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Tracing Crop Water Requirement in the Pumping, Gravitational and Inundation Irrigation Schemes Using Cloud–Based IrriSAT Application

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Abstract

Tracing crop coefficient (K_c) at all the stages of crop growth is commonly essential for an accurate estimation of crop water use. This study applied the cloud–based IrriSAT application to trace the dynamic values of crop coefficient in three different sorts of irrigation schemes; pumping, gravitational and inundation irrigation for estimating crop water requirement in the Chao Phraya River Basin (CPYRB), Thailand. Three selected irrigation schemes; Bang Bal (BB), Thabua (TB), and Yom–Nan (YN) representing pumping, gravitational, and inundation irrigation schemes were selected to trace crop coefficient values of in–season and off–season crops and to estimate long–term crop water requirement (ET_c) from 2015–2020. The results of dynamic values of K_c–IrriSAT were verified and adjusted with average K_c established by the Royal Irrigation Department (K_c–RID) which were calculated as a function of K_c from field observation for the different types of crops and accumulated area size monitored by the Geo–Informatics and Space Technology Development Agency (GISTDA). The results revealed the similar patterns of average K_c generated by IrriSAT corresponding to the average K_c–RID. After the calibration procedure was successfully done, the correlations between K_c–IrriSAT adjusted and average K_c–RID for BB, TB, and YN irrigation schemes are relatively higher with R^2 of 0.8304, 0.8466, and 0.8314, respectively. In addition, it shows the explicit variability on monthly and yearly crop water demands of these three sorts of irrigation schemes when the adjusted K_c–IrriSAT was employed. It would be concluded that cloud–based IrriSAT application can be a very supportive tool in estimating the actual crop water requirement particularly for irrigators to evaluate the current status of irrigation water use and to improve the irrigation efficiency at the field scale.

Keywords: Crop Coefficient, Crop Water Requirement, Reference Crop Evapotranspiration, Cloud–Based IrriSAT Application, Normalized Difference Vegetation Index.

1. INTRODUCTION

Thailand is one of the top leaders for agricultural production in the Southeast Asia (BOI, 2021). It is stated that the economic development of Thailand has been predominantly driven by the agricultural sector (Singhapreecha, 2014). Therefore, enhancing agricultural productivity in the large–scale irrigation schemes play an important role to raise livelihood of the local people and to drive the economic growth of the country (Ministry of Agriculture and Cooperatives of the Kingdom of Thailand, 2016). Importantly, water supply facilities and sufficient irrigation water should be provided to farmers in association with the agricultural water demand to increase crop yields.

Increasing water demand for multiple uses in the Chao Phraya River Basin (CPYRB) which is located in the central region of Thailand, has embraced the risk in water resource management specially to satisfy agricultural water demand in the Greater Chao Phraya Irrigation Schemes (GCPYIS). Due to uncertainty of water supply from the headwater of the Chao Phraya River, the extreme events of flood and drought have been frequently occurred in the past few decades (Thanadachophol et al., 2020). Therefore, tracing crop water requirement (ET_c) at all the stages of crop growth in the various sorts of irrigation schemes is necessarily essential to estimate the right amount of crop water demand in GCPYIS.

Crop Water Requirement (CWR) is principally the precise amount of water consumed through evapotranspiration and to meet crop water needs during the specified time periods. In other words, CWR, also known as crop evapotranspiration (ET_c), is described as the depth of water (millimeters) needed to compensate for the water losses through crop evapotranspiration. The main factors affecting crop water requirement are climate factors, crop types, and growth stage of crops. Crop water requirement can be derived based upon the reference crop evapotranspiration (ET_o) and crop coefficient (K_c). The reference evapotranspiration (ET_o) is the rate of evapotranspiration from a hypothetical reference crop which is relatively subject to climate conditions (Pereira & Alves, 2005). The crop coefficient (K_c) varies accordingly with crop types and development stages of the crops. The values of crop coefficient for a given crop have represented the dynamics of crop evapotranspiration (Pandey, 2021).

