Temporal water depletion from public RS data.
The districts and irrigation zones of Ferghana Province, Uzbekistan.

Yann Chemin*
Alexander Platonov**

*PhD student in remote sensing applications (AIT-STAR)
206/7 Kamathawatte Road, Rajagiriya, Sri Lanka
Tel: (94)-1-886053
E-mail: ychemin@yahoo.com
FRANCE

**Leading Engineer-Programmer (GIS/RS)
Scientific Information Center of Inter State Coordination on Water Commission of the Central Asia
B11, Karasu-4, Tashkent 700187, Uzbekistan
Tel: +998-71-2652554 – Fax: +998-71-2650558
E-mail: alexp@icwc-aral.uz
UZBEKISTAN

KEY WORDS: evapotranspiration, water depletion, remote sensing, district, irrigation system, Uzbekistan

ABSTRACT:

The quality of decision making in water resources management is proportionally dependent on the quality (reliability, standardization, spatial and temporal dimensions) of the information pertaining to water fluxes into the unit managed, may it be an irrigation system, an administrative unit or an hydrological (sub)basin. The availability of publicly distributed daily remote sensing data through the Internet comes forth as a high-probable information source for water resources monitoring, within economically strained Central Asian countries.
The case of Ferghana province of Uzbekistan in the Syr-Darya river basin, where water is managed across administrative units rather than along basin approach, is analyzed. Remote sensing is proving to be an interesting support tool to analyze variations of spatial nature of water resource depletion in Ferghana Province, but the temporal aspect of the information is of highest interest to pin-point timely restricted water scarcity in some districts and/or irrigated areas. It can be concluded that water management in the Ferghana Province can be supported by public remote sensing measurement of water depletion available within critical return periods.

1. INTRODUCTION

The national resources managers in most countries where high-technology monitoring is not directly available to national bodies are confronted with the paucity of reliable information, leading to inadequate and inappropriate analysis. This is particularly true in the field of water management, where water resources have to be managed very clearly from the water basin to the irrigated fields, eventually reaching to smaller areas and users. Adequate, reliable, and consistent information is not always available at various geographical scales of intervention, even some large to medium size areas, like (sub)basin and (sub)system scale. Returns on the use of appropriate, reliable, and consistent information at the basin scale might be high as the improved management will benefit larger areas. The macro-level analysis of information can not only help understand the patterns and implications of the existing management strategies on the overall water use, it can also indicate the necessary changes required to manage water more beneficially and minimize the negative impacts.

For analyzing water use patterns and to understand the underlying factors impacting water use, one approach is to use of evapotranspiration data (Bastiaanssen et al., 2001). Measuring the evapotranspiration is of highest importance for understanding and eventually intervening into the water cycle of natural systems, especially in the water balance of the different critical users of water, like large scale irrigated areas. If reliable and consistent information regarding evapotranspiration can be accessed at low cost, it can be used to analyze the performance of irrigation systems and devise better management alternatives. Remote sensing is one of such alternatives, as it has come out, over the last decade, with local methods for calculating the actual evapotranspiration (ETa) (Vidal and Perrier 1989; Bastiaanssen 1995).

The Ferghana Province, located in the Ferghana Valley, is a sub-basin of the Syr-Darya taking its source in the Tan Shien High Plateau in the far-Western borders of the People's Republic of China. It reaches Ferghana Valley by its Kyrgyzstan's border before entering Uzbekistan and its Ferghana Province. The major cropping pattern in summer is Cotton and also Wheat. The stress on management of water in the upper catchment of Uzbekistan's land is understood better when realizing that the extent of irrigated areas following downstream reaches KarakalPakistan, but does not reach anymore the Aral Sea. All of the areas irrigated, because of expansions to the limit of water availability, are under strenuous constraints to be more water efficient in order to keep water for downstream use, being a similar water constraint found widely across Asia today.

2. Objectives

Understanding of temporal water depletion during the period of 15 March-15 September 2001, in order to support the water resources management of the Ferghana Province.

3. METHODS

3.1. Satellite Images

A set of 12 NOAA AVHRR images were downloaded from Internet through the Satellite Active Archive website (Table 1), having publicly available satellite imagery archives. These NOAA AVHRR image archives are going back to November 1988 in the actual resolution of 121 ha (1.1 x 1.1 Km). The Active Archive can be accessed through the following web address: http://www.saa.noaa.gov/.

