International Journal of Environmental Sciences

(A peer-reviewed International Journal)

Use of Remote Sensing and Soils database for Sustainable Management of Irrigation Water in Desert Landforms

International Journal of Environmental Sciences, Vol. 1 No. 2. pp.77-84 , 2277-1948. 2012

ISSN *2277 – 1948*

Article type *Full Length Research Article*

Submission date *01 April 2012*

Acceptance date *30 March 2012*

Publication date *15 April 2012*

Article URL *http://www.crdeep.org/category/ijes*

Authors *R.R. Ali[1*] and M. Abd El-hady[2]*

Center for Rural Development Ecology and Environment Protection

CRDEEP Head Office:315/10, Kaulagarh Road, Rajendranagar, Indervihar, Dehradun, 248001, Uttrakhand, India.

International Journal of Environmental Sciences Vol.1 No.2. 2012. Pp. 77-84

Full Length Research Paper

Use of Remote Sensing and Soils database for Sustainable Management of Irrigation Water in Desert Landforms

R.R. Ali[1*] and M. Abd El-hady[2]

National Research Centre, Egypt

[1]Soils and Water Use Dept., [2]Water Relations & Field Irrigation Dept.

****Corresponding author: R.R. Ali***

ABSTRACT

The scarceness of water resources in dry regions imposes considerable attention in both cropping pattern and irrigation management. The main objective of this study is to use the thermal band of the Landsat ETM+ and the soil database for setting a sustainable management of irrigation in the desert landforms. A newly reclaimed area located to the west of the Nile Delta was selected for this study. A Landsat ETM+ image acquired during the year of 2009 and a Shuttle Radar Topography Mission (SRTM) data were processed using ENVI 4.7 software to identify the main landforms in the area. The recognized landforms comprised; an old deltaic plain, Aeolian plain and depression with alluvial deposits. Twenty four soil profiles and thirty six observation points were undertaken to represent the different mapped units. The morphological description of the soil profiles is carried out and representative disturbed soil samples are collected and analyzed. A GIS based soil database is created using both the landform map and the results from the soil analysis. The irrigation management is discussed with respect to the soils properties. The crop evapotranspiration (ET), of the main crops in the area under investigation, was estimated from Landsat ETM+ thermal band using the surface energy balance algorithm for land (SEBAL). Results indicate that the calculated ET of all crops varies from one landform to another; the highest crop ET values are associated with the high terraces, eroded terraces, gently undulating, and almost flat alluvial deposits. Considering the crop ET and soil properties, two cropping patterns are identified. Wheat, Beans, Sugar beet and Groundnut pattern is proposed for the winter season while, Maize, Sunflower, Tomato and Sesame, for the summer.

Keywords: *Soil database, Landsat ETM+, SRTM, crop ET, SEBAL, west Nile Delta*

INTRODUCTION

Increasing water use efficiency (WUE) is a major challenge that many countries trying to achieve. The rapid growth of the world population exerts a direct pressure on agriculture production, which will involve consumption of a huge volume of water (Stephen, 2008). It is anticipated that for the world to meet the growing demand of water resources in 2025, about 17% of the water being used for more irrigation will be required (Molden et al., 2000). In arid and semi-arid regions, surface and ground water resources are naturally limited, and the challenge to produce more food under increasing water scarcity is real (Bouman, 2007). Crop water management requires accurate estimations of proper water consumption using detailed methods relating applied water, crop production, and irrigation efficiency (Bausch, 1995). Traditional methods of managing WUE are based on the crop coefficient (Kc) approach that requires the determination of reference evapotranspiration (ETo) and Kc. Potential evapotranspiration is then determined as a product of the ETo and Kc (Allen, 2000). Values of Kc from a reference table assume homogeneity over a respective area and may contribute to an error in estimating crop water requirements due to their empirical nature (Ray and Dadhwal, 2001). In the view of this limitation, new techniques for estimating actual evaporation and transpiration are developed using spatial and temporal information needed for crop water management. These techniques have been categorized under hydrological models, remote sensing and field based methods (Kite and Droogers, 2000). The quantification of CWR using satellite data is the optimum way to independently and regularly measure of water requirements on a field-by-field basis over large land areas. In Egypt, typical field sizes of the most of newly reclaimed lands range between 10 and 30 acres (GARPAD, 1997). These sizes require high resolution images to extract spatial information about such small areas. Soil properties and landforms are most significant factors controlling the irrigation water management (IWM). Moreover, soil information database can improve the estimation of the current and the future land potential productivity and can help identifying land and water use limitations (FAO/IIASA, 2008). In this work remote sensing and soil database are used to estimate crop ET and propose a suitable cropping pattern that realize the sustainable management of irrigation water in the desert landforms.

