University of Tehran Press

Online ISSN: 2345-475X

DESERT

Home page: https://jdesert.ut.ac.ir/

Development and Introduction of AgriAide Software, a Tool for Reference Evapotranspiration Calculation

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Article Info.

Article type:
Research Article

Article history:
Received: 04 May 2026
Received in revised from: 22 Jun. 2026
Accepted: 25 Jun. 2026
Published online: 27 Jun. 2026

Keywords:
AgriAide Software,
ERA5,
Reference Evapotranspiration,
Water Consumption,
Meteorological Data.

ABSTRACT

Countries with arid and semi-arid climates face the dual challenge of water scarcity and increasing food demand. One of the key parameters for addressing this challenge is reference evapotranspiration (RET). Numerous methods, ranging from empirical equations to machine learning algorithms, have been developed for RET estimation. However, these methods often require considerable expertise and access to meteorological data, limiting their widespread application and reducing the adoption of up-to-date approaches in water resources management. Therefore, this study developed AgriAide, a software tool capable of generating long-term daily RET data for regions lacking meteorological stations or complete weather records without requiring any user-provided input data. The software calculates RET based on the FAO-56 Penman–Monteith equation using the ERA5 reanalysis dataset for a 20-year period and provides the results through a simple and user-friendly interface. To evaluate its performance, RET estimates were compared with station-based calculations from 16 meteorological stations using standard statistical indicators. The results showed excellent agreement between the software outputs and the reference values, with coefficients of determination (R^2) greater than 0.90 and normalized root mean square error (nRMSE) values below 20% for most stations. These findings demonstrate that AgriAide provides reliable RET estimates and can be confidently applied in regions where meteorological stations are unavailable or where weather records are incomplete for applications such as irrigation management, hydrological studies, drought monitoring, and water resources management.

Cite this article: Barideh, R., Nasimi, F. (2026). Development and Introduction of AgriAide Software, a Tool for Reference Evapotranspiration Calculation. DESERT, 31 (1), DOI: 10.22059/jdesert.2026.108264

DOI: 10.22059/jdesert.2026.108264

Publisher: University of Tehran Press

1. Introduction

The management of water resources stands as one of the most pressing challenges for societies across the globe. With a growing global population and declining water availability, the issue of water scarcity has become particularly severe in semi-arid and arid regions. At the same time, the increasing need to produce sufficient food for the expanding population has led to a significant rise in water usage within the agricultural sector. In this context, accurately estimating the water requirements for agriculture becomes essential, and it depends heavily on the precise calculation of reference evapotranspiration (RET). RET is not only fundamental for effective water resource management but also plays a critical role in monitoring drought conditions (Dong *et al*., 2023; Golian *et al*., 2019), managing groundwater resources, and understanding the water cycle (Allen *et al*., 2007; Carrillo-Rojas *et al*., 2016).

Several approaches are employed to estimate agricultural water requirements, including both direct and indirect methods. Direct methods, such as lysimeter experiments, often face challenges related to high costs and technical complexities, making them impractical in many cases (Barideh *et al*., 2022). As a result, mathematical equations are widely regarded as a more practical alternative. Among these, equations like Hargreaves-Samani, FAO Penman-Monteith (FPM), Makkink, Turc, Priestley-Taylor, and Blaney-Criddle have been developed for reference evapotranspiration estimation. Extensive research has demonstrated that the FPM equation is the most precise and reliable method for estimating reference evapotranspiration (Jeon *et al*., 2019; Sabanci *et al*., 2023; Trajkovic & Kolakovic, 2009; Veysi *et al*., 2024). However, the accuracy of these equations heavily depends on the availability of precise meteorological data, which is not consistently accessible in all regions, potentially impacting the reliability of these models.

With advancements in technology, a range of software tools such as CROPWAT, RET-ET and ET-calculator have been developed for estimating reference evapotranