INTERNATIONAL JOURNAL OF INTEGRATED ENGINEERING
ISSN: 2229-838X e-ISSN: 2600-7916

IJIE

Vol. 17 No. 5 (2025) 290-299
https://publisher.uthm.edu.my/ojs/index.php/ijie

# Impact of Data Source on Evapotranspiration Calculation: On-Site Vs. METMalaysia Weather Stations

**Wan Fazilah Fazlil Ilahi[1,2]*, Nur Syaffiqa Izleen Rosdi[1], Muhammad Hazim Shahemi[1]**

[1] *Department of Agriculture Technology, Faculty of Agriculture Universiti Putra Malaysia, 43400 Serdang, Selangor, MALAYSIA*
[2] *Institute of Tropical Agriculture and Food Security Universiti Putra Malaysia, 43400 Serdang, Selangor, MALAYSIA*

*Corresponding Author: wanfazilah@upm.edu.my
DOI: https://doi.org/10.30880/ijie.2025.17.05.022

**Article Info**

Received: 22 August 2024
Accepted: 7 May 2025
Available online: 30 August 2025

**Keywords**

Crop water requirement, evapotranspiration, durian, weather station

**Abstract**

Crop water requirement is the estimation of water that needs to be replenished due to the crop evapotranspiration ($ET_c$) by the crop. This process is critical for ensuring adequate irrigation and maximizing crop yield. In Malaysia, climate data from Malaysia Meteorological Department (METMalaysia) stations are commonly used for $ET_c$ estimation. Although these METMalaysia stations are not located directly within the plantation area, these data are easily accessible and widely utilized for $ET_c$ calculation. However, misleading climate data will result in a wrong estimation of evapotranspiration (ET), which may lead to over or under-irrigation, resulting in plant damage thus decreasing the yield. Durian (*Durio zibethinus*), known as the "king of fruits", holds significant economic importance in Malaysia due to its high demand in both domestic and export markets across ASEAN countries. Understanding the ET of durian is essential for optimizing irrigation practices and enhancing crop revenue for farmers. The objective of this study is to compare $ET_c$ from climate data consisting of daily minimum and maximum temperature, humidity, wind speed, and sun radiation, obtained from on-site weather station and METMalaysia weather station. This study is conducted in a durian plantation at Durian Valley, Kluang, Johor. Data analyses were conducted using a T-test. The result shows a significant difference between calculated $ET_c$ using climate data obtained from the on-site weather station compared to data from the METMalaysia weather station which emphasizes the importance of accurate, location-specific climate data for effective irrigation management in durian cultivation.

## 1. Introduction

Water is a critical resource for agricultural production, playing a pivotal role in the growth and yield of crops. This is particularly true for durian cultivation, which is significant in Southeast Asian countries such as Thailand, Malaysia, Singapore, Brunei, Cambodia, and the Philippines. The high demand for durian in these regions underscores the importance of efficient water management to ensure optimal production and profitability for farmers.

Agricultural success hinges on maximizing production and profitability while minimizing costs. Effective water irrigation is crucial, significantly enhancing crop yields and revenue [1]. However, improper irrigation can

This is an open access article under the CC BY-NC-SA 4.0 license.

lead to crop diseases, pests, and fungi, such as root and stem rot due to overwatering, resulting in plant death and virus infections [2]–[4].

Ensuring adequate crop water is crucial for achieving high crop yields and water efficiency. This study aims to determine the total water requirement for durian plantations and assess the capability of aquifers to meet these needs. This study also compares calculated crop evapotranspiration ($ET_c$) values derived from Malaysian Meteorological Department (METMalaysia) climate data with those obtained from on-site weather stations. The goal is to ensure accurate irrigation practices that prevent water excess or deficit, thereby protecting durian trees and maximizing yield. By understanding and optimizing the water requirements for durian cultivation, this research aims to support sustainable agricultural practices and enhance the profitability of durian farming in Southeast Asia.

## 2. Literature Review

### 2.1 Introduction to Crop Water Requirement and Evapotranspiration

Effectively managing water resources hinges on accurately assessing crop water needs, a process that involves calculating crop evapotranspiration ($ET_c$). This calculation is performed by multiplying reference evapotranspiration ($ET_o$) with a crop-specific coefficient, known as $K_c$ [5]. ETo is especially important because it influences multiple facets of water management.

Beyond its role in scheduling irrigation, $ET_o$ is also critical in providing input data for hydrological water-balance models, which help in evaluating water availability across regions and basins. Additionally, precise $ET_o$ estimation is necessary for determining actual evapotranspiration, a key factor in optimizing water use efficiency in agriculture [6]. Consequently, any inaccuracies in $ET_o$ calculation can have significant implications for irrigation strategies and the broader management of water resources.