MATERIALS AND METHODS

Study area

The study area is located to the west of the Nile Delta, and extended between 30º 31´ 30″ and 30º 46´ 04 ″ E longitudes, and 30º 19´ 45″ and 30º 31´ 15″ N latitudes, (Fig. 1). It covers an area of 113.49 km^2.This area has always been confined as a possible area for reclamation and utilization due to its location and the presence of ground water that is suitable for irrigation (El- Maghraby, 1990). It is considered as an extremely arid region where, the mean annual rainfall, evaporation and temperature are 41.4 mm, 114.3 mm and 21ºC, respectively (Egyptian Meteorological Authority, 1996). The main landforms exhibit the west Nile Delta region are, river terraces, levees, flood plain, old deltaic plain and windborne deposits (Sadek, 1984). The Pleistocene deposits which are composed of sand and gravel in this area are of assorted sizes bordering the cultivated areas where they form a series of various elevation terraces (CONOCO, 1990).

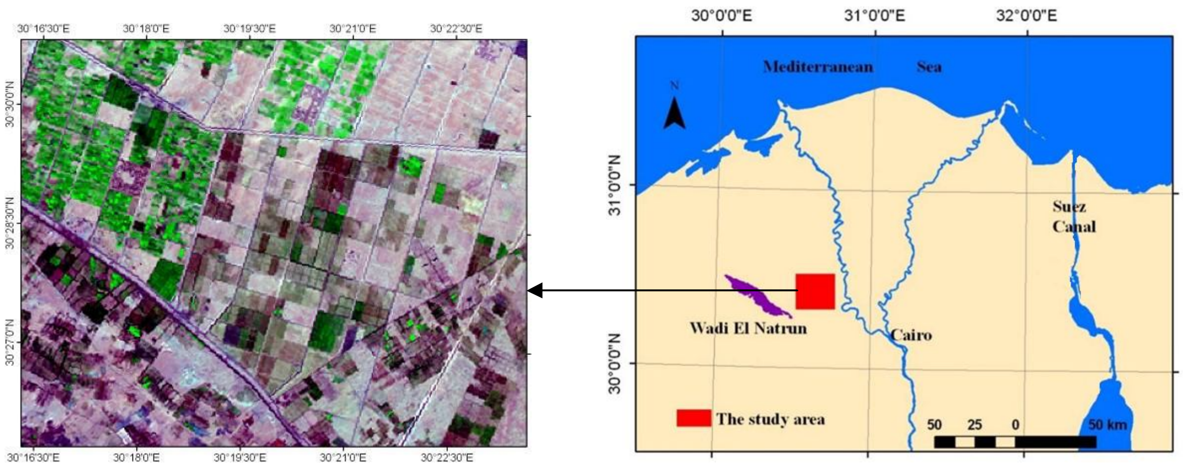

Fig. 1. Location of the study area (right), Landsat ETM+ (bands 7, 4, 2) of the area (left)

Satellite based estimations

Land surface Temperature (LST)

The thermal bands of Landsat ETM+ (band 6) manifests the amount of infrared radiant flux (heat) emitted from different objet surfaces. Generally, long infrared waves are radiations that are detected as heat energy; therefore, the thermal IR band effectively correlate with the temperature of the surfaces it scans (EOSC, 1994).

Six Landsat ETM+ images band 6, of path 177 and row 39, acquired during the period 3/7/2008 and 19/05/2009 are employed in the current study. Sensors acquire temperature data and store this information as digital numbers (DN) with a range between 0 and 255. The DN values are converted to temperature degrees in Celsius using two steps.

-The first step is to convert the DNs to radiance values using the bias and gain values obtained from the image header file.

$$CVR = G * (CVDN) + B \quad \text{(eq 1)}$$

where: CVR is the cell value as radiance, CVDN is the cell value digital number, G is the gain and B is the bias (or offset), (NASA, 2002).

-The second step converts the radiance data to degrees in Celsius as follows:

$$T = [K2 / \ln (K1 / CVR + 1)] – 273 \quad \text{(eq 2)}$$

where: T is degrees in Celsius, CVR is the cell value as radiance, K1 and K2 are two constant with values of 666.09 and 1282.71 respectively (NASA, 2002).

Normalized Difference Vegetation Index (NDVI)

NDVI show patterns of vegetative growth by indicating the quantity of actively photosynthesizing biomass on a landscape (Burgan et al., 1996). The NDVI can be estimated as follows:

$$NDVI = (NIR - RED) / (NIR + RED) \quad \text{(eq 3)}$$

where: NIR is the near infrared band and RED is the red band. The equation produces values ranging from –1 to 1. Negative values are indicate non vegetated areas or non-reflective surfaces, while positive values denote vegetated or reflective surfaces (Burgan and Hartford, 1993).