Since most of the irrigated land area in Thailand are continually cultivated throughout the year, it is rarely possible to clearly determine the beginning of cultivation and to find the dynamic changes of K_c and crop evapotranspiration (ET_c) values over a year. As the satellite–based crop monitoring platform is well proven its capability to monitor crop growth status and vegetation indices, this study aims at tracking the dynamic values of crop water requirement (ET_c) using cloud–based IrriSAT application in the different sorts of irrigation schemes to provide useful information and tools for the analysis of agricultural water requirement in the Chao Phraya River Basin. The cloud–based IrriSAT application is satellite–based irrigation scheduling service developed in 2005. It was designed to help farmers with irrigation management at a wide range of irrigation scales (Hornbuckle et al., 2016). The reference crop evapotranspiration (ET_o) is estimated by FAO Penmen Monteith equation using observations from weather stations. IrriSAT can also anticipate crop water requirement by referring to the strong relations between the Normalized Difference Vegetation Index (NDVI) from the cultivated land and crop coefficient (K_c) (Hornbuckle et al., 2016). Moreover, water balance deficit in the root zone of crops based upon the water balance approach can be traced to indicate the levels of irrigation water requirements.

2. METHODOLOGY

2.1 Study Area

The study area is in the Greater Chao Phraya Irrigation Scheme (GCPYIS) occupying an irrigation service area of more than 19,654 km^2 (12 million rai). GCPYIS lies in the Lower Ping (LPRB), Lower Nan (LNRB) and Chao Phraya–Thachin (CPY–TCRB) River Basins which are major parts of river basin cluster of CPYRB as can be seen in Fig.1–Fig.3. The general characteristics of 35 irrigation schemes in CPYRB are summarized in Table 1. However, only three different sorts of irrigation schemes in GCPYIS representing pumping, gravitational, and inundation irrigation were selected to trace the dynamic values of crop water requirement in this study; Bang Bal (BB), Thabua (TB), and Yom–Nan (YN). Pumping irrigation is powered by pumping system installed at the site to supply the irrigation water to the fields. For gravitational irrigation, the flow irrigation water is directly supplied to the fields through the canals off taking from the headworks. Inundation irrigation, also known as river–canal irrigation, is a type of direct irrigation without construction of hydraulic structures to control the water level in the river.

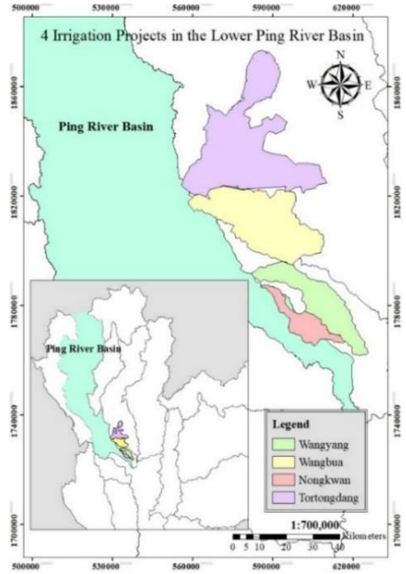


Figure 1 Four irrigation schemes in LPRB

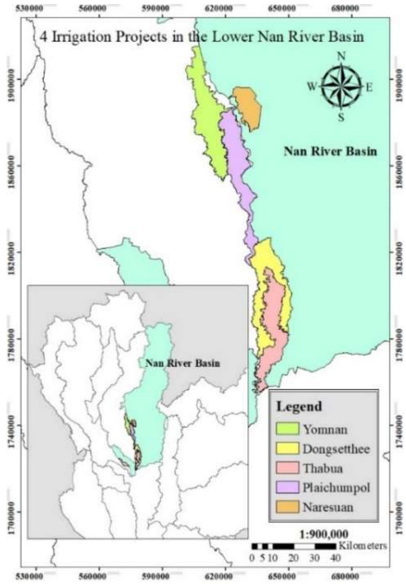


Figure 2 Five irrigation schemes in LNRB

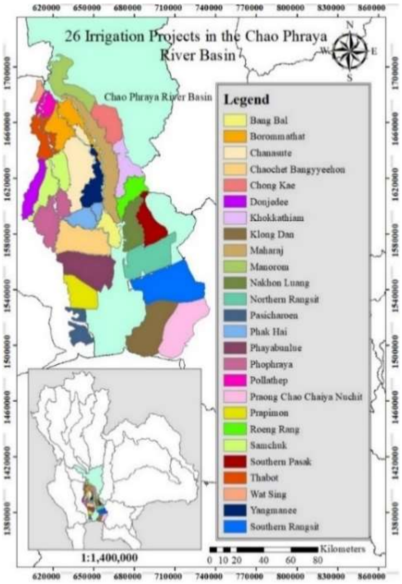


Figure 3 Twenty-six irrigation schemes in CPY–TCRB

Table 1 General characteristics of irrigation schemes in CPYRB

No.	Name of Irrigation Scheme	Type of Irrigation Scheme	Irrigation Area (km^2)
Lower Ping River Basin			
1	Tortongdang	Inundation	992
2	Wangyang	Inundation	1,336
3	Wangbua	Inundation	1,129
4	Nongkwan	Inundation	
Lower Nan River Basin			
1	Dongsetthee	Gravitation	449
2	Thabua*	Gravitation	398
3	Plaichumpol	Gravitation	433
4	Naresuan	Gravitation	172
5	Yom–Nan*	Inundation	515
Chao Phraya–Thachin River Basin			
1	Wat Sing	Pumping	123
2	Bang Bal*	Pumping	268
3	Pollathep	Gravitation	200
4	Thabot	Gravitation	338
5	Samchuk	Gravitation	609
6	Donjedee	Gravitation	270
7	Phophraya	Gravitation	659
8	Borommathat	Gravitation	677
9	Chanasute	Gravitation	880
10	Yangmanee	Gravitation	403
11	Phak Hai	Gravitation	338
12	Maharaj	Gravitation	853
13	Manorom	Gravitation	529
14	Chong Kae	Gravitation	449
15	Khokkathiam	Gravitation	421
16	Roeng Rang	Gravitation	320
17	Southern Pasak	Gravitation	404
18	Nakhon Luang	Gravitation	476
19	Northern Rangsit	Gravitation	773
20	Southern Rangsit	Gravitation	1,112
21	Chaochet Bangyeehon	Gravitation	754
22	Phayabunlue	Gravitation	814
23	Prapimon	Gravitation	426
24	Pasicharoen	Gravitation	337
25	Klong Dan	Gravitation	819
26	Praong Chao Chaiya Nuchit	Gravitation	978
		Total	19,654

As CPYRB is in the tropical climate influenced by northeast and southwest monsoons, rainfall data exhibits the temporal and spatial variation particularly at the river basin level. The mean annual rainfall in the Central Thailand from 2003 to 2007 ranges between 899 and 1,136 millimeters (mm). The mean monthly temperature data evaluated from the long–term record steadily varies between 22^{o}–31^{o}Celsius. Dry season which is a period of low rainfall and off–season crops cultivation is undertaken, runs from November to April. Wet season generally begins in May and lasts in October when in–season crops cultivation is sparsely implemented during time periods. In addition, high values of monthly evaporation loss are obviously found in this region ranging between 120–130 mm for the period 1991–2000 of climatological data reported by the Thai Meteorological Department (TMD).

2.2 Data Collection

Data required for this study includes (1) GIS shapefiles of the study area collected from the Land Development Department (LDD) of Thailand, (2) crop coefficient values provided by the Royal Irrigation Department (RID) of Thailand, (3) planting area of four main types of crops including rice, maize, sugarcane, and cassava monitored by the GISTDA from 2018 to 2019, and (4) climate data collected from the Thai Meteorological Department (TMD) from 2000 to 2020 from the nearest climate stations. The simplified overview of data collection process is presented in Fig.4.

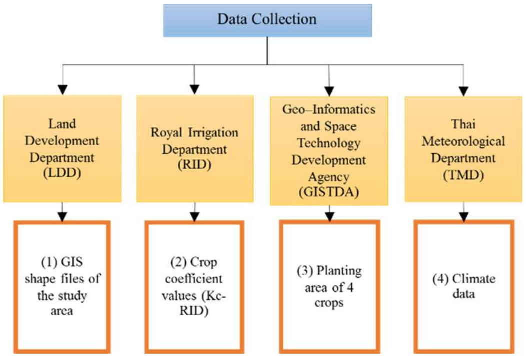


Figure 4 Simplified overview of data collection process

The GIS shapefiles were used to delineate the location of the irrigation area by IrriSAT application. Crop coefficient values (K_c) corresponding to Penman–Monteith equation of major crops, which are publicly provided by the Royal Irrigation Department (RID) from field measurement, was used to validate the results of K_c estimation from IrriSAT. The planting area of four main types of crops monitored by GISTDA using remote sensing technique was used to verify the area size of each crop. In addition, the long–term monthly climate data including atmospheric pressure, temperature, relative humidity, wind speed as well as sunshine duration from 2000 to 2020 from the nearest climate stations in the study area was used to calculate the reference crop evapotranspiration (ET_o).

2.3 Estimating Crop Coefficient Using Cloud–Based IrriSAT Application

Estimating the dynamic values of crop coefficient over the growth stages can be commonly implemented by cloud–based IrriSAT application which is the satellite–based decision support tool for irrigators (Hornbuckle et al., 2016). In fact, cloud–based IrriSAT application has been developed to estimate K_c, ET_o and to predict daily and seven–day crop water use (ET_c) (Hornbuckle et al., 2016). These are presented as aggregated values at various spatial and temporal scales. Due to the limits of global climate data at ground stations in Thailand available on the cloud platform, consequently, ET_o and ET_c cannot be generated and presented. However, the aggregated values of crop coefficient can be only evaluated by IrriSAT. To identify the crop growing area as input data of cloud–based IrriSAT application, the GIS shape files of three irrigation schemes must be converted into Keyhole Markup Language (KML) files as typically illustrated in Fig.5.

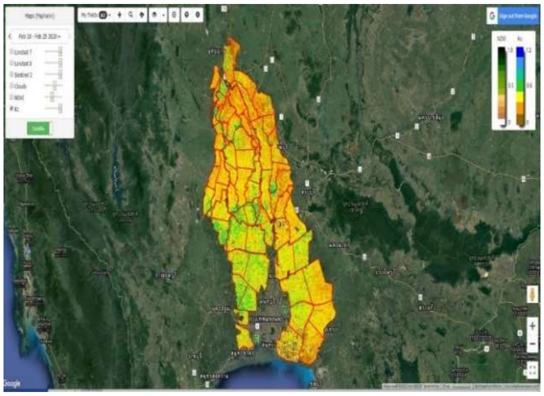


Figure 5 Display of the study area imported in cloud–based IrriSAT application

The maximum, average and minimum crop coefficient (K_c) values were then achieved. The results were automatically displayed in the form of the time series of the crop coefficient according to the specified duration of planting and harvesting dates of crops. However, crop water demand was not directly calculated by IrriSAT in this study. Therefore, the crop water demand (ET_c) for each irrigation area was computed by referring to the calculated reference crop evapotranspiration (ET_o) and crop coefficient performed by IrriSAT (K_c–IrriSAT). ET_o calculator (Raes, 2012) was used as the analytical tool to calculate reference crop evapotranspiration. The chart of crop coefficient generated from IrriSAT is illustrated in Fig.6.

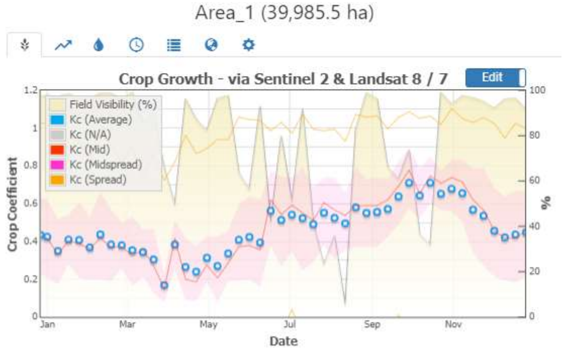


Figure 6 Typical chart of crop coefficient generated by cloud–based IrriSAT application

Cloud–based IrriSAT application was brought to estimate crop coefficient for three main irrigation schemes; BB, TB, and YN from 2015 to 2020. Various forms of crop efficient namely; K_c(average), K_c(observed), K_c(override), K_c(stddev), K_c(min), K_c(Q1), K_c(median), K_c(Q3), and K_c(max) as well as field visibility (%) were accordingly generated. However, only K_c(average) was used to compare with those values of crop coefficient (K_c–RID) performed by using observation data from RID and GISTDA.

2.4 Estimating Average Crop Coefficient (Average Kc–RID) Using Observation Data

The results of dynamic values of K_c–IrriSAT from 2015 to 2020 were verified and adjusted with average K_c–RID which were calculated as a function of K_c from field observation for the different types of crop and accumulated area size of crops monitored using the remote sensing technique (GISagro 4.0) by GISTDA. Due to the limit of GISagro 4.0, the average K_c–RID on the weekly scale can be computed based upon four main types of crop namely; (1) rice, (2) sugarcane, (3) maize, and (4) cassava by using the Eq. (1).

$$\text{Average } K_c\text{–RID} = \frac{(\text{Kcri x Areari}) + (\text{Kcsu x Areasu}) + (\text{Kcmi x Areami}) + (\text{Kcca x Areaca})}{\text{Total Area}} \tag{1}$$

where, Kcri, Kcsu, Kcmi, Kcca are crop coefficients of rice, sugarcane, maize, and cassava, respectively. Areari, Areasu, Areacmi, Areaca are the accumulated planting areas of rice, sugarcane, maize, and cassava, respectively.

Therefore, the calculation of average K_c–RID of BB, TB, and YN irrigation schemes was accordingly estimated based upon these four major crops planted from 2018 to 2019 which occupied only 58%, 66%, and 64% of the total cultivated areas, respectively.