### 2.2 Impact of Data Sources on ET Calculation

The precision of estimating crop evapotranspiration ($ET_c$) is heavily influenced by the sources of data used to derive reference evapotranspiration ($ET_o$). $ET_o$ can be gathered from on-site weather stations or METMalaysia stations, and differences in the quality and detail of this data can result in varying $ET_c$ estimates. These discrepancies can influence irrigation practices and impact overall water use efficiency. The selection of data sources is crucial for accurate ET calculations in agricultural management.

Research has shown that different sources can lead to diverse outcomes in ET estimation. A study combined atmospheric data with Landsat imagery to assess surface evapotranspiration in the Heihe River Basin, with the goal of improving water resource management [7]. For instance, research has explored maize evapotranspiration under drought conditions using a dual crop coefficient method, underscoring the importance of soil water stress factors in obtaining accurate ET estimates [8].

Another study introduced an innovative technique that bypasses traditional crop coefficients, employing modern technologies to estimate water requirements and highlighting the value of daily crop coefficient data in ET calculations [9]. The importance of accurate data in $ET_c$ calculations is evident when using detailed crop and growth stage data to derive $ET_c$ from $ET_o$ and $K_c$ [10]. However, research also demonstrates that, in the absence of comprehensive weather data, practical estimations of ETc can still be achieved based on ETo, highlighting the adaptability of ET assessments using available resources [11].

### 2.3 Integrating Water Management and Agricultural Practices

Integrating water management with agricultural practices is vital for promoting sustainable farming and making the most of available resources. Merely managing water supplies may not sufficiently address water stress; it is essential to complement precise irrigation methods with comprehensive agricultural practices [12]. For example, drip irrigation combined with optimized fertilization (DIF) has been found to lower water usage and reduce nitrogen runoff, which enhances both water efficiency and crop yields [13]. Accurate crop evapotranspiration ($ET_c$) calculations are essential for these methods to be effective, highlighting the need for dependable weather data.

Real-world applications of drip irrigation reveal its significant benefits. Studies have shown that implementing drip irrigation in horticultural crops allows for precise water application, leading to the conservation of both water and fertilizers while increasing crop yields [14]. Similarly, other research highlights that drip irrigation enhances water efficiency, reduces water loss, manages soil salinity, and boosts overall crop production [15]. These observations illustrate the benefits of combining advanced irrigation methods with accurate $ET_c$ measurements to improve water management and enhance agricultural productivity.

## 2.4 Sensor-Based Irrigation Scheduling and Its Importance

In modern agriculture, sensor-based irrigation scheduling has become increasingly important for optimizing water use by monitoring soil moisture levels and adjusting irrigation as needed [16]. For crops like durian, which can demand up to 360 liters of water per day for mature trees, precise estimation of crop evapotranspiration ($ET_c$) is vital. This accuracy prevents both under- and over-irrigation, ensuring optimal yields and preventing unnecessary water use [17].

Advanced irrigation systems now utilize technologies such as the Internet of Things (IoT) and Wireless Sensor Networks (WSN) to provide detailed moisture data and enhance irrigation schedule [18]. These systems are designed to minimize water consumption, improve irrigation efficiency, and either sustain or increase crop yields [19]. They offer a significant improvement over traditional irrigation methods, effectively addressing common issues and enhancing water management in various agricultural contexts [20].

The benefits of sensor-based irrigation are evident across different crops. For example, research has shown that integrating these systems with surge flow irrigation techniques can significantly reduce water use while maintaining crop yields and boosting economic returns [21]. The effectiveness of sensor-based irrigation extends to crops like winter wheat, okra, and potatoes, where it has been found to enhance water productivity and crop performance [22]–[24].

Moreover, integrating soil moisture sensors with computer models offers a robust method for predicting irrigation needs more accurately and reducing uncertainties in scheduling [25]. By incorporating sensor feedback and wireless moisture monitoring, precision irrigation can be achieved, leading to better water use and improved crop yields [26].

## 2.5 Sustainable Use of Water and Soil Resources

Effective and sustainable management of water and soil resources is essential for agriculture, as intensive irrigation practices directly influence various aspects of crop growth, including the accumulation of dry matter. In durian trees, for instance, dry matter accumulation is significantly affected by irrigation practices, which in turn are influenced by micro-environmental factors such as soil moisture and local climate conditions [27]. These factors are closely related to evapotranspiration (ET), as accurate ET estimations help optimize irrigation schedules, ensuring sufficient water availability without over-irrigation. This balance supports both dry matter accumulation and overall crop health, highlighting the need to manage micro-environmental factors effectively for sustainable agricultural outcomes.

