International Journal of Environment and Climate Change

Volume 13, Issue 2, Page 126-133, 2023; Article no.IJECC.95959
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Water Requirements of Wheat Crops in a Small Watershed by Using CROPWAT

Abhishek Ranjan [a#*], Derrick Mario Denis [a†], Arpan Sherring [a†], Mukesh Kumar [b‡], Vikram Singh [c‡] and Shalini Masih [d]

[a] *Irrigation and Drainage Engineering, VIAET, SHUATS, Prayagraj, India.*
[b] *Centre for Geospatial Technology, VIAET, SHUATS, Prayagraj, India.*
[c] *Soil and Water Conservation, VIAET, SHUATS, Prayagraj, India.*
[d] *Department of Mathematics and Statistics, VIAET, SHUATS, Prayagraj, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i21662

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95959

Original Research Article

Received: 01/12/2022
Accepted: 03/02/2023
Published: 23/02/2023

ABSTRACT

A study was conducted to determine the water demand of wheat crops in the area around the Tonna Pumping Canal. It used 2017-2018 climate data to determine the need for wheat crops in water in CROPWAT. Reference crop evapotranspiration (ETo) was determined using the FAO Penman Monteith method. When considering wheat crops, four stages of crop growth were considered: early stage, development stage, mid-maturity, and late-maturity stages. Crops were planted in the 2017 rabi season and yields were determined for each. This study shows that baseline evapotranspiration (ETo) in the study area ranges from 1.48 to 3.98 mm/day. Crop evapotranspiration (ETc) and water demand for wheat crops ranged from 0.44 to 3.75 mm/day and 1.9 to 39.8 mm/day. The maximum water demand was 0.13 l/s/ha or 1.1 mm/day

---

[#] *PhD Scholar;*
[†] *Professor;*
[‡] *Assistant Professor;*
**Corresponding author: E-mail: abhishekshiats023@gmail.com;*

with 65% efficiency. The irrigation water demand was estimated at about 27.93 mm/day, and the actual water intake was 81,000.29 m^3. The canal can therefore provide a convenient supply of the water needed to irrigate the area.

Keywords: Crop evapotranspiration; reference evapotranspiration; crop water requirement; peak water requirement; total crop water requirement; and climatic data.

ABBREVIATIONS

l/s/ha : Litres/Second/Hectare,
mm/day : Millimetre/days,
Eta : Crop Evapo-transpiration,
NIWR : Net irrigation water requirement,
ETo : Reference crop Evapo-transpiration.

1. INTRODUCTION

"Water is important for plant growth and meals manufacturing. there is competition among municipal, industry customers and agriculture for the finite quantity of to be had water, estimating irrigation water necessities accurately is essential for water undertaking planning and management" [1]. The number one objective of irrigation is to apply water to preserve crop evapotranspiration (and many others) while precipitation is inadequate [2-4]. The finite general amount of to be had water is essential for the economic system, health, and welfare of a totally massive a part of the developing world [5-7]. Hess [8] defined crop water necessities as the overall water wanted for evapotranspiration, from planting to harvesting a given crop in a selected weather regime, while adequate soil water is maintained by way of rainfall and/or irrigation in order that it does no longer restriction plant growth and crop yield. FAO [9] defined crop water requirement (CWR) for a given crop as:

CWR = Kc x ETo

Where, Kc is the Crop coefficient of the given crop and ETo is the Reference evapotranspiration. Each crop has its personal water necessities. net irrigation water requirements (NIWR) in a genuine scheme for a given 12 months are hence the sum of individual crop water requirements (CWR) meant for each irrigated crop. more than one cropping (numerous cropping periods in keeping with yr.) is for that reason automatically occupied into account via rather computing crop water necessities for in my opinion cropping duration. with the aid of dividing with the aid of the region of the scheme, a fee for irrigation water requirements is acquired and can be expressed in mm or in m^3/ha. FAO [10], Smith et al. (1991) and Smith (1992) reported that "CROPWAT is supposed as a realistic device to help agrometeorologists, agronomists, and irrigation engineers to perform general calculations for evapotranspiration and crop water use research, and extra especially the layout and control of irrigation schemes [11-13]. It allows the development of recommendations for stepped forward irrigation practices, the making plans of irrigation schedules underneath varying water deliver situations, and the assessment of production underneath rainfed conditions or deficit irrigation [14-17]. Broner and Schneckloth [18] said that "water necessities of vegetation depend especially on environmental situations. plants use water for cooling purposes and the riding force of this system is triumphing climate situations. specific crops have specific water use necessities, below the equal climate situations. crops will transpire water on the most fee while the soil water is at field capacity". Broner [18] mentioned that "understanding seasonal crop water requirements is crucial for planning your crop planting aggregate specially at some point of drought years. Adequate facts on irrigation water requirements of most plants are not always available in growing nations of the arena. that is one of the motives why for the failure of large-scale irrigation initiatives in most developing nations of the sector [19-23]. The objective of this look at turned into to determine crop water requirements of wheat at Harrai".