2.5 Calibrating Crop Coefficient Values Done by IrriSAT

Calibrating K_c values performed by IrriSAT was conducted using least square criterion to envisage the degree of agreement between K_c–IrriSAT and average K_c–RID and to find the adjusted factors for the specified time periods (Kyaw et al., 2020). The method of least squares is a standard approach in regression analysis to approximate the solution of overdetermined systems by minimizing the sum of the squares of the residuals made in the results (Demaison & Vogt, 2020). In this study, two different periods of planting in–season and off–season crops in the area were identified to compute the adjusted factors of K_c–IrriSAT. These adjusted factors were solved using optimization solver based upon the long–term data sets of K_c–IrriSAT and average K_c–RID.

2.6 Estimating Reference Crop Evapotranspiration (ET_o)

The monthly calculations of reference crop evapotranspiration (ET_o) was implemented based upon the FAO Penman–Monteith equation using ET_o calculator (Saha, 2020). The Penman–Monteith equation requires air temperature, humidity, solar radiation, and wind speed data as key inputs as expressed in Eq. (2).

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \qquad (2)$$

where, ET_o is reference evapotranspiration (MJ m^{-2} day^{-1}), R_n is net radiation at the crop surface (MJ m^{-2} day^{-1}), G is soil heat flux density (MJ m^{-2} day^{-1}), T is the mean air temperature at 2 m height (°C), u_2 is the wind speed at 2 m height (m s^{-1}), e_s is saturation vapor pressure (kPa), e_a is actual vapor pressure (kPa), $e_s - e_a$ is the saturation vapor pressure deficit (kPa), Δ is the slope of the vapor pressure curve (kPa $°C^{-1}$), and γ is the psychometric constant (kPa $°C^{-1}$).

2.7 Calculating Long–Term Crop Water Requirement (ET_c)

The final step is to calculate long–term crop water requirement (ET_c) from 2015–2020 using Eq. (3) (Allen et al., 1998) after the calibration procedure for K_c adjustment and ET_o calculations were successfully done.

$$ET_c = K_c \times ET_o \qquad (3)$$

where, ET_c is crop water requirement (mm/period), K_c is crop coefficient done by could–based irrisat application (K_c–irriSAT adjusted) and average K_c–RID, and ET_o is reference crop evapotranspiration (mm/period).

3. RESULTS AND DISCUSSIONS

3.1 Crop Coefficient (K_c) Generated from Cloud–Based IrriSAT Application

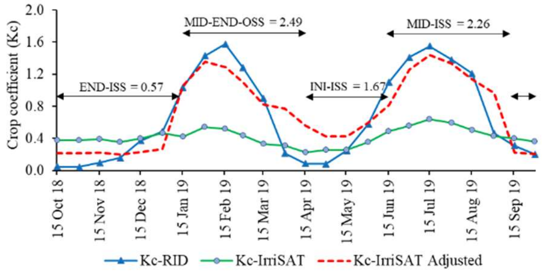
The dynamic values of K_c–IrriSAT of three irrigation schemes were generated in many forms from 2015 to 2020 and were displayed in almost one week timeframe. However, only maximum K_c(average) was presented and used to compare the results with average K_c–RID as summarized in Table 2. It is found that the maximum values of K_c(average)–IrriSAT are 0.7019, 0.7997, and 0.7763 for BB, TB, and YN irrigation schemes, respectively which are relatively lower than those received from K_c(average)–RID with 1.4638, 1.4402, and 1.5042, respectively. In addition, the average values of K_c–IrriSAT among these different types of irrigation schemes are in the same range.

Table 2 Characteristics of crop coefficient values obtained from cloud–based IrriSAT application

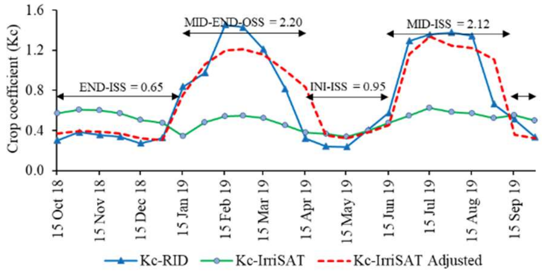
Name of Irrigation Scheme	**Type of Irrigation Scheme**	**Max. K_c(avg.)–IrriSAT**	**Max. K_c(avg.)–RID**
BB	Pumping	0.7019	1.4638
TB	Gravitation	0.7997	1.4402
YN	Inundation	0.7763	1.5042