Accurate determination of crop evapotranspiration ($ET_c$), derived from reference evapotranspiration ($ET_o$) and crop coefficients ($K_c$), is fundamental to optimizing irrigation practices. $ET_c$ calculations help ensure that crops receive adequate water without the risk of over-irrigation, which can lead to nutrient leaching, soil degradation, and wasted water resources. This precision is particularly important in managing micro-environmental factors that directly affect crop health, yield, and resource efficiency.

However, errors in $ET_c$ estimations often arise from inconsistencies or inaccuracies in weather data inputs, such as temperature, wind speed, relative humidity, and solar radiation. These discrepancies can lead to misaligned irrigation schedules, resulting in either water stress or excessive water application. For instance, overestimating $ET_c$ may prompt unnecessary irrigation, exacerbating issues such as waterlogging, increased salinity, and soil erosion. Conversely, underestimating $ET_c$ could lead to water shortages, reducing crop growth and productivity.

# 3. Methodology

## 3.1 Study Area, Planting Material, and Experimental Design

The study was conducted in the durian plantation at Sri Lalang, Kluang, Johor (2.014°N, 103.226°E). The total area of the plantation as shown in Fig. 1 is 40 acres consisting of 83% Musang King, 8% Black Horn, and 5% Golden Pheonic. All trees were at the vegetative growth stage aged between 5 and 8 months. The source of water is from the groundwater pump, and it will flow to the main line and next to the 16 sub-main lines. From the sub-main, water will flow into the laterals where the durian trees are in the study area. As many as five (5) drips were attached to a looped pipe for each tree. The flow rate of each drip was 8 L/h.

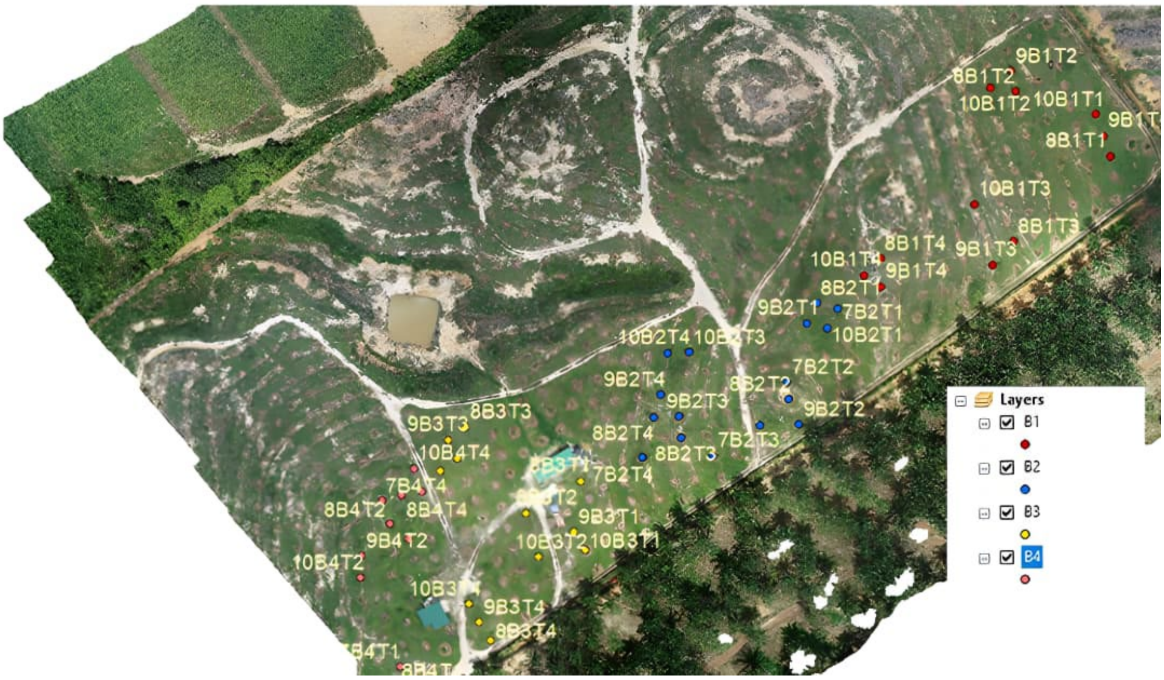


**Fig. 1** *Durian plantation at Sri Lalang, Kluang, Johor*
*Note: B1, B2, B3, and B4 represent the treatment blocks*

The study consists of two (2) treatments which are labeled as treatment 1 (TI) for climate data obtained from the on-site weather station (Spectrum Watchdog 2900ET, Spectrum Technologies. Inc. Aurora Illinois, United States) and treatment 2 (T2) for Climate data obtained from the MET weather station. Each treatment contained eleven (11) calculated $ET_c$ values from February until December. On-site weather station and METMalaysia weather station have been used to obtain climate data to calculate $ET_c$. Data will be calculated using the CROPWAT 8.0 software. The $ET_c$ in mm/day can be calculated from the equation below:

