff (basin)	218	-24	mm
area (basin)	46550	47192	km^2
net loss (lake)	826	1055	mm
area (lake)	5887	5245	km^2
lake IN	10.2	-1.1	km^3
lake OUT	4.9	5.5	km^3
IN - OUT	5.3	-6.7	km^3
change in lake level	**0.90**	**-1.27**	**m**

In the table (above) a simple water balance for a closed hyrdological basin is presented. Runoff was calculated as precipitation minus the actual ET. It is assumed there is no interaction with the groundwater and that all runoff arrives at the lake (no human influence). Lake OUT is calculated as the actual ET from the lake minus the precipitation. As the area of the lake is known, the change in lake level can be calculated as the net change in water volume divided by the lake area. During the 93-94 season, the water level rose with 90 cm, whereas in the dry 99-00 season, the lake water level dropped by more than one meter. The results fit fairly well with the change in height variation measured by TOPEX/POSEIDON (see figure on first page).

Conclusions

The first step had been made in a detailed spatial anlysis of the hydrology of the Uromiyeh basin. The SEBAL products are objective and provide hydrological insights in the water depletion and runoff into the inland lake.

The tool provides unique spatial quantitative data on water depletion in the basin. In the basin irrigated agriculture is with 8% volumetric consumption a smaller water user than rainfed agriculture (12%). The marshlands and salty wetlands are major habitats for birds and they consume 1-3% only

Previous projects have revealed that the combination of SEBAL products derived from satellite images in combination with hydrological models form a powerful tool for analysing the hydrology of large areas.

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