Evapotranspiration (ET)

The surface energy balance for land (SEBAL) is used to estimate the ET. The pre-processing parameters required for SEBAL were derived from digital image processing producing the NDVI, emissivity, broadband surface albedo, and LST. The broadband albedo was calculated using the weighting factors of all visible, NIR and short wave infrared (SIR) bands (Liang et al. 1999). Surface emissivity of the sensor was calculated from the derived NDVI. Bastiaanssen (1995) procedure is used to calculate the net incoming radiation and soil heat flux, while Tasumi et al. (2000) procedure is incorporated to determine the sensible heat flux. Temperature difference between air and soil for the "hot" pixel (i.e., where the latent heat flux is assumed null) is calculated. Air density is obtained by generalizing meteorological data of relative humidity while maximum air temperature is obtained from the local station at the time of the satellite overpass. The ET is calculated using SEBAL from the instantaneous evaporative fraction (Λ) and the daily averaged net radiation, Rn24 (Hafeez, 2003) as follows:

$\Lambda = \lambda E \ / \ R_n$ -

$G_o = \lambda E / \lambda E + H_o$ (eq 4)

$ET_{24} = \Lambda * [\ R_{n24} * ((2.501 - 0.002361 * LST) * \ 10^6)]$ mm∗d^{-1} (eq 5)

where: λE is the latent heat flux (the energy allocated for water evaporation),

Rn is the net radiation absorbed or emitted from the earth's surface (radiative heat), G_0 is the soil heat flux (conduction), H_0 is the sensible heat flux (convection), ET_{24}= daily ET actual (mm∗day^{-1}); Rn24 is the average daily net radiation (W/m^2); and LST is the land surface temperature (°C).

The difference between the instantaneous evaporative fraction at the moment of satellite overpass and the evaporative fraction derived from the 24-hour integrated energy balance is marginal, and may be neglected (Brutsaert and Sugita 1992, Crago 1996, Farah 2001). For the time scales of 1 day or longer, G_0 can be ignored and the net available energy (Rn - G_0) is now reduces to net radiation (Rn). The output of the abovementioned equations in integration with some weather conditions and water availability in the field, ET_{24} could be obtained. The ET_{24} calculation, through remote sensing, on specific dates displayed reasonable results of its spatial distribution. However, this information could not be used directly as ET_{24} mainly depends upon weather conditions and water availability in the field, which varies from one hour to another. It is therefore, it is necessary to simulate daily values to get an accurate estimation of seasonal ET. A larger sample of timely ET observations is necessary to obtain an accurate result and to adjust the daily fluctuation of ET_{24} for integration of seasonal ET_{24}. As proposed by Tasumi et al. (2000), missing values of ET_{24} could be obtained by daily calculation of ETo using the modified Penman-Monteith method. The crop evapotranspiration (ETc) mm d-1 could be calculated as:

$ETc = Kc * ET_{24}$ mm∗d-1 (eq 6)

where: Kc is the crop coefficient

Establishing soils database

Landsat ETM+ image acquired during the year 2009 (bands 1, 2, 3, 4, 5, and 7) is calibrated to radiance using the inputs of image type, acquisition date and time. The image is stretched using linear 2%, smoothly filtered, and their histograms are matched according to Lillesand and Kiefer (2007). The atmospheric correction is done using FLAASH module. The image is radiometrically and geometrically corrected (ITT, 2009). The Landsat 7 Enhanced Thematic Mapper Plus (ETM+) scan line corrector (SLC) failed on May 31, 2003, causing the scanning pattern to exhibit wedge-shaped scan-to-scan gaps. The ETM+ has continued to acquire data with the SLC powered off, leading to images that are missing approximately 22 percent of the normal scene area (Storey et al., 2005). To improve the utility of the SLC-off data, the original SLC-off image have been replaced with estimated values based on histogram-matched scenes using ENVI4.7 software.

The Shuttle Radar Topography Mission (SRTM) is one of the most significant space surveys of earth ever undertaken, using precisely positioned radar to map its surface at intervals of 1-arc seconds (~30 meters). The SRTM data can be used in conjunction with controlled imagery sources to provide better visualization of the terrain. The Landsat ETM+ image and SRTM data are processed in ENVI 4.7 software to identify the different landforms and establish the soil database of the studied area using the methodology described by Dobos et al., (2002) and Zink and Valenzuala (1990). The data extracted from satellite images; topographic and geological maps generate a preliminary geomorphologic map. A semi detailed survey is carried out throughout the investigated area in order to gain an appreciation on soil patterns, land forms and the landscape characteristics. Twenty four soil profiles and thirty six observation points are collected to represent the different preliminary mapping units. The morphological description of the profiles is carried out according to the guidelines outlined by FAO (2006) and the soil color is defined according to Munssel Color Charts (Soil Survey Staff, 1975). Representative disturbed soil samples are collected and analyzed using the soil survey laboratory methods (USDA, 2004). The obtained data from land survey and laboratory analyses are recorded in the attribute table of the landform map using Arc-GIS 9.2 software.