Table 1: Dates of NOAA AVHRR images used (Year 2001)

NOAA AVHRR	***images used***
April 08	July 01
April 26	July 11
May 15	July 23
May 26	August 01
June 04	August 21
June 20	September 06

NOAA AVHRR imagery is one of the most stable sources of information available publicly from Internet. It is convenient to download and process because of the small file size, while being available at least once every day for most of the land area of the planet. It is covering consequent areas (1000 x 3000 Km) while having a spatial resolution (1 x 1 Km) at the merging of climatic and agricultural applications. One of its main weaknesses is the poor geographical registration that is inherent to its advantages related to its large area cover.

3.2. Actual Evapotranspiration calculation

The method used in this study is estimating the actual ET using Surface Energy balance Algorithm for Land (SEBAL) by Bastiaanssen (1995). SEBAL is a thermodynamically based model, which partitions the sensible heat flux and the latent heat flux of vaporization. The author has originally developed SEBAL in Spain and Egypt using Landsat 5TM. Further, Roerink et al. (1997) also applied the same sensor for monitoring irrigation performance in Argentina. Water consumption of large irrigation systems has been addressed also with NOAA AVHRR in Pakistan (Bastiaanssen et al., 1999; validation in Bastiaanssen et al., 2002. Combinations of Landsat and NOAA are found in Timmermans and Meijerink (1999) where Landsat 5TM was used, and in Chemin and Alexandridis (2001) who used Landsat 7ETM+. Later on, Hafeez and Chemin (2002) applied SEBAL using TERRA/ASTER sensor in the Upper Pumpanga River Integrated Irrigation System (UPRIIS), Philippines. Finally, more specific details about its applications in this study are found in Chemin et al. (2002).

3.3. Data extraction according to units of interests

Information was extracted through GIS according to the administrative and Irrigation units. The vector files (Figure 1 and 2) were prepared by the Scientific Information Center of Inter State Coordination on Water Commission of the Central Asia (SIC-ICWC) from 1:250,000 scale topo-maps, updated with a GPS survey performed in September 2001 identifying bridges and some Districts boundaries' key locations. Finally, acquisition of better quality maps from the local Water Management administration of Ferghana Province permitted to correct the hydrological uncertainties between District boundaries not discernable in 1:250,000 scale maps.