2. MATERIALS AND METHODS

2.1 Study Area

It is located on the banks of the Tons canal within 7 km of Rampur on the Mirzapur highway in Prayagraj. Harrai village come under the Karchhana block. In this village farmers are depending on canals and artificial resources for water supply in agriculture and most of the farmer do the maximum cultivation of wheat and paddy under the cereal-based farming system. Some general class farmers also do animal husbandry along with farming. In which most of the farmers reared cows and buffaloes. In Harrai

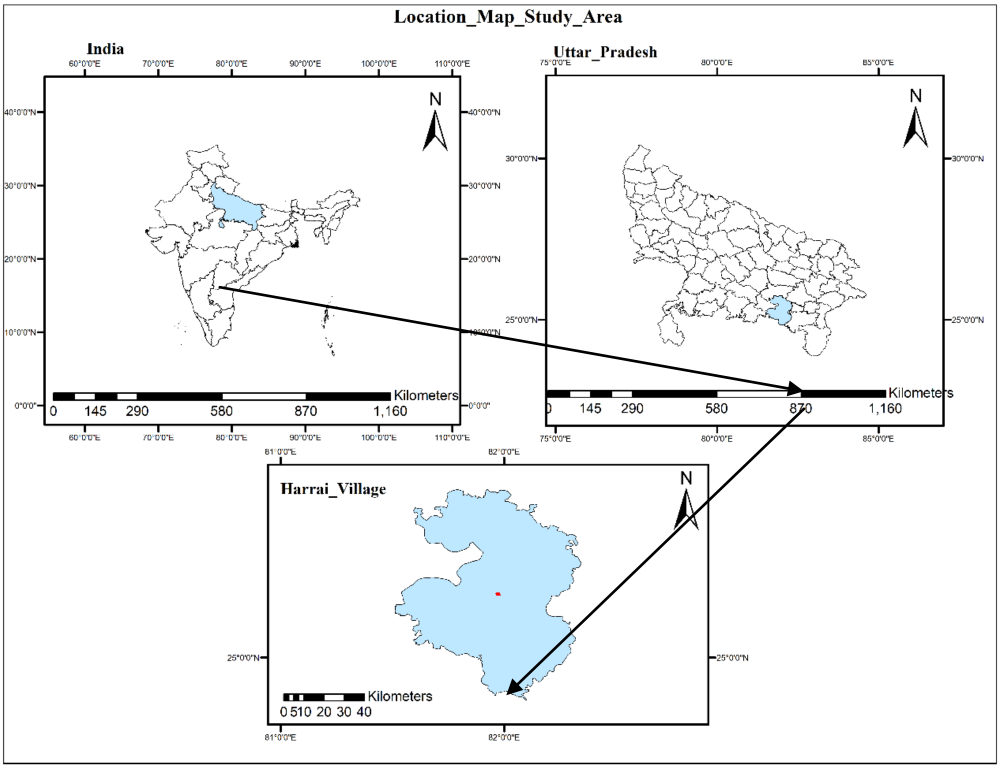

Fig. 1. Study areas at Harrai village, Prayagraj

village some lower- and middle-class farmer is also rearing pig and goat.

Harrai village lies between the longitude and latitudes are 81.9624 to 81.9813 and 25.2806 to 25.2876.