RESULTS AND DISCUSSION

Soils database

The landforms of the study area are delineated by using the digital elevation model, Landsat ETM+ and ground truth data. the following landforms was recognized:

- **Old deltaic plain:** This landscape covers an area of 53.56 Km^2; representing 47.20 % of the total area. The main landforms in this landscape are high terraces (18.98 Km^2), moderately high terraces (16.38 Km^2), low terraces (8.30 Km^2) and eroded terraces (9.90 Km^2).

- **Aeolian plain:** This landscape covers an area of 46.30 Km^2, i.e. 40.80 % of the total area. It includes the landforms of almost flat sand sheet (30.71 Km^2), gently undulating sand sheet (9.42 Km^2) and undulating sand sheet (6.17 Km^2).

- **Depression:** This unit covers an area of 13.63 km^2, representing 12.00 % of the total area. It is subdivided into gently undulating alluvial deposits (6.14 km^2) and almost flat alluvial (7.49 km^2).

The morphological description and laboratory analyses of the representative soil samples are classified and coded then attached to the attribute table of the landform map. The obtained data show high homogeneity of soils within each landform. Therefor, soil properties of the different landforms are generalized and illustrated in tables 1 and 2.

The soils of the study area are, in general, characterized by very pale brown (10 YR 7/3) to pale brown (10YR 6/3). The soil texture is sandy in the Aeolian plain landforms, while it differs from loamy sand to gravely sand in the old deltaic plain. Surface gravel is few in the Aeolian plain landforms, while it differs from few to many on the surfaces of old deltaic plain. Soil structure is single grained, except for the soils of low and moderately high terraces, which have a weak sub-angular blocky structure. These types of soil structure indicate initial stage of soil development that may be related mainly to an increase in sand percentage and a decrease in organic matter (OM) content. Soil stickiness and plasticity are none to slight as they coincide with the soil texture. The particle size distribution shows that the medium and fine sand is dominated in the soils. The soil profiles in the different landforms are deep as the soil depth differs from 110 to 160 cm. The Hydraulic conductivity of the soils changes from rapid (23.7 cm /hour) to moderate (15.9 cm /hour), which is mainly due to the sandy texture, single grain texture and low OM content. Field capacity and wilting point ranged between 13.5 to 15.3 % and 4.5 to 7.4 %, respectively. The percent of OM is very low in the different landforms of the study area as it not exceeds 0.61%. Calcium carbonate changes from 18.7 % in the soils of eroded terraces to 3.6 % in the undulating sand sheet landform. The electrical conductivity (EC) values ranged from 2.5 to 14.9 dS/m, the high values characterized the soils of the old deltaic plain which could be ascribed to its high $CaCO_3$ content. The obtained data represent positive correlation between EC from side and $CaCO_3$ (0.596*), OM (0.645*) and fraction < 0.125 mm (0.511*). These correlations reflect their effect on the incensement of EC values in the old deltaic plain. The exchangeable sodium percent (ESP) varies from 11.9 to 17.8, representing a high positive correlation with EC (0.895**), $CaCO_3$ (0.761**) and fraction < 0.125 mm (0.588*).

Land surface temperature and crop ET

The surface energy balance algorithm for land (SEBAL) model is used for estimating ET and mapping its spatial distribution and seasonal variation on the area. A total of six cloud free Landsat Enhanced Thematic Mapper (ETM+) satellite images (03 July, 05 Sep., and 26 Dec. /2008 and 27 Jan, 16 Mars and 19 May /2009) are processed to generate ET maps for winter and summer seasons. Land surface temperature (LST) is derived (eqs 1 & 2) for all acquired images. The LST averages of winter and summer seasons for the study area are shown in Figures 2 and 3. The obtained data indicate that the calculated averages of LST during the winter 2009 differ from 15.6 to 23.3 °C, while it differs from 26.3 to 33.2 °C in the summer 2008. It is noticed that the gently undulating alluvium, almost flat alluvium, high terraces and eroded terraces have the highest values of surface temperature in both winter and summer. Daily reference evapotranspiration (ET_{24}) is computed by solving the surface energy balance (eqs 4 and 5); the spatial distribution and seasonal variation are represented in Figures 4 and 5. The obtained data refers that the winter values of ET_{24} differ from 2.5 to 3.72 mm/day while the computed summer values vary from 4.21 to 5.32 mm/day.