3.2 Relationship between K_c–IrriSAT and average K_c–RID

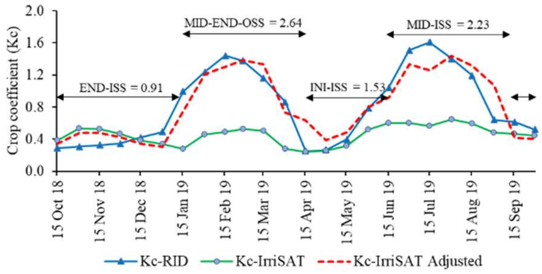
The relationships between K_c–IrriSAT and average K_c–RID before and after the calibration procedure corresponding to specific growing periods of three main irrigation schemes are presented in Fig.7 and Fig.8. Before calibrating, the patterns of K_c–IrriSAT and average K_c–RID over the growth stages of crops are likely similar. However, the K_c values calculated by IrriSAT for three irrigation schemes are highly deviated from average K_c–RID values in some growing periods in both in–season and off–season crops. It is found that the values of K_c–IrriSAT are higher than average K_c–RID from filed observation in initial and late stages of crop growth in dry and wet seasons for these three irrigation schemes as can be seen in Fig.7. Meanwhile, the lower values of K_c–IrriSAT are found in the mid–stages of dry and wet seasons. The reason might be that evaluating K_c by IrriSAT on cloud–based platform entails the entire planting area. However, calculating average K_c–RID is manipulated based upon some specific types of crop in a given area. Therefore, calibrating K_c values performed by IrriSAT was then conducted using least square criterion to envisage the degree of agreement (R^2) to the average K_c–RID. After calibrating, the adjusted factors corresponding to time periods identified can be made as presented in Table 3. The comparison of K_c–IrriSAT before and after adjustments with the average K_c–RID are shown in Fig.7. Correlations between K_c–IrriSAT after adjusted and average K_c–RID for BB, TB, and YN irrigation schemes are relatively higher with R^2 of 0.8304, 0.8466, and 0.8314, respectively as can be seen in Fig.8.



(a) Bang Bal



(b) Thabua

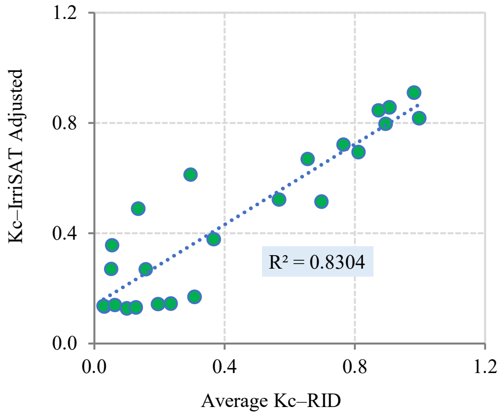


(c) Yom–Nan

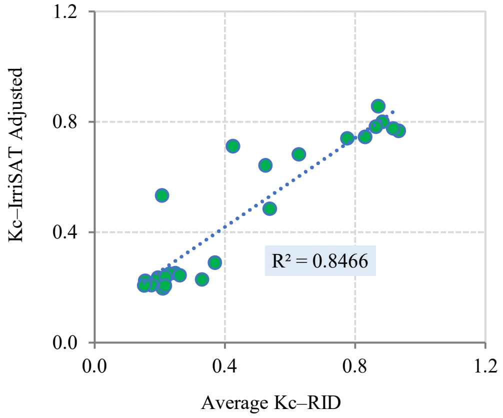
Figure 7 Pattern of K_c value over the growth stages of crops

Table 3 Characteristics of crop coefficient values obtained from cloud–based IrriSAT application

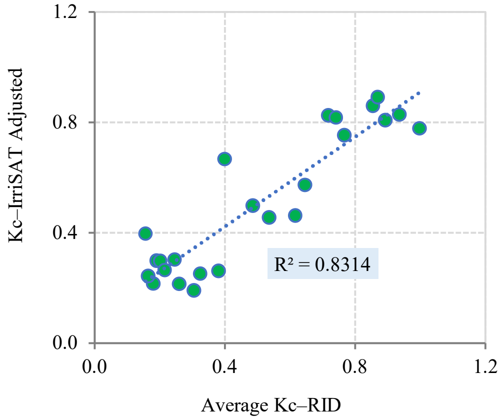
	Adjusted Factors			
Crop	**Off Season Crop (OSS)**	**In Season Crop (ISS)**		
Stage	Mid–End	Initial	Mid	End
Period	1st Jan to 15th Apr	15th Apr to 15th Jun	15th Jun to 1st Sep	1st Sep to 1st Jan
BB	2.49	1.67	2.26	0.57
TB	2.20	0.95	2.12	0.65
YN	2.64	1.53	2.23	0.91



(a) Bang Bal



(b) Thabua



(c) Yom–Nan

Figure 8 Correlation between K_c–IrriSAT adjusted and K_c–RID

3.3 Results of Reference Crop Evapotranspiration (ET_o)

The calculation of the reference crop evapotranspiration (ET_o) for BB, TB, and YN irrigation schemes was accomplished using observed climate data at the nearest weather stations located in Ayutthaya, Phichit–Nakhon Sawan, and Phitsanulok–Sukothai Provinces, respectively.