2.2 Stages of Growth

Four awesome ranges of plant growth had been utilized in determining water requirement of the crop. A long time encompass I, II, and III at the same time as the crop growth stages include preliminary level, improvement level, mid-season, and late season level.

2.3 Estimation of Water Requirement

Crop water requirement became determined from the interrelationships of the ET, soil kind, bulk density of the soil, discipline potential and everlasting wilting point of the soil and the powerful root sector of okra plant on the project website. The crop ET (and so forth) became expected by using FAO Penman-Monteith equation (FAO, 1998) Hatfield and Fuchs (1992) and Smith et al.,1991)

ETo = ETc = Kc (ETo)

where the reference crop ET (mm/day) is as defined in equation below as:

$$ETo = 0.408\Delta(Rn-G) + \gamma\,[900/(T + 273)]\,u2\,(ea - ed)/\Delta + \gamma(1 + 0.34u2)$$

Where, ETo = reference evapotranspiration [mm day^{-1}], Rn = net radiation at the crop surface [MJ m-2 day^{-1}], G = soil heat flux density [MJ m^{-2} day^{-1}], T = mean daily air temperature at 2 m height [°C], u2 = wind speed at 2 m height [ms^{-1}], es = saturation vapour pressure [kPa], ea = actual vapour pressure [kPa], es - ea = saturation vapour pressure deficit [kPa], D =slope vapour pressure curve [kPa $°C^{-1}$], g =psychrometric constant [kPa$°C^{-1}$]. Irrigation frequency was calculated using the relationship discussed by Michael [1] Irrigation frequency (days) = Field capacity of Soil – Moisture content before irrigation / Daily consumptive use,

fi = dg / Cu

where, fi = irrigation frequency (days), dg = gross depth of application (mm), and CU = daily consumptive use (mm/day). The CROPWAT 8.0 programme developed for the FAO Penman-Monteith approach (FAO, 56) become applied for estimating the crop water requirement of wheat plants studied. To make sure the integrity of computations, the weather measurements were made at 2 m (or converted to that height) above an in-depth floor of green grass, shading the floor. The climatic information used for the calculations were received from a meteorological station located at SHUATS Prayagraj.

3. RESULTS

3.1 Reference Crop Evapotranspiration

The results acquired while a 2017-2018 duration was used with the FAO-Penman Monteith approach to decide the reference crop evapotranspiration (ETO) for the place under study show that ETo various from a minimal cost of 1.48 mm/day in December to the best price of 3.98 mm/day in April given underneath in Table 1. The consequences display that ETO turned into lowest all through the peak of the winter season to maximum during the height of the summer time.

3.2 Crop Water Requirement

Outcomes display that for wheat, crop evapotranspiration (and so forth) and crop water requirement for various from zero.44 to 3.75 mm/day and 0.19 to 3.98 respectively (Table 2).

3.3 Scheme Irrigation Requirement

The estimation of actual irrigation requirement at Harrai village changed into performed (Table 3). The net irrigation water requirement is 259.3 mm/season (Table 3). this is summation of the water requirement values from Planting date (27th Nov, 2017 to20th April, 2018). the use of an irrigation application frequency of 65%, the gross water requirement of 398.92 mm/season turned into obtained. consequently, the whole land vicinity of 102.14 ha would require 0.292 mm/day/ha water. The consequences show that the canal can easily supply the water required for irrigation inside the region.

Table 1. Reference crop evapotranspiration

Country: India Meteorological Station: SHUATS Crop: Wheat Duration: 145 days		Planting date: 27-11-2017	Harvesting date: 20-04-2018		Altitude: 98m		
Day	**Min Temp (°C)**	**Max Temp (°C)**	**Humidity (%)**	**Wind (km/day)**	**Sun (hours)**	**Rad (MJ/m²/day)**	**ETo (mm/day)**
Nov	9	28	38.75	1	8.55	15.425	1.59
Dec	9.7	27.6	42	1	7.5	13.9	1.48
Jan	8.5	25.8	48	1	6.1	13	1.55
Feb	11.7	30.2	43	1	7.2	16.1	2.24
Mar	18.8	36.3	37	1	8.7	20.5	3.31
Apr	24.56	39.31	38.55	2.45	8.04	21.15	3.98

where ETo = Reference Crop Evapotranspiration computed using the FAO Penman-Monteith Method.

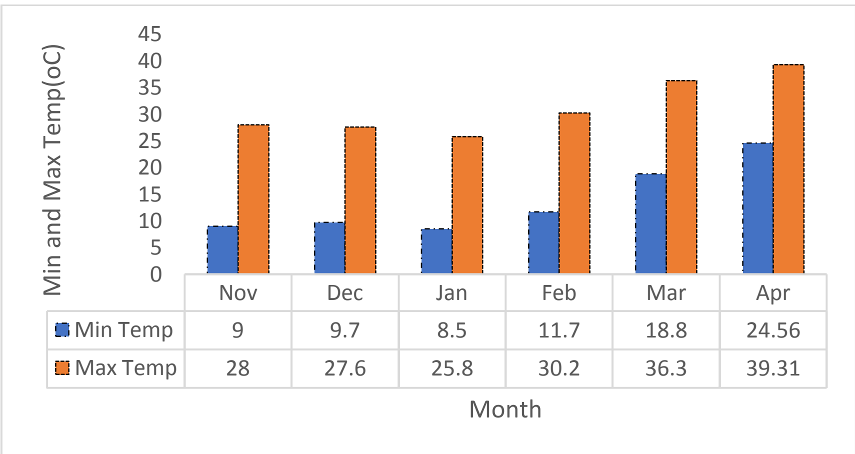

Fig. 2. Minimum and Maximum Temperature 2017-2018

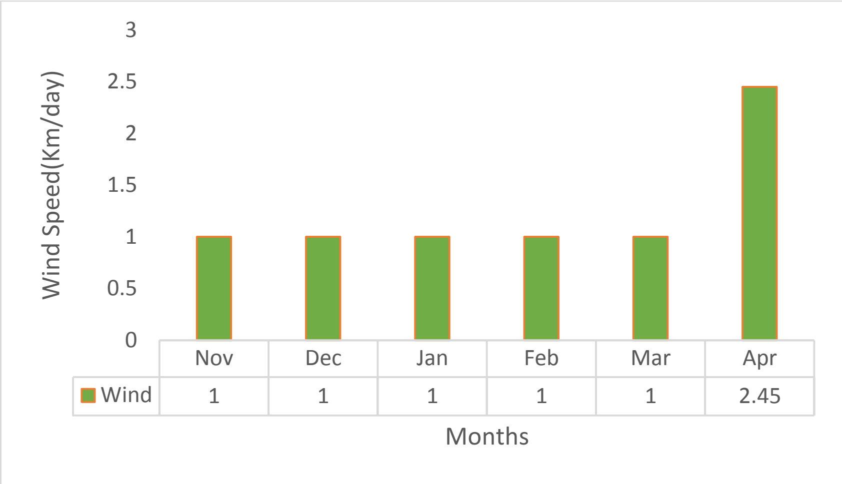

Fig. 3. Wind Speed 2017-2018

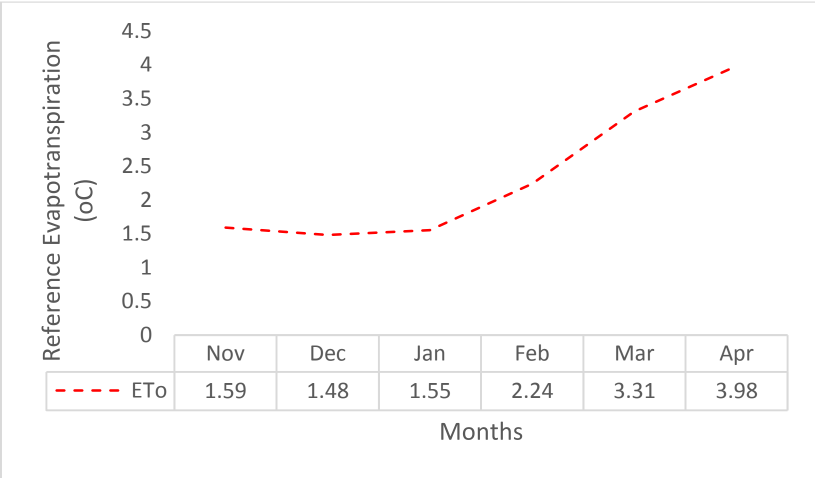

Fig. 4. Reference Evapotranspiration 2017-2018

Table 2. Evapotranspiration and Irrigation Requirement for Wheat 2017-2018

Month	Decade	Stage	Crop Coeff (Kc)	ETc (mm/day)	ETc (mm/dec)	Eff rain (mm/dec)	IR. Req. (mm/dec)	IR. Req. (mm/day)
Nov	3	Init	0.3	0.48	1.9	0	1.9	0.19
Dec	1	Init	0.3	0.44	4.4	0	4.4	0.44
Dec	2	Init	0.3	0.46	4.6	0	4.6	0.46
Dec	3	Deve	0.33	0.47	5.2	0	5.2	0.52
Jan	1	Deve	0.52	0.65	6.5	0	6.5	0.65
Jan	2	Deve	0.73	1.13	11.3	0	11.3	1.13
Jan	3	Deve	0.95	1.75	19.2	0	19.2	1.92
Feb	1	Mid	1.13	2.23	22.3	0	22.3	2.23
Feb	2	Mid	1.14	2.46	24.6	0	24.6	2.46
Feb	3	Mid	1.14	3.01	24.1	0	24.1	2.41
Mar	1	Mid	1.14	3.35	33.5	0	33.5	3.35
Mar	2	Mid	1.14	3.75	37.5	0	37.5	3.75
Mar	3	Late	0.99	3.62	39.9	0.1	39.8	3.98
Apr	1	Late	0.68	2.5	25	0.2	24.9	2.49
Apr	2	Late	0.38	1.63	16.3	0.3	16.1	1.61

IR = Irrigation Requirement (mm/day), IR = Irrigation Requirement (mm/dec), Kc = Crop Coefficient and ETc = Crop Evapotranspiration (mm/day) and ETc = Crop Evapotranspiration (mm/dec).