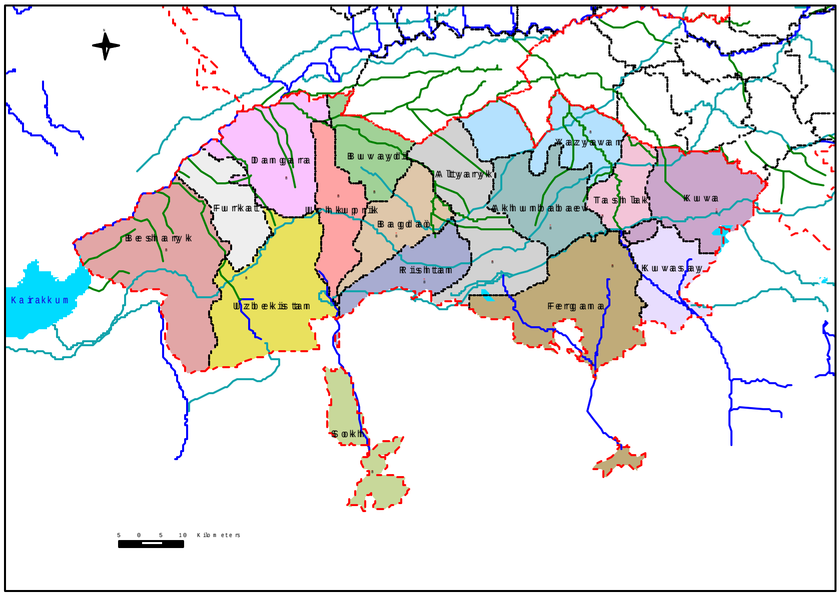

Figure 1: Districts in Ferghana Province

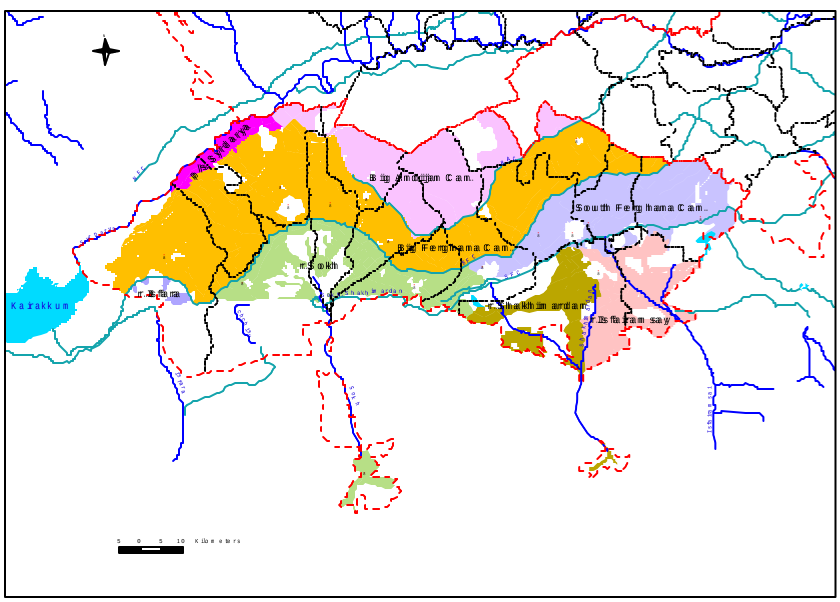

Figure 2: Irrigation Zones in Ferghana Province

4. RESULTS

Highest evapotranspiration areas are located in the Districts of Uckuprik, Buvaydi, Bagdat, Furkat and Dangara (Chemin et al., 2002). Monthly ETa values for the Ferghana Province and a sample of its Districts (Figure 3) has been compiled from daily information available. Lower monthly ETa values appear regularly in Ferghana District, because of the widely represented geological features (consisting of barren hills) within its boundary. Regularly high values are marking out Uckuprik District confirming the high water availability and reliability in this area of the Province.

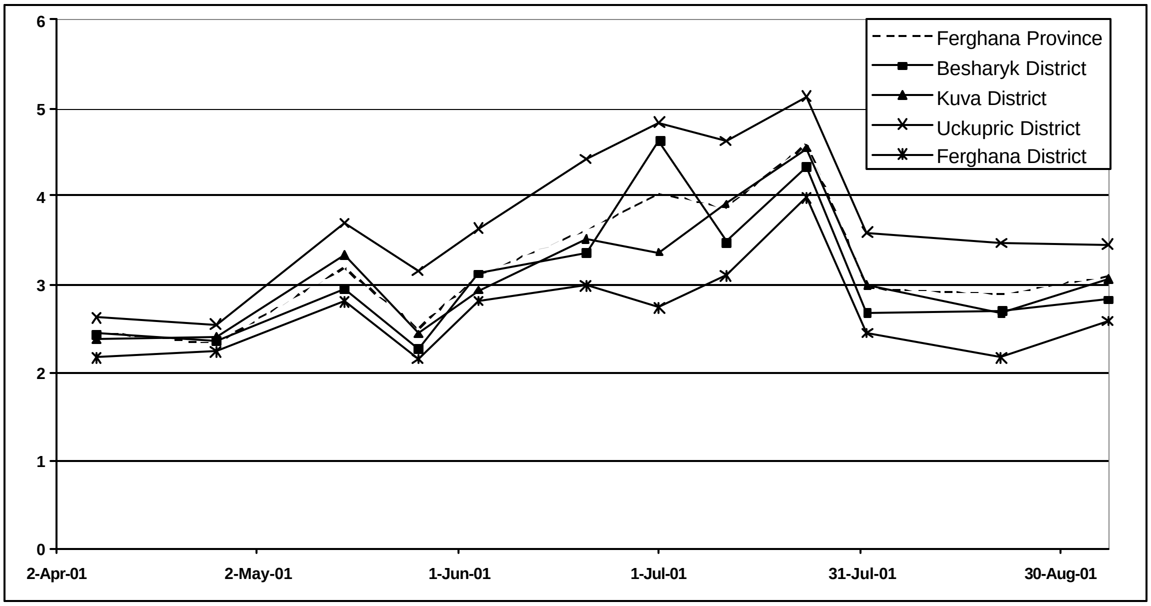

Figure 3: Temporal variation of ETa for some districts and for the whole Province (mm/day)