The results of ET_o calculation are illustrated in Table 4. It is found that the average values of ET_o in the Pichit and Nakhon Sawan Provinces are relatively closer to the Phitsanulok and Sukhothai Provinces due to the similar physical circumstances in the Lower Nan Basin. On the other hand, the values of ET_o calculated using climate data in the Ayutthaya Province in the Chao Phraya–Thachin River Basin seem to be bigger over the year. However, the ranges of ET_o in this region vary between 4.30–6.10, 2.61–5.45, and 2.78–4.37 mm/day for BB, TB, and YN, respectively which is in a similar range comparing with those previously reported by several studies (HII, 2012a; 2012b, 2012c, 2012d; NRCT, 2022).

Table 4 Reference crop evapotranspiration values estimated by the FAO–Penman Monteith formula

Month	**ET_o (mm/day)**		
	FAO–Penman Monteith Formula		
	BB	**TB**	**YN**
Jan	4.69	2.95	2.87
Feb	4.47	3.88	3.37
Mar	5.35	5.00	3.88
Apr	5.39	5.45	4.28
May	5.23	5.08	4.37
Jun	5.29	4.84	4.26
Jul	5.23	4.61	4.19
Aug	4.98	4.33	4.14
Sep	4.31	3.85	3.94
Oct	4.30	3.32	3.54
Nov	4.79	2.84	3.03
Dec	5.29	2.61	2.78

3.4 Comparison of Crop Water Requirement between ET_c–IrriSAT and ET_c–RID

Fig.9 and Table 5 show the calculated values of monthly and yearly crop water demands (ET_c) for three different sorts of irrigation schemes using two kinds of K_c namely, (1) K_c–IrriSAT adjusted and (2) average K_c–RID. It is illustrated that applying the average K_c–RID and adjusted K_c–IrriSAT values provide the similar patterns of the monthly crop water demands from 2015 to 2020 for BB, TB, and YN irrigation schemes. In addition, it shows the equality of mean of the yearly crop water demands of two datasets for these three irrigation schemes. However, when the adjusted K_c–IrriSAT was adopted under the same circumstances of cultivated area size used, the explicit variability on yearly crop water demands of BB, TB, and YN irrigation schemes was found. This is because the cloud–based IrriSAT application can provide the dynamic values of K_c in accordance with the changes in planting area size and NDVI values (Hornbuckle et al., 2016). Among the different sorts of irrigation schemes selected in GCPYIS, the mean values of monthly and yearly crop water demand performed by adjusted K_c–IrriSAT are likely close to those obtained by K_c–RID for all sorts of irrigation. Moreover, the greater variability in the values of monthly and yearly crop water demands made by adjusted K_c–IrriSAT are predominantly found. However, the further study on the performances of IrriSAT in estimating K_c and ET_c values and relation between K_c and Normalized Difference Vegetation Index (NDVI) in the different sorts of irrigation is highly encouraged for the achievement of satellite–based crop water requirement estimation.

4. CONCLUSION

The cloud–based IrriSAT application can be a very supportive tool for tracking the dynamics of crop coefficient which is a key parameter for accurate estimation of crop water use. This study revealed the application of IrriSAT in estimating actual crop water demand promptly on cloud–based platform in various types of irrigation schemes in Thailand. In addition, the calibration procedures to find the adjusted factors of dynamic crop coefficients estimated by IrriSAT were also envisaged. The results show that the cloud–based IrriSAT application can deliver the explicit variability on monthly and yearly crop water demands in these three sorts of irrigation schemes which represent the pumping, gravitational and inundated irrigation in GCPYIS. In addition, it can be used for crop water demand estimation particularly in small to large scale irrigation areas. Importantly, it is very helpful for the water resources planners to identify affordable water delivery and to improve the irrigation efficiency at the field scale corresponding to the dynamic values of estimated crop water demand and water supply status.