$$ETc = Kc \ x \ ETo \tag{1}$$

Crop coefficient, $K_c$ is the standard crop coefficient, where $K_c$ = 0.6 for durian trees at the vegetative growth stage [28]. $ET_o$ is the reference evapotranspiration rate over a water well-watered crop land completely covered by a short green, grass-like crop. $ET_o$ will be calculated from the Penman-Monteith formula using CROPWAT 8.0 software, incorporating the average previous five (5) years of climate data for Kluang station obtained from METMalaysia. The climate data includes daily temperature, wind speed, sun radiation, and humidity. For this treatment, irrigation was also given twice daily.

## 3.2 Weather Station Components

The weather station (Spectrum Watchdog 2900ET, Spectrum Technologies. Inc. Aurora Illinois, United States) includes several essential sensors that monitor different environmental conditions. Thermometers measure temperature in Celsius (°C), with a range of 30 meters to 100 feet, offering valuable temperature data for weather tracking. A hygrometer measures relative humidity (%RH) by detecting changes in capacitance, which occur as water molecules from the air are absorbed by a capacitor. Barometers monitor atmospheric pressure in pascals (Pa), with a pressure range of 300 to 1100 hPa and an accuracy of ±4 to 2 hPa, providing insight into atmospheric shifts. An anemometer tracks both wind speed (km/h) and direction (°), using a cup anemometer with three aluminum cups placed at a 45° angle for ±5% accurate speed readings. The wind vane detects wind direction within a 360° range. Rain gauges measure rainfall in millimeters (mm), using a 159.6mm ABS plastic bucket that accurately records precipitation from 0 to 4 mm/min, with a detection accuracy of ±0.4mm, and operates within a temperature range of 0 to 60°C. These sensors work together to provide comprehensive data that is crucial for agricultural planning and weather forecasting.

For agricultural purposes, the station should be situated in a location that accurately reflects field conditions. This is essential due to the high spatial variability of rainfall and the impact of built environments on temperature. To ensure accurate observations, stations should be positioned to minimize the influence of obstructions like buildings and trees, as shown in Fig. 2.


**Fig. 2** *An on-site weather station at the study area field*

## 3.3 Data Collection

Fig. 3 shows the flow of data collection of in this research. Monthly $ET_o$ is calculated using CROPWAT 8.0 by accessing climatic data from both the on-site weather station (T1) and the METMalaysia climatic database (T2). The climate data obtained from the weather station located on-site will be collected daily and thereafter uploaded in the form of an Excel file. Data collection started in the seventh (7$^{th}$) week following the installation of the on-site meteorological station, and it took place from April to December 2020. For T2, a total of five (5) years of historical climate data for the Kluang station were acquired from METMalaysia. The METMalaysia weather station in Kluang, Johor, is situated at a distance of 10 km from the research area.

Once the data has been gathered from both sources, the estimation of $ET_o$ will be performed using CROPWAT 8.0, which utilizes the Penman-Monteith equation [29]. The calculation of $ET_c$ in millimeters per day can be achieved using Equation 1.