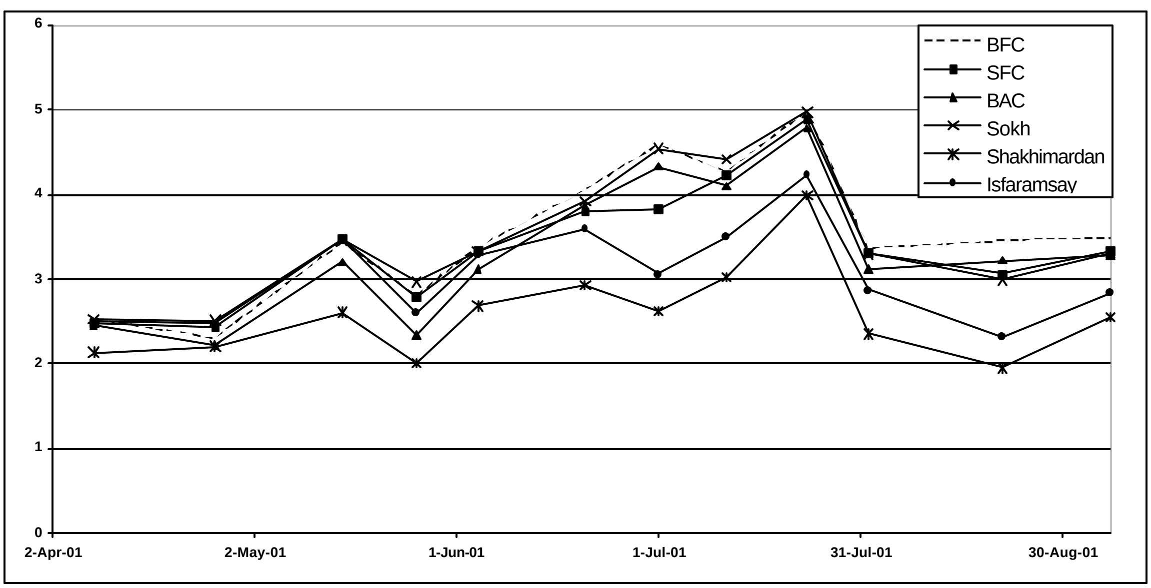

Figure 4: Temporal variation of ETa for the irrigation zones (mm/day)

The range of values of the mean ETa in Figure 3 provides an interesting view of the "system" of Ferghana Province through its district-wise water management. In the months of May and June, values and ranges are relatively low; they increase in a non-linear way in function of the district during June and July. It is very clear that Besharyk district got a massive amount of water coming form the all Ferghana Oblast in the first week of July, coinciding with a slight depression of water depletion at the head of

Ferghana Province, the District of Kuva. Overall water consumption is following the cotton cropping season, with a flowering/maturity in June-July (high consumption) and a harvesting season in August-September (drying of the fields leading to a large drop in ETa).

Figure 4 provides an interesting point of view of the Ferghana Province according to the hydrological irrigation boundaries. Indeed, if the small systems of Isfara and Shakhimardan are occulted, then a very compact evolution of the systems ETa can be noticed all over the season. In the same line of observation, the month of July will be still the time of the greatest variation between the ETa values of different systems. The South Ferghana Canal (SFC) is then showing a slight lowering of its value compared to BFC, BAC and Sokh. This consistency is not surprising (as noticed already above) because of the definition of irrigation zones vs. administrative zones, the earlier not including the geological formations (bare soil hills) that the later does.

Finally, both the administrative and irrigation aggregation are showing that July 1st especially, and to a certain extent May 26th too, are two periods where some identified units are not having homogeneous water depletions. If said differently about the irrigated areas, water distribution is not fulfilling the crop needs for all the units equally for the period of time represented (respectively 10.5 days for July 1st and 10 days for May 26th).

5. CONCLUSIONS

The availability of a larger number of processed images (i.e. one per decade minimum) would ascertain what this analysis as shown about the very sensitive capacity that such publicly available remote sensing imagery has to detect local temporal water scarcity within sub(basin) and (sub)system units. It is especially of critical use for irrigation systems as widely represented in Uzbekistan, regarding the management potential of monitoring water through its succession of management units. Identification of major water scarcity areas can help addressing both timely and spatially related water resources non-adequacy issues. Eventually, practical understanding of the real management constraints at multi-levels through monitoring may lead to better water distributions by promoting transparency in timely bound transactions within systems and basins.

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