5. ACKNOWLEDGMENT

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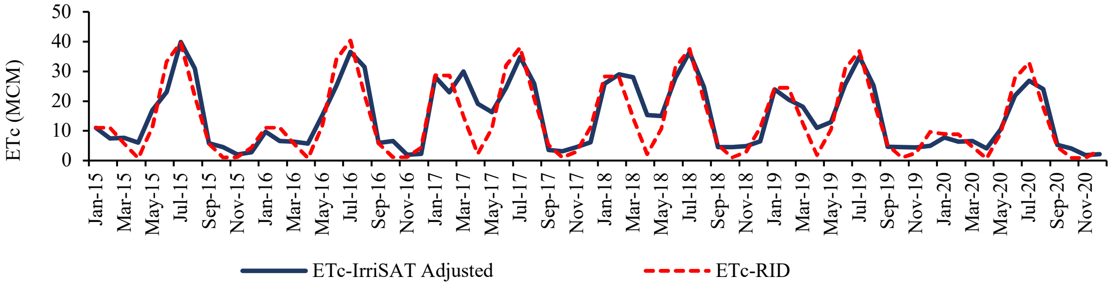
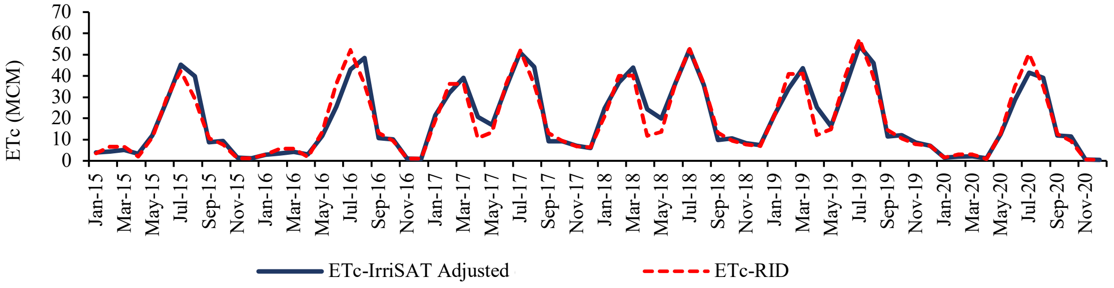
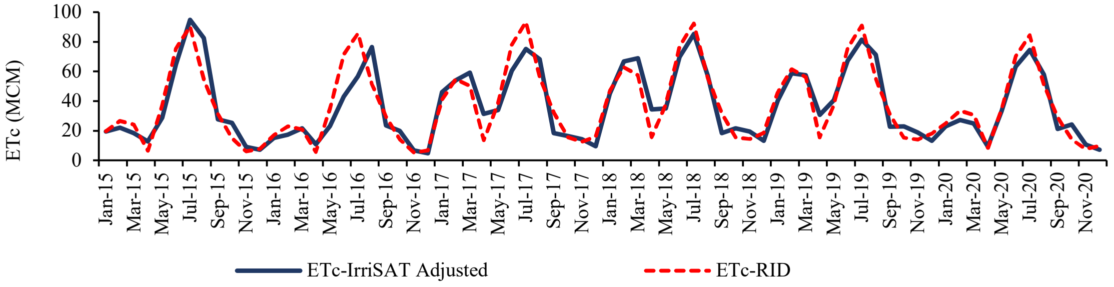


(a) Bang Bal



(b) Thabua



(c) Yom–Nan

Figure 9 Patterns of monthly ET_c values from 2015 to 2020 in each irrigation project

Table 5 Yearly crop water requirement values from 2015 to 2020

Year	Crop Water Requirement, ETc (MCM)					
	Bang Bal (BB)–Pumping		Thabua (TB)–Gravitation		Yom–Nan (YN)–Inundation	
	Kc–IrriSAT Adjusted	Average K_c–RID	Kc–IrriSAT Adjusted	Average K_c–RID	Kc–IrriSAT Adjusted	Average K_c–RID
2015	157.83	146.23	163.34	151.90	413.24	394.47
2016	153.20	148.46	165.41	178.92	319.60	366.20
2017	218.61	195.91	291.79	275.60	487.18	501.78
2018	222.21	193.22	310.28	289.91	535.16	526.37
2019	190.35	179.70	315.26	307.44	525.43	516.58
2020	121.00	120.62	153.39	165.03	376.51	398.45
Avg.	177.20	164.02	233.25	228.13	422.85	450.64
SD.	40.06	30.19	79.94	70.11	86.92	71.70
Var.	1,604.65	911.53	6,390.70	4,914.90	7,554.81	5,141.48

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