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Investigation on the Use of IKONOS Data to Estimate the Irrigation Needs for Crops in a Medium size Mediterranean Hydrological Basin

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1. Introduction

The IKONOS 2 satellite launched in September 1999 by Space Imaging Inc. is the world's 1 commercial satellite offering high spatial resolution imagery. The IKONOS sensor suite is capable of generating 1m panchromatic images with off-nadir viewing up to 60° in any azimuth for a frequent revisit rate and stereo capabilities. The idea of the approach stems from the hypothesis that IKONOS-2 data can produce very high resolution map products such as crop thematic maps and thus discriminating and mapping the crop area with a considerable accuracy of ± 2 meters. By extracting the different type and the various crop areas it is possible to estimate the water needs for each crop type using also other parameters such as statistical and meteorological data and calculation of the evapotranspiration for each crop type.

2. Methodology

For the purpose of this study only one IKONOS data set (pan-sharpened all four bands) was acquired during the maximum stage of the crops' phenological cycle (June 2002). This data set was referred to the downstream valley which hosts all the crop types (figure 1). This data set was geometrically corrected using more than 20 GCPs and 20 m digital elevation model (DEM). The root mean square error of the GCPs was less than 0.8 pixels, while the same

error at the checkpoints was less than 1 pixel. This shows that in areas where elevation changes are not large, the necessity for large-scale DEMs is diminished. The working team also demonstrated that users can process IKONOS GEO data to the same standards of accuracy available from the Precision IKONOS data all at a lower cost and in less time.

Twenty classes were selected and processed such as urban, water, forest, corn, olives, vines, lemon tress, greenhouses, urban-ceramic, asphalt, gravels, bare soil, wheat, melon, rice, pastures, alfa alfa and sand dunes.

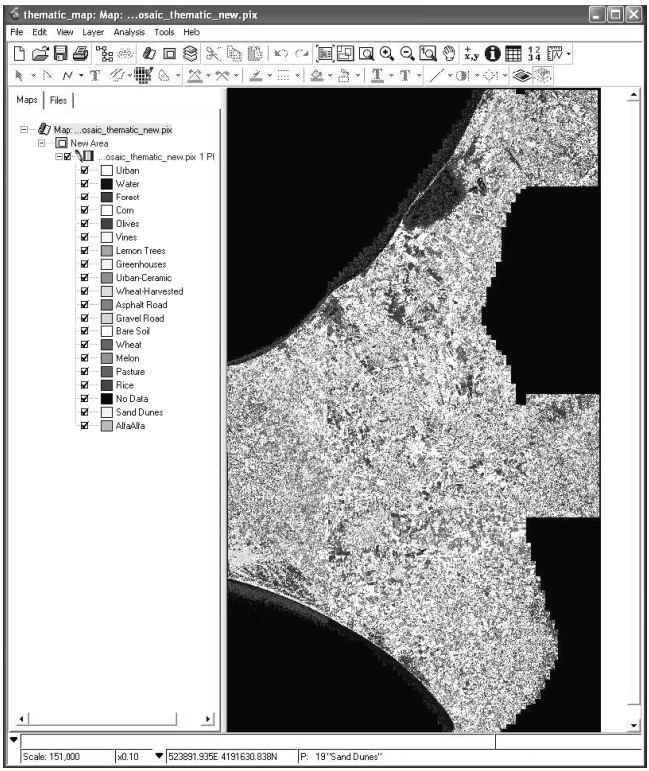

Fig. 1. IKONOS-2 classified image of the downstream valley
Rys. 1. Obraz programu IKONOS-2 zlewni dolnego biegu rzeki z podziałem na sposób użytkowania

Additionally, a Landsat ETM (figure 2) image was acquired on the same date to provide the overview land-cover and land-use of the area and also to help to extract the land-use of the upper stream basin where most of the water quantity is generated and flown to the downstream valley.

An incorporated ARC/INFO spatial model was used to estimate the water quantity of the area at the upper stream basin. Data such as land-use,

digital elevation model, slope and aspect, drainage patterns, geology and weather data from the surrounded meteorological stations were used to estimate that water quantity.

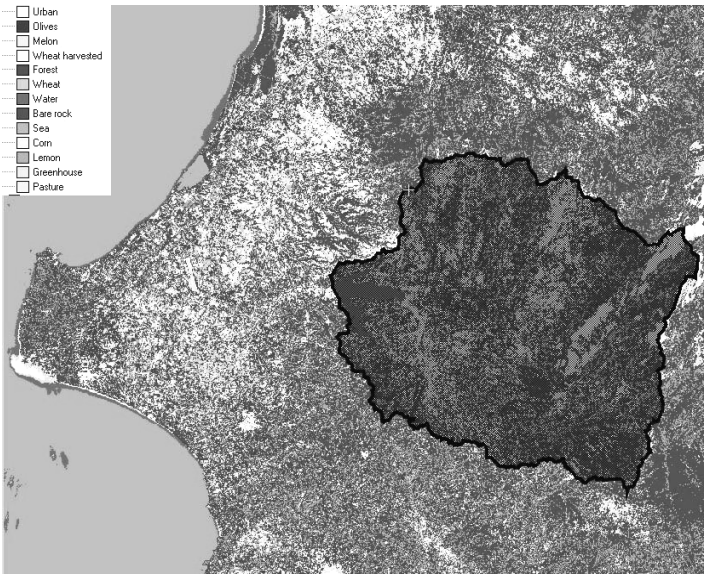

Fig. 2. Landsat ETM image showing as shadowed area the upper stream basin
Rys. 2. Obraz satelitarny pokazujący zlewnię górnego biegu rzeki (obszar zacieniony)