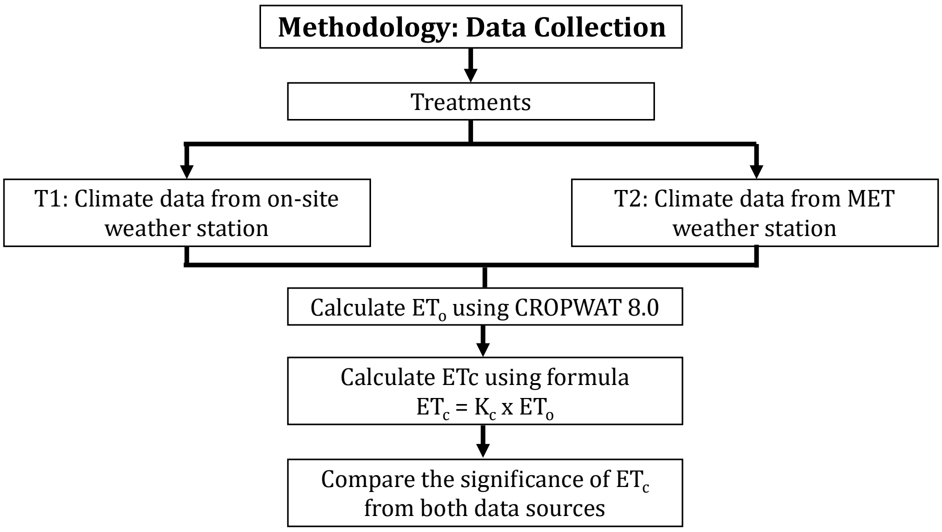


**Fig. 3** *Data collection framework*

## 3.4 Data Analysis

The $ET_c$ values obtained from the two sources were statistically analyzed by t-test (independent t-test) using Excel 2013 (Microsoft Corp, Redmond, WA, USA). A t-test was performed to determine the statistical significance of the varying water requirements at the vegetative stage of durian, resulting from different sources of data. A significant difference is anticipated between the ETc values calculated using climate data from the on-site weather station and the METMalaysia weather station.

## 4. Finding and Analysis

Tables 1 and 2 show the results of ETo and ETc for both weather stations from different climatic resources. The results show a significant difference in ETo, ETc between the METMalaysia weather station and the on-site weather station. The values for ETo, and ETc for the on-site weather station were higher than the METMalaysia weather station for all months.

**Table 1** *Value of $ET_o$, $ET_c$ for on-site weather station (T1)*

| Month | $ET_o$ x $K_c$ | $ET_c$ |
|---|---|---|
| February | 5.32 x 0.6 | 3.192 |
| March | 5.57 x 0.6 | 3.342 |
| April | 5.46 x 0.6 | 3.276 |
| May | 5.04 x 0.6 | 3.024 |
| Jun | 4.85 x 0.6 | 2.91 |
| July | 4.94 x 0.6 | 2.964 |
| August | 5.20 x 0.6 | 3.12 |
| September | 5.41 x 0.6 | 3.246 |
| October | 5.38 x 0.6 | 3.228 |
| November | 5.00 x 0.6 | 3 |
| December | 4.84 x 0.6 | 2.904 |

**Table 2** *Value of $ET_o$, $ET_c$ for MET weather station (T2)*

| Month | $ET_o$ x $K_c$ | $ET_c$ |
|---|---|---|
| February | 4.3 x 0.6 | 2.58 |
| March | 4.49 x 0.6 | 2.694 |
| April | 4.27 x 0.6 | 2.562 |
| May | 3.92 x 0.6 | 2.352 |
| Jun | 3.67 x 0.6 | 2.202 |
| July | 3.65 x 0.6 | 2.19 |
| August | 3.87 x 0.6 | 2.322 |
| September | 3.93 x 0.6 | 2.358 |
| October | 3.75 x 0.6 | 2.25 |
| November | 3.47 x 0.6 | 2.082 |
| December | 3.26 x 0.6 | 1.956 |

Based on the results, $ET_c$ for the on-site weather station was higher than the METMalaysia weather station in Kluang, Johor. This discrepancy is due to the differing distances between the stations and the study area; the METMalaysia weather station in Kluang, Johor is 10 km away from the study area. Additionally, the on-site weather station is located near the plants and provides current climate data, while the METMalaysia data is historical data from the past five years. In Malaysia, annual daily mean temperature, daily mean maximum temperature, and daily mean minimum temperature increased significantly at all stations, with rural areas showing a significant increment for mean and warm extreme indices [30].

From Table 3, there is a significant difference between both $ET_c$ calculated from on-site and METMalaysia weather stations for all months. As a whole, all $ET_c$ values from the on-site weather station had higher $ET_c$ values compared to $ET_c$ from the METMalaysia weather station. This difference is likely because the on-site weather station is located at the experimental site, making it more accurate for capturing the specific microclimatic conditions that influence ETc. Studies have shown that localized weather stations provide more reliable data for site-specific agricultural modeling compared to regional stations, as they account for field-level variations in temperature, humidity, and solar radiation [31]. This agrees with the finding that in a time series of climatological data, numerous inconsistencies can occur due to alterations in measurement systems, such as station relocations, updates to instruments, changes in exposure settings, or variations in observational methodologies, rather than actual climate variations [32].