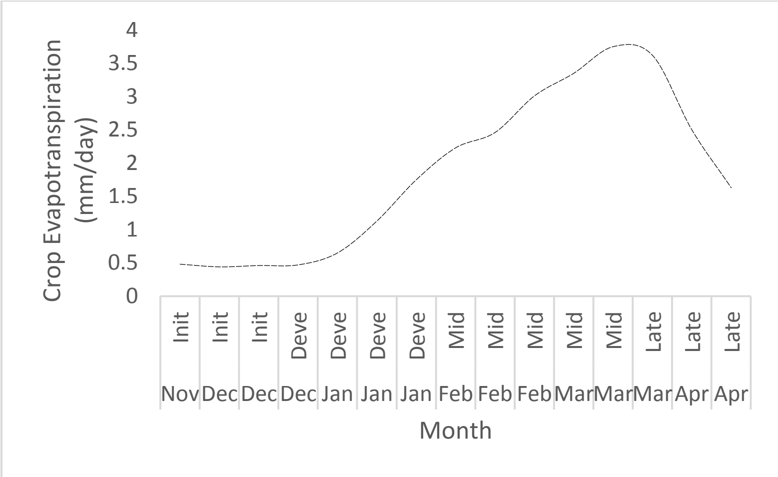

Fig. 5. Crop Evapotranspiration 2017-2018

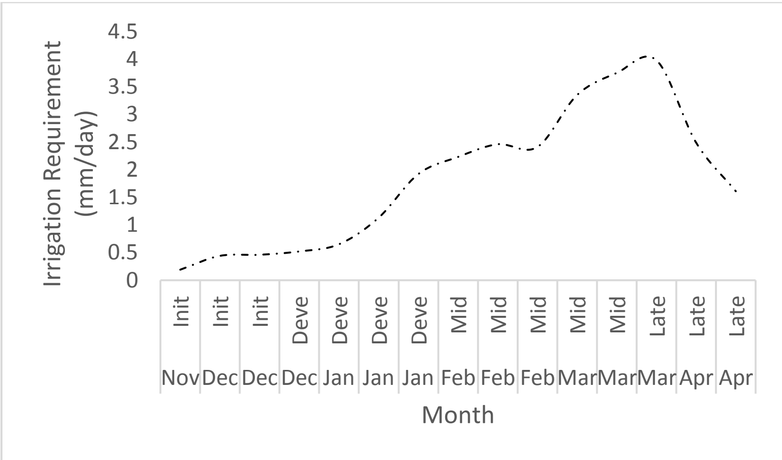

Fig. 6. Irrigation Requirements 2017-2018

Table 3. Scheme irrigation requirements

ETo Station: SHUATS		Rain Station: SHUATS		Cropping Pattern: Wheat		
	Nov	**Dec**	**Jan**	**Feb**	**March**	**April**
Wheat	1.9	14.2	37.1	71.0	110.8	4.09
Net Scheme Irr. Req.						
mm/day	0.1	0.4	1.1	2.4	3.4	1.3
mm/month	1.8	13.3	34.9	66.7	104.1	38.5
l/sec/h	0.01	0.05	0.13	0.28	0.39	0.15
Irrigated area						
Total area (Ha)	102.14	102.14	102.14	102.14	102.14	102.14
Irr. Req. for actual area						
l/sec/h	0.01	0.05	0.14	0.29	0.41	0.16

4. DISCUSSION

The effects showed that reference and crop evapotranspiration (ETo and etc) had been higher in plants with an extended developing season than in plants with a shorter developing season. also, ETo and and so forth have been better in dry season than in wintry weather. FAO [9] suggested that summer season-grown crops require more water than winter-grown vegetation. Water demand became very low all through peak season (due to heavy rainfall) and very high all through peak season (because of loss of rain), so the variety of water needs for small-discipline wheat changed into especially high. The ratio of and so on to that of the ETo was occupied as Kc of the crop at every respective growth stage and the sum of each level and so on had been taken as seasonal and so on of wheat. From the end result of this studies the averaged periodic etc of wheat is 18.42 mm with the average and so forth for preliminary, development, mid-season, and late season stage 3.63, 10.55, 28.04 and 27.06 respectively. The seasonal Kc values at initial, development, mid-season and late-season stage had been located to be 0.3, 0.63, 1.13 and 0.68 respectively. while the seasonal irrigation water requirement values at initial, development, mid-season and past due-season of wheat level have been located to be 3.63, 10.55, 28.4 and 26.93 respectively.

5. CONCLUSION

The take a look at indicates that dams can provide sufficient water for irrigation across the regions and lands currently in use. The effects obtained from the have a look at can be used by farmers to manual the choice of irrigation water amount and frequency for the vegetation beneath examine. due to the fact irrigation is a key driver of water use. Quantitative and qualitative degradation of water resources is regularly pragmatic, and demonstrating the requirement for appropriate water management. The method to be had right here dedication facilitate diverse spatially allotted evaluation, in addition to water needs of agriculture, quantitative pressures on water resources (in aggregate with assessment up to now water availability), water saving potentials (as discrepancies between abstractions and water needs). additionally effects of land use change and climate change on agricultural water wishes and agricultural pressures at the environment can be assessed. The outcomes of this study depend on without delay on the quality of the underlying data foundations (irrigated regions, land use). The values of and so on and Kc of this experiment slightly distinctive from FAO and different outcomes. This indicates the robust want for nearby calibration of crop and so on and Kc. the prevailing result of and many others and Kc and different record reviewed showed that these variables are dependent on crop, area, neighbourhood climatic situation and growing season.