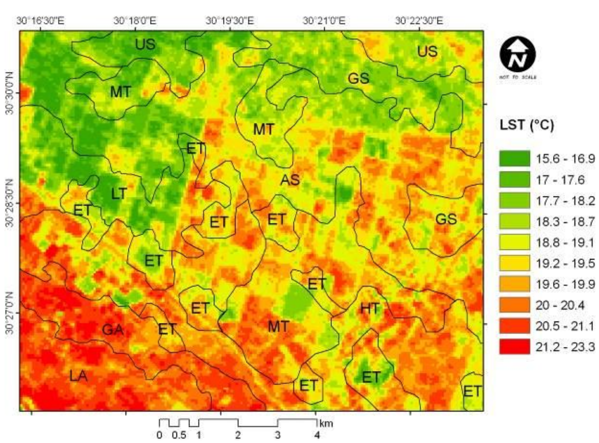

Fig. 2. Average of land surface temperature (winter 2009)

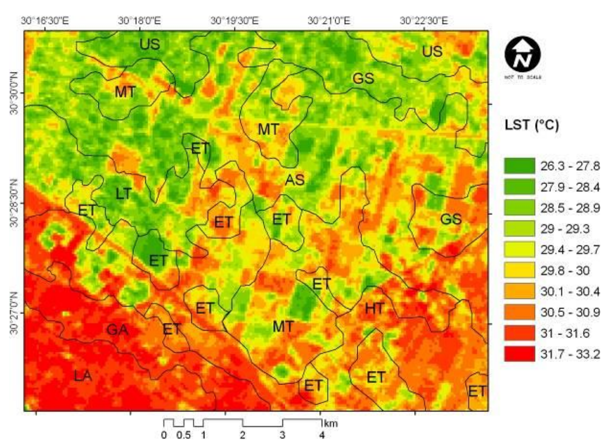

Fig. 3. Average of land surface temperature (summer 2008)

Table 1. Morphological description of the soils in the different landforms

Landform	Slope %	Color		Texture	Surface gravel	Structure	Stickiness	Plasticity	Cementation	Carbonates
		Dry	Moist							
High terraces (HT)	G	10YR7/3	10YR6/3	GS	Ma	Sg	NST	NPL	W	**ST**
Moderately high terraces (MT)	A	10YR7/6	10YR6/6	LS	C	WSB	SST	SPL	M	ST
Low terraces (LT)	A	10YR7/4	10YR6/4	LS	F	WSB	SST	SPL	M	ST
Eroded terraces (ET)	U	10YR7/4	10YR6/4	GS	Ma	Sg	NST	NPL	M	ST
Almost flat sand sheet (AS)	A	10YR7/4	10YR7/3	S	F	Sg	NST	NPL	W	MO
Gently undulating sand sheet	G	10YR7/3	10YR6/3	S	F	Sg	NST	NPL	W	MO
Undulating sand sheet (US)	U	10YR7/4	10YR6/4	S	F	Sg	NST	NPL	W	MO
Gently undulating alluvial (GA)	U	10YR7/6	10YR6/6	S	C	Sg	NST	NPL	W	ST
Low elevated alluvial (LA)	A	10YR7/4	10YR7/3	LS	C	WSB	SST	SPL	M	ST

Note: G= Gently undulating, A= Almost flat, U= Undulating, GS= Gravelly sand, LS= Loamy sand, S= Sandy, C= Common, F= Few, Ma= Many, Sg= Single grains, WSB= Weak sub-angular blocky, NST= Non sticky, SST= Slightly sticky, NPL= Non plastic, SPL= Slightly plastic, W= Weak, M= Moderate, ST= Strong effervescence with HCl, MO= Moderate effervescence with HCl

Table 2. Some physical and chemical properties of the soils in the different landforms

Landform	Soil depth (cm)	Particle size distribution (mm) %						HC (cmh^{-1})	FC	WP	AW	OM	$CaCO_3$	EC (dS/m)	ESP
		2-1	-0.5	-0.25	-0.125	-0.063	<0.063		%volume basis						
High terraces (HT)	150	15.97	23.74	35.37	24.14	0.46	0.32	19.5	15.3	7.4	7.9	0.61	9.08	12.8	14.3
Moderately high terraces (MT)	160	3.55	12.36	47.18	23.31	2.90	10.7	18.6	14.7	4.9	9.8	0.42	7.54	10.9	16.7
Low terraces (LT)	150	10.37	25.17	42.49	9.35	0.39	12.23	16.7	13.8	4.5	9.3	0.52	12.5	8.4	14.8
Eroded terraces (ET)	110	18.5	16.59	30.11	27.10	5.58	2.12	16.3	15.4	6.9	8.5	0.58	18.7	14.9	17.2
Almost flat sand sheet (AS)	170	0.63	7.93	39.19	48.64	3.17	0.44	22.3	13.5	5.8	7.7	0.36	4.6	2.5	12.5
Gently undulating sand sheet	120	0.42	10.14	35.67	50.27	3.15	0.35	19.8	14.2	6.6	7.6	0.41	6.7	3.6	11.9
Undulating sand sheet (US)	130	2.00	21.62	37.44	33.65	5.16	0.13	23.7	14.5	6.1	79	0.33	3.6	4.8	12.4
Gently undulating alluvial (GA)	140	1.59	18.42	35.53	41.63	2.24	0.59	19.4	15.2	6.3	8.9	0.39	6.7	6.2	13.6
Low elevated alluvial (LA)	110	4.25	15.35	43.28	23.45	2.35	11.32	16.4	14.3	4.7	9.6	0.53	11.3	7.1	14.7

Note: HC= Hydraulic conductivity, FC= Field capacity, WP= Wilting point, AW=available water, ESP= exchangeable sodium percent, OM=organic matter

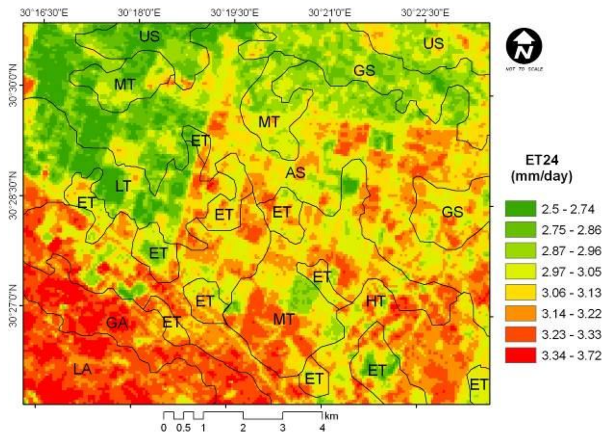

Fig. 4. Spatial distribution of daily ET (winter 2009)

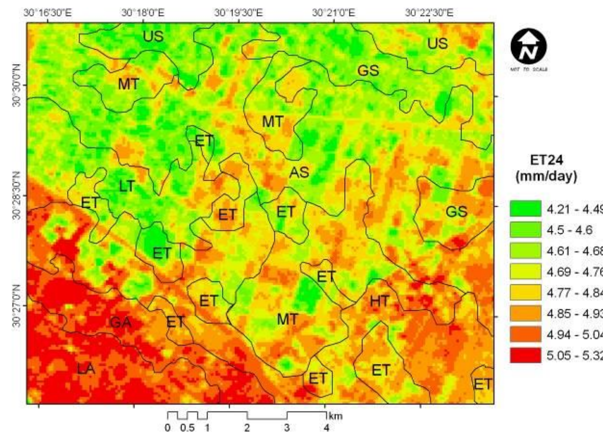

Fig. 5. Spatial distribution of daily ET (summer 2008)

Irrigation water management

Soils are considered as the integral part of the landscape and their characteristics are largely governed by the landforms on which they are developed. The physiographic influence on soil properties is recognized and ultimately leads to evolution of the soil-landscape relationship (Mini et al. 2007). Irrigation water management (IWM) depends mainly on the crop water management program as well as managing soil properties to supply plant by its needed nutrient and water. The available data in tables 1 and 2 indicate that the increasing moisture content at FC and WP is related mainly to the particle size distribution where the lowest values of WP were observed at moderately high terraces and low terraces and hence the highest values of the AW are expected. While high terraces have the highest values of WP and FC and hence AW low values are found. This result may be due to highest content of sand (2-1, 1-0.5 and till 0.250 mm) which reflect that the coarse pores are dominant in the high and eroded terraces, in spite of the highest amount of $CaCO_3$. This means that $CaCO_3$ does not have any role as cement material, where these landforms have a single grain structure. Increasing HC value is recognized in these landforms, whereas, the improvement of hydro-physical properties through increasing OM content is a must. Under these conditions, irrigation intervals are very short in moderately high and low terraces than the other landforms to set up low discharge emitters to avoid water loss through evaporation and deep percolation. Short intervals will take place in case of the high and eroded terraces according to the slope aspect (gently undulating and undulating topography) to save system pressure and fulfill high uniformity distribution. According to the high EC and ESP values in the soils of eroded terraces, leaching requirements must be added to the irrigation water to drive salts away active root zone. The Aeolian plain in the study area includes the landforms of almost flat, gently undulating and undulating sand sheets. In which complete homogeneity is attained as values of the soil water constant (FC, WP and AW) range between 13.5 to 14.5, 5.8 to 6.6 and 7.6 to 7.9 % on the volume basis. The HC values are the highest ones in the studied landforms where it is 19.8 and 23.7 cmh^{-1} for gently undulating sand sheet and undulating sand sheet respectively. These results could be ascribed to their own characteristics such as sandy texture, single grain structure and weak cementation. The clear homogeneity in all the studied features of these landforms except slope gradient means that the application of a small amount of irrigation water is necessity to eliminate water loss by the ways mentioned above, especially runoff if the irrigation requirement exceeds the soil ability to retain water. So lateral length and emitters discharge, relative to soil HC, are the most important parameters must take place in irrigation system design. The depression landscape contains two landforms, gently undulating alluvium and almost flat alluvium, where the second one decreases by about 15.5, 5.9 and 25.4 % for HC, FC and WP, respectively. While the AW, $CaCO_3$, EC and ESP values are increased by 7.9, 68.7, 14.5 and 8.11 % respectively in the same sequence. This result could explain in short irrigation intervals in gently undulating alluvial than almost flat one. Also, application of Ca^{++} source and leaching requirements to decrease ESP and leach excess of Na^{+} from active root zone. In scheduling irrigation, it is as well important to identify the critical periods during which plant water stress has the most pronounced effect on growth and yield of crops, since this is also directly related to the nutrient requirements by the crop. The usual problem of the conventional methods for estimating ETc is that they can only provide accurate ET measurements for a homogeneous region around a meteorological station, and this cannot be extrapolated to other sites. It also disregarded the effects of soil properties and land cover types on the land surface temperature. However, this became feasible from a technical and economical point of view by remote sensing (Tsouni et al., 2008). One of the most important factors affect the sustainability of irrigation management is the cropping pattern. The studied area includes different winter and summer crops; the actual ET of these crops in the different landforms was estimated (eq 6). Cultivation of Wheat, Beans, Sugar beet and Groundnut as winter crops and Maize, Sunflower, Tomato, and Sesame as summer crops is the recommended cropping pattern, where the calculated ET values of these crops in the different landforms are relatively low compared with other crops. It is noticed that the calculated ET for all crops differs from landform to another. The highest values are associated with the high terraces, eroded terraces, gently undulating, and almost flat alluvial so the relatively low ET crops (beans, groundnut, and sesame) are recommended for these landforms. The low values of crop ET are marked in the low terraces and undulating sand sheet landforms, this can be explained on the basis of the differences in soil properties, and surface elevation of various landforms. It worth to mention that the satellite based estimation indicate that the average crop ET for Wheat, Beans, Sugar beet, Groundnut, Maize, Sunflower, Tomato, and Sesame in the different landforms are 452.99, 313.04, 458.59, 366.57, 468.08, 500.44, 524.78 and 299.44 mm/season. While, by traditional estimation they attain 490.40, 328.20, 516.65, 427.50, 548.50, 584.70, 625.50 and 345.30 mm/season respectively.