The $ET_c$ from the on-site weather station uses current climate data measured in the study area, surrounded by the durian trees. These climate data represent the actual environmental conditions of the area and can provide accurate information for $ET_c$ estimation for the durian trees. Conversely, $ET_c$ from the METMalaysia weather station uses an average of five years of historical climate data for $ET_c$ estimation. Historical climate data pertain to past events and conditions specific to the area of the durian plantation. Such data include most manually or automatically generated data within a certain purpose. Analyzing historical data to discern trends, correlations, and other statistical relationships can provide insights into current conditions. However, five years of historical data from the METMalaysia station must be used cautiously when estimating $ET_c$, as the actual data from the on-site weather station have proven to be significantly different. Due to climate change, with variations in long dry seasons and less wet seasons, it is almost impossible to predict the same climate trends in subsequent years. Based on the water requirements for the durian trees in the study area, more irrigation is needed according to the on-site weather station compared to the METMalaysia weather station. Moreover, accurately determining crop water requirements can conserve water and reduce overall irrigation management costs [33].

**Table 3** *$ET_c$ calculated from weather station data and on-site weather station data from February to December 2020, presented as monthly averages (n = ± 30 days per month)*

| Months | Treatment | | Significance |
|---|---|---|---|
| | T1: On-site Weather Station $ET_c$ (mm/day) | T2: METMalaysia Weather Station $ET_c$ (mm/day) | |
| Feb | 3.189 | 2.588 | t(52) = -18.5* |
| Mar | 3.342 | 2.694 | t(58) = -31.6*, |
| Apr | 3.272 | 2.535 | t(57) = -21.1*, |
| May | 3.004 | 2.353 | t(38) = -19.0* |
| Jun | 2.908 | 2.224 | t(58) = -28.9* |
| Jul | 2.961 | 2.188 | t(38) = -34.1* |
| Aug | 3.12 | 2.321 | t(48) = -41.1* |
| Sep | 3.244 | 2.389 | t(47) = -21.9* |
| Oct | 3.229 | 2.247 | t(54) = -55.1* |
| Nov | 3.002 | 2.09 | t(49) = -48.2* |
| Dec | 2.904 | 1.957 | t(50) = -44.2* |

Note: *significant at p<0.05, respectively.

## 5. Conclusion

This study compared durian $ET_c$ at the study area in Kluang, Johor, using data from the METMalaysia weather station in Kluang and an on-site weather station. The METMalaysia data comprised five years of historical records, while the on-site data were collected and transferred by plantation workers. The study revealed significant differences in $ET_c$ values between the two sources, with higher $ET_c$ values from the on-site station indicating a greater water requirement for durian trees. This demonstrates that different climate data sources result in varying $ET_c$ values.

The findings highlight the significant impact of Malaysia's climate on crop water requirements, emphasizing the importance of accurate $ET_c$ estimation to optimize water use and reduce costs for farmers. Installing on-site weather stations near plantations is crucial for accurately calculating $ET_o$ and determining precise crop water needs, ultimately enhancing crop production and quality.

## Acknowledgement

The authors express gratitude to the Ministry of Higher Education Malaysia for providing funds through the Long Term Research Grant Food Security Niche Area LRGS/1/2019/UPM/01/2/1, which supports this study. The authors would like to thank the staff members from the Faculty of Agriculture Universiti Putra Malaysia and the staff of Durian Plantation Sri Lalang, Kluang, Johor for their assistance.

## Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows:* ***study conception and design:*** *Wan Fazilah Fazlil Ilahi, Nur Syaffiqa Izleen Rosdi, Muhammad Hazim Shahemi;* ***data collection:*** *Wan Fazilah Fazlil Ilahi, Muhammad Hazim Shahemi;* ***analysis and interpretation of results:*** *Wan Fazilah Fazlil Ilahi, Nur Syaffiqa Izleen Rosdi, Muhammad Hazim Shahemi;* ***draft manuscript preparation:*** *Wan Fazilah Fazlil Ilahi, Nur Syaffiqa Izleen Rosdi. All authors reviewed the results and approved the final version of the manuscript.*

## References

[1] Olayide, O. E., Tetteh, I. K., & Popoola, L. (2016) Differential impacts of rainfall and irrigation on agricultural production in Nigeria: Any lessons for climate-smart agriculture?, *Agricultural Water Management*, *178*, 30–36, https://doi.org/10.1016/j.agwat.2016.08.034

[2] Koshariya, A. K., Mahant, M. M., Afsana, C., & Reddypriya, P. (2023) *Introduction to Plants Pathology*. Ag Publishing House (AGPH Books).

[3] Sain, S., & Singh, P. (2016) A Perspective on Integrated Disease Management in Agriculture. Bio Bulletin.

[4] Savva, A., & Frenken, K. (2002) *Irrigation Manual Module 3 Agronomic Aspects of Irrigated Crop Production Developed by*. https://openknowledge.fao.org/server/api/core/bitstreams/614dd18f-5d69-42cc-9e02-2894497c7ca2/content

[5] Allen, R. G., Pereira, L. S., Raes, D., & Herrera, L. E. T. (1998). Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56.