The future enhancement and enlargement of the statistical proof will therefore additionally extend the model assessment of irrigation water requirements and wishes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Michael AM. Irrigation theory and practice. Vikas Publishing House, New Delhi, India. 1999;530-539.
2. Luca E, Nagy Z, Berchez M. Water requirements of the main field crops in Transylvania. Journal of Central European Agriculture. 2003;3(2):98-102.
3. Popova Z, Kercheva M, Pereira LS. Validation of the FAO methodology for computing ETo with limited data. ICID 21st European Regional Conference, Frankfurt, Slubice; 2005.
4. Proceedings of the 4th International Crop Science Congress, Brisbane, Australia (26 Sept – 1 Oct 2004). Avaiable:http:/www.cropscience.org.au
5. Doorenbos J, Pruitt WO. Crop water requirement: Food and agriculture organization of the United Nations. FAO Irrigation and Drainage Paper 24, Rome. 1977;144.
6. Droogers P, Allen RG. Estimating reference evapotranspiration under inaccurate data conditions. Irrigation and Drainage Systems. 2002;16:33-45.
7. Edward PG, Huete, AR, Nagler PL, Nelson SG. Relationship between remotely sensed vegetation indices, canopy attributes and plant physiological processes: What vegetation indices can and cannot tell us about the landscape. Sensors. 2008;8:2136-2160. Environment, 48:119-126.
8. Hess T. Crop water requirements, water and agriculture, water for agriculture. WCA infoNET; 2013. Available:http://silsoe.cranfield.ac.uk/iwe/dailyet.htm
9. Food and Agriculture Organization (FAO). Irrigation water requirements, In: Irrigation Potential in Africa: A Basin Approach, Chapter 5, FAO Corporate Document Repository, FAO, Rome; 2005. Available:http://www.fao.org/docrep/W4347E /w4347e00.htm.
10. Food and Agriculture Organization (FAO). CROPWAT: A Computer Program for

Irrigation Planning and Management, by M. Smith. FAO Irrigation and Drainage Paper No. 46. Rome; 1992.

11. Allen RG, Perrier LS, Raes D, Smith M. Crop evapotranspiration: Guidelines for computing crop requirements. Irrigation and Drainage Paper No. 56, FAO, Rome, Italy; 1998.
12. Anderson JH, Weber KT, Gokhale B, Chen F. Inter calibration and evaluation of resourcesat-1 and landsat-5 NDVI. Canidian Journal of Remote Sensing. 2011;37(2):213–219.
13. Battay A. El. Comparative study of SAVI and NDVI vegetation indices in Sulaibiya Area (Kuwait) Using Worldview Satellite Imagery. International Journal of Geosciences and Geomatics. 2013;50. ISSN:2052-5591
14. Ryua SY, Baldocchi DD, Black TA, Dettoc M, Lawd BE, Leuninge R, Miyataf A, Reichsteing M, Vargash R, Ammanni C, Beringer J, Flanagank LB, Gul L, Hutleym LB, Kimn J, McCaugheyo H, Moorsp EJ, Rambal S, Vesalar T. On the temporal upscaling of evapotranspiration from instantaneous remote sensing measurements to 8-day mean daily sums. Agricultural and Forest Meteorology. 2012;152:212-222.
15. Schwab GO, Fangmeier DD, Elliot WJ, Frevert RK. Soil and water conservation engineering. 4th ed. John Wiley and Sons. 1993;390-395.
16. Tasumi M, Allen RG. Satellite-based ET mapping to assess variation in ET with timing of crop development. Agricultural Water Management. 2007;88:54-62.
17. Yoder BJ, Waring RH. The normalized difference vegetation index of small douglas-fir canopies with varying chlorophyll concentrations. Remote Sensing of Environment. 1994;49:81-91.
18. Broner I, Schneekloth J. Seasonal water needs and opportunities for limited irrigation for colorado crops, newsletter of the extension irrigation services, Dept. of Civil Engineering, Colorado State University. No. 4.718; 2003. Available:http:/www.google search/water requirement.
19. Food and Agriculture Organization (FAO). Crop evapotranspiration guidelines for computing crop water requirements: guidelines for computing crop water requirements (FAO Irrigation and Drainage Paper No.56,); 2002.
20. Gitelson AA. Remote estimation of crop fractional vegetation cover: The use of noise equivalent as an indicator of performance of vegetation indices. International Journal for Remote Sensing. 2013;34:6054–6066.
21. Hargreaves GH, Samani ZA. Reference crop evapotranspiration from temperature. Applied Engineering in Agriculture. 1985;1:96-99.
22. Huete A, Didan K, Van Leeuwen W,Miura T, Glenn E. MODIS vegetation indices. In Land remote sensing and global environmental change. NASA's Earth Observing System and the Science of ASTER and MODIS; 2008.
23. Jehanger WA, Turral H, Masih I. Water productivity of rice crop in irrigated areas; 2004.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/95959