CONCLUSION

Irrigation water management in arid regions must achieve the integration between the crop water requirements and soil properties. Remote sensing data facilitate the mapping of crop ET over the landforms. and propose a suitable cropping pattern consequently, sustainable water resources management. Crop ET is significantly differs from one landform to another under the same atmospheric conditions; this can be explained assuming the differences in soil properties, NDVI and surface elevation of various landforms. The calculations of crop evapotranspiration by using the thermal bands takes into account the effect of top-soil properties, land cover and landform on the land surface temperature. Spatial analysis is an effective tool that represents the relation between landforms and crop ET, and then suitable cropping pattern can then be proposed for each landform. In the studied landforms cultivation of Wheat, Beans, Sugar beet and Groundnut as winter crops and Maize, Sunflower, Tomato, and Sesame as summer crops is recommended. On the other hand the results of this study indicate that the application of satellite based estimation can save 7.63, 4.62, 11.24, 14.25, 14.66, 14.41, 16.10 and 13.28 % of the irrigation water of these crops respectively.

REFERENCES

Allen, R. G., 2000. Using the FAO-56 dual crop coefficient method over an irrigated region as a part an evapotranspiration intercomparison study. Journal of Hydrology 229 (1-2): 27-41.

Bastiaanssen W.G.M., 1995. Regionalization of surface flux densities and moisture indicators in composite terrain, a remote sensing approach under clear skies in Mediterranean climates. Report 109, Agricultural Research Department, Wageningen, the Netherlands.

Bausch, W.C. 1995. Remote sensing of crop coefficients for improving the irrigation scheduling of corn. Agric. Water Management 27:55-68.

Bouman, B. A. M. 2007. A conceptual framework for the improvement of crop water productivity at different spatial scales. Agricultural Systems 93 (1-3): 43-60.

Brutsaert, W. and M. Sugita, 1992. Application of self-preservation in the diurnal evolution of the surface energy budget to determine daily evaporation. J. of Geophysical Res., 97, D17: 18,322-18,377.

Burgan, R. E.; Hartford R. A. 1993. Monitoring vegetation greenness with satellite data. Gen. Tech. Rep. INT-297. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station. 13 p.

Burgan, R. E.; Hartford R. A.; Eidenshink J. C. 1996. Using NDVI to assess departure from average greenness and its relation to fire business. Gen. Tech. Rep. INT-GTR-333. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station. 8 p.

CONOCO, 1989. Startigraphic Lexicon and explanatory notes to the geological amp of Egypt 1: 500,000, eds. Maurice Hermina, Eberhardklitzsch and Franz K. List, pp. 263, Cairo: CONOCO Inc., ISBN 3-927541-09-5.

Crago, R.D., 1996. Conservation and variability of the evaporative fraction during the day time. J. Hydrol. 180: 173-194.