[6] Gong, L., Xu, C., Chen, D., Halldin, S., & Chen, Y. D. (2006) Sensitivity of the Penman–Monteith reference evapotranspiration to key climatic variables in the Changjiang (Yangtze River) basin, *Journal of Hydrology*, *329(3-4)*, 620-629, https://doi.org/10.1016/j.jhydrol.2006.03.027

[7] Pang, Z. (2024). Intelligent monitoring of surface evapotranspiration in the Heihe River basin based on dual-source modelling, *Applied and Computational Engineering, 63(1)*, 68-77, https://doi.org/10.54254/2755-2721/63/20240996

[8] Yuan, H., Yi, C., Ning, S., Jiang, S., Xianjiang, Y., & Guang-min, T. (2019) Estimation of maize evapotraspiration under drought stress - a case study of Huaibei Plain, China. *Plos One, 14(11)*, e0223756, https://doi.org/10.1371/journal.pone.0223756

[9] Ragab, R., Evans, J., Battilani, A., & Solimando, D. (2017) Towards accurate estimation of crop water requirement without the crop coefficient Kc: New approach using modern technologies, *Irrigation and Drainage, 66(4)*, 469-477, https://doi.org/10.1002/ird.2153

[10] Alsenjar, O., Çetin, M., Aksu, H., Akgül, M., & Golpinar, M. (2023) Cropping pattern classification using artificial neural networks and evapotranspiration estimation in the eastern Mediterranean region of Turkey, *Journal of Agricultural Science*, *29(2)*, 677-689, https://doi.org/10.15832/ankutbd.1174645

[11] Awal, R., Rahman, A., Fares, A., & Habibi, H. (2022) Calibration and evaluation of empirical methods to estimate reference crop evapotranspiration in west Texas, *Water, 14(19)*, 3032, https://doi.org/10.3390/w14193032

[12] Wang, W., Yu, Z., Zhang, W., Shao, Q., Zhang, Y., Luo, Y., … Xu, J. (2014) Responses of rice yield, irrigation water requirement and water use efficiency to climate change in China: Historical simulation and future projections, *Agricultural Water Management*, *146*, 249–261, https://doi.org/10.1016/j.agwat.2014.08.019

[13] Haofeng Lv, Lin, S., Wang, Y., Lian, X., Zhao, Y.-G., Li, Y., … Klaus Butterbach-Bahl. (2019) Drip fertigation significantly reduces nitrogen leaching in solar greenhouse vegetable production system, *Environmental Pollution*, *245*, 694–701, https://doi.org/10.1016/j.envpol.2018.11.042

[14] Islam, M. S., Hossain, M. F., & Pervin, S. (2023) Enhancing broccoli (brassica oleracea var. italica) growth, yield and water productivity through irrigation and mulching techniques in local climate, *Asian Journal of Agricultural and Horticultural Research, 10*(4), 440-454, https://doi.org/10.9734/ajahr/2023/v10i4284

[15] Tamoor, M., ZakaUllah, P., Mobeen, M., & Zaka, M. A. (2021) Solar powered automated irrigation system in rural area and their socio economic and environmental impact, *International Journal of Sustainable Energy and Environmental Research, 10(1)*, 17-28, https://doi.org/10.18488/journal.13.2021.101.17.28

[16] Kloß, S., Niels Schütze, & Urs Schmidhalter (2014) Evaluation of very high soil-water tension threshold values in sensor-based deficit irrigation systems, *Journal of Irrigation and Drainage Engineering-Asce*, *140(9),* https://doi.org/10.1061/(asce)ir.1943-4774.0000722

[17] Jaafar, M. (1998) The performance of durian clones under supplementary irrigation (Prestasi klon durian yang diberi pengairan tambahan), *Trop. Agric. And Fd. Sc*, *26(1)*, 65–72, http://jtafs.mardi.gov.my/jtafs/26-1/Supplementary%20irrigation.pdf

[18] Singh, C. D., Rao, K. V., Kumar, M., & Rajwade, Y. A. (2023) Development of a smart IoT-based drip irrigation system for precision farming, *Irrigation & Drainage*, *72(1)*, https://doi.org/10.1002/ird.2757

[19] Bryant, C., Spencer, G., Gholson, D., Plumblee, M., Dodds, D., Oakley, G., … & Krutz, L. (2023) Development of a soil moisture sensor-based irrigation scheduling program for the Midsouthern United States, *Crop Forage & Turfgrass Management, 9(1)*, https://doi.org/10.1002/cft2.20217