Table 1. Comparison of water quantity from the upper stream basin and calculated water needs
Tabela 1. Porównanie ilości wody spływającej z basenu górnego biegu cieku i obliczonego zapotrzebowania na wodę

Available water		Demanding water	
Hydrological Years	Run-off m^3	Years	Real demands m^3
1995÷1996	169,373,520	1996	100,900,273
1996÷1997	136,317,240	1997	102,970,930
1997÷1998	102,764,520	1998	105,143,505
1998÷1999	177,183,360	1999	93,883,574
Mean / Year	146,409,660	Mean / Year	99,268,032
MAX	177,183,360	MAX	105,143,505
MIN	102,764,520	MIN	93,441,880

The crop area extracted from the IKONOS images were used to estimate the crop water needs. A program was built based on Windows XP, Excel environment and Visual Basic programming language. The program made a use of the Penman Monteith equation plus other parameters such as crop area, Kc and meteorological data. The calculated water needs for the crop types were then compared against with the water quantity that is flowing from the upper stream basin.

3. Data sets and tools

In this study an IKONOS data set (pan-sharpened all four bands figure 3) was procured together with a Landsat ETM data (July 2002). Moreover, general land-use topo maps (1/50.000) were acquired from the Hellenic Army Geographical Service (HAGS) and also Geological Maps of the same scale from the Institute of Geology and Mineral Exploration (IGME), Athens. The field work was featured with a CANON 5-megapixel digital camera (figure 4) and a GARMIN 12 XL personal navigator GPS system. The entire image processing was done on GEOMATICA v9.1 and the spatial modelling on ARC/INFO v8.3.

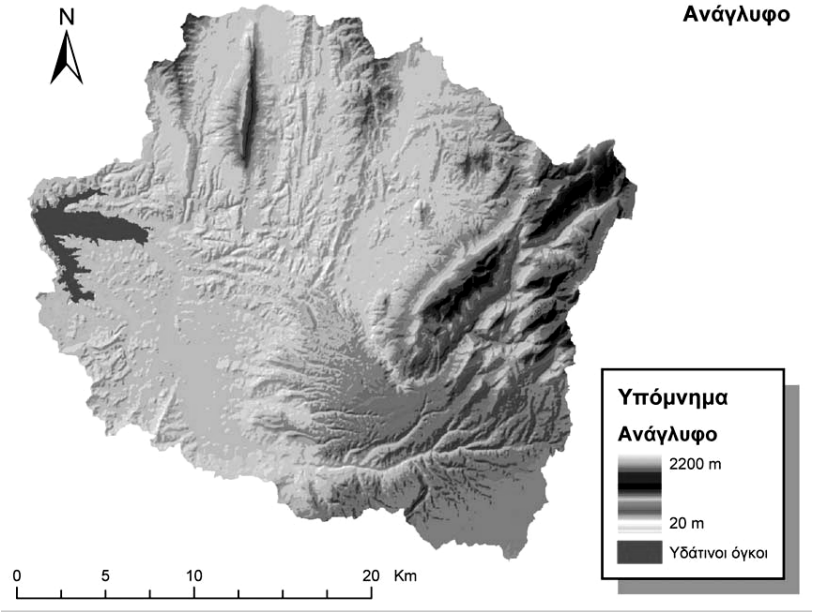

Fig. 3. The landscape of the upper stream basin
Rys. 3. Ukształtowanie trenu zlewni górnego biegu rzeki

Fig. 4. Vineyards as depicted by the digital camera on ground (left) and by IKONOS 3,2,1 (RGB) pan-sharpened imagery (right)
Rys. 4. Winnice sfotografowane na ziemi (po lewej) i przez satelitę IKONOS 3,2,1 (RGB) – po wyostrzeniu (po prawej)

4. Results

The mixed and multiple land-use and the different practises over the same crop created some problems in the classification process. The need of an object based classification algorithm rather than a pixel based classification algorithm might be the ideal tool for this kind of landscapes. The average run-off which was estimated for the years (1995÷1999) for the upper-stream basin was about 146 millions m^3 while the corresponding average of the water demands of the downstream valley was 95 millions $m^{3.}$ This difference happened simply because the water losses, the other use of water and the water consumption by the greenhouses were not considered in the total water demands of the downstream valley.

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Badania nad wykorzystaniem danych z satelity IKONOS do szacowania zapotrzebowania na wodę upraw w średniej wielkości basenie hydrologicznym położonym na półwyspie Peloponeskim

Streszczenie

Artykuł przedstawia wyniki badań nad wykorzystaniem obrazów wysokiej rozdzielczości z satelity IKONOS-2 do szacowania ilości wody potrzebnej do nawadniania pól uprawnych znajdujących się w basenie hydrologicznym rzeki Pinios w Elii w północno-wschodniej części półwyspu Peloponeskiego w Grecji. Dane z IKONOS-2 pozwalają uzyskać takie produkty, jak wysokiej rozdzielczości mapy z rozmieszczeniem poszczególnych upraw z dokładnością do ± 2 metrów. Oszacowanie zapotrzebowanie na wodę do nawadniania dla każdego rodzaju upraw oparto na wyznaczeniu ich obszaru. Jednakże do oceny zapotrzebowania na wodę w cyklu fenologicznym poszczególnych upraw potrzebne są długookresowe badania.