Dobos, E. Norman, B. Bruee, W. Luca, M. Chris, J. and Erika, M. 2002. The Use of DEM and Satellite Images for Regional Scale Soil Database. 17th World Congress of Soil Science (WCSS), 14-21 August 2002, Bangkok, Thailand.

Egyptian Metrological Authority, 1996. Climatic Atlas of Egypt. Published, Arab Republic of Egypt, Ministry of Transport.

El- Maghraby, M.M. 1990. Geographical and hydorological studies of Sadat City, Egypt. M.Sc.Thesis, Fac. Sci., Alexandria University.

EOSC, 1994. Landsat system status report. September 1994: Lanham, Md., Earth Observation Satellite Company (EOSC), p. 1-11.

FAO, 2006. Guidelines for soil description. 4th edition. FAO, Rome, Italy.

FAO/IIASA, 2008. Harmonized World Soil Database. version 1.0, FAO, Rome, Italy & IIASA, Laxenburg, Austria.

Farah, H.O., 2001. Estimation of regional evaporation using a detailed agro-hydrological model. J. of Hydrology, 229(1-2): 50-58.

GARPAD, 1997. Strategy for Horizontal Expansion Land Reclamation up to 2017 in Relation with National Horizontal Expansion Strategy, 1997. Central Directorate for Studies of Agricultural Projects, GARPAD, Cairo, Egypt.

Hafeez, M. M., 2003 Water accounting and productivity at different spatial scales in a rice irrigation system: a remote sensing approach. Ph.D.Thesis, University of Bonn, Volume 8.

ITT, 2009. ITT corporation ENVI 4.7 software. 1133 Westchester Avenue, White Plains, NY 10604, USA.

Kite, G. and P. Droogers, 2000. Comparing evapotranspiration estimates from satellites, hydrological models and field data. Journal of Hydrology 229 (1-2): 1-2.

Liang S, Strahler A. H. and Walthall C. W., 1999. Retrieval of land surface albedo from satellite observations: Journal of Applied Meteorology, 38, 712-725.

Lillesand TM. , Kiefer RW., 2007. Remote sensing and image interpretation, 5th ed. Paper back September 2007, John Wiley, New York, pp. 820.

Mini, V., Patil P. L. and Dasog, G. S., 2007. A Remote Sensing Approach for Establishing the Soil Physiographic Relationship in the Coastal Agro Eco system of North Karnataka.

Molden, D.; F. Rijsberman; Y. Matsuno; and U. Amerashinghe., 2000. Increasing water productivity: A requirement for food and environmental security. Dialogue on Water for Food and Environmental Security, Colombo, Sri Lanka:International Water Management Institute.

NASA, 2002. Landsat7 Science Data Users Handbook. Landsat Project Science Office, NASA Goddard Space Flight Center, Greenbelt, MD, Ver.8, Nov.2002.

Ray, S. S. and V. K. Dadhwal, 2001. Estimation of crop evapotranspiration of irrigation command area using remote sensing and GIS. Agricultural Water Management 49 (3): 239-249.

Sadek, Sh. A., 1984. Soil mapping and pedological features of the interference zone between the Nile Delta deposits and the western desert deposits, Egypt. Ph.D. Thesis, Fac. Agric., Cairo Univ.

Soil Survey Staff, 1975. Soil Munssel Colour Chart. Soil Conservation Service, U.S. Dept. of Agric., Washington D.C.,47 pp.

Stephen M. K., 2008. Exploring application of remote sensing in estimating crop evapotranspiration: comparison of S-SEBI algorithm and adapted FAO 56 model using landsat TM 5 and MODIS. M.Sc. international institute for Geo-information science and earth observation, ITC, Enschede, the Netherlands.

Storey, J. C., Scaramuzza, P., and Schmidt, G., 2005. Landsat 7 scan line corrector-off gap filled product development. PECORA 16 Conference Proceedings, Sioux Falls, South Dakota (pp. 23-27).

Tasumi, M, Bastiaanssen, WGM and Allen, RG. 2000. Application of the SEBAL methodology for estimating consumptive use of water and stream flow depletion in the Bear River Basin of Idaho through Remote Sensing. EOSDIS Project Report, Raytheon Systems Company and the University of Idaho, USA.

Tsouni, A., Kontoes C., Koutsoyiannis D., Panagiotis E., and Mamassis, N., 2008. Estimation of Actual Evapotranspiration by Remote Sensing: Application in Thessaly Plain, Greece. Sensors 2008, 8, 3586-3600; DOI: 10.3390/s8063586.

USDA, 2004. Soil Survey Laboratory Methods Manual. Soil Survey Investigation Report No. 42 Version 4.0 November 2004.

Zinck, J.A. and Valenzuela, C. R., 1990. Soil geographic database: structure and application examples. ITC j. 3, 270.