[20] Kaptein, N., Light, M., & Savage, M. (2019) Review: Sensors for the improvement of irrigation efficiency in nurseries, *Water SA, 45(3)*, https://doi.org/10.17159/wsa/2019.v45.i3.6750

[21] Bryant, C., Krutz, L., Falconer, L., Irby, J., Henry, C., Pringle, H., … & Wood, C. (2017). Irrigation water management practices that reduce water requirements for mid-south furrow-irrigated soybean, *Crop Forage & Turfgrass Management, 3(1)*, 1-7, https://doi.org/10.2134/cftm2017.04.0025

[22] Sharma, V., Singh, P., Bhakar, S., Yadav, K., Lakhawat, S., & Singh, M. (2021) Pan evaporation and sensor based approaches of irrigation scheduling for crop water requirement, growth and yield of okra, *Journal of Agrometeorology, 23(4)*, 389-395, https://doi.org/10.54386/jam.v23i4.142

[23] O'Shaughnessy, S., Andrade, M., Colaizzi, P., Workneh, F., Rush, C., Evett, S., … & Kim, M. (2020) Irrigation management of potatoes using sensor feedback: Texas high plains, *Transactions of the Asabe, 63*(5), 1259-1276, https://doi.org/10.13031/trans.13925

[24] Munyaradzi, M., Hapanyengwi, G., Masocha, M., Mutandwa, E., Raeth, P., Nyambo, B., … & Mashonjowa, E. (2022) Precision irrigation scheduling based on wireless soil moisture sensors to improve water use efficiency and yield for winter wheat in sub-Saharan Africa, *Advances in Agriculture*, *2022*, 1-11, https://doi.org/10.1155/2022/8820764

[25] Thorp, K. (2023) Combining soil water content data with computer simulation models for improved irrigation scheduling, *Journal of the Asabe,* 66(5), 1265-1279, https://doi.org/10.13031/ja.15591

[26] Al-Ghobari, H. (2014) The assessment of automatic irrigation scheduling techniques on tomato yield and water productivity under a subsurface drip irrigation system in a hyper arid region, *185*, 55-66, https://doi.org/10.2495/si140061

[27] Jerapat, S., & Siriphanich, J. (2008) Effect of irrigation on dry matter of durian pulp cv. Monthong. *Acta Horticulturae*, *768*, 251–255, https://doi.org/10.17660/actahortic.2008.768.31

[28] Hiranpradit, H., Lee-ungulasatian, N., Chandraparnik, S., & Jantrajoo, S. (1992) Quality standardization of Thai durian, Durio zibethinus murr. *Acta Horticulturae*, 321, 695–704, https://doi.org/10.17660/actahortic.1992.321.86

[29] Allen, R. G., Pruitt, W. O., Wright, J. L., Howell, T. A., Ventura, F., Snyder, R., … Elliott, R. (2006), A recommendation on standardized surface resistance for hourly calculation of reference $ET_0$ by the FAO56 Penman-Monteith method, *Agricultural Water Management*, *81(1-2)*, 1–22, https://doi.org/10.1016/j.agwat.2005.03.007

[30] Rosli, M. A. M., & Ash'aari, Z. H. (2023) Analysis of trends in extreme temperature indices over selected areas in Peninsular Malaysia from 1991-2020, In *IOP Conference Series: Earth and Environmental Science*, *1167(1)*, 012008, https://doi.org/10.1088/1755-1315/1167/1/012008

[31] Colston, J. M., Ahmed, T., Mahopo, C., Kang, G., Kosek, M., de Sousa Junior, F., Shrestha, P.S., Svensen, E., Turab, A., & Zaitchik, B. (2018) Evaluating meteorological data from weather stations, and from satellites and global models for a multi-site epidemiological study, *Environmental research*, *165*, 91-109, https://doi.org/10.1016/j.envres.2018.02.027

[32] Acquaotta, F., Fratianni, S., Aguilar, E., & Fortin, G. (2019) Influence of instrumentation on long temperature time series, *Climatic Change*, *156*, 385-404, https://doi.org/10.1007/s10584-019-02545-z

[33] Fazlil Ilahi, W. F., Rosdi, N. S. I., Zulkapli, M. F., Che' Ya, N. N., Mat Su, A. S., Ping, T. N., Ramlee, S. I., & Hock, O. C. (2024) Growth performance of durian based on crop water requirement (ETc) using irrigation system. *Journal of Tropical Resources and Sustainable Science (JTRSS)*, *12(1)*, 51–56, https://doi.org/10.47253/jtrss.v12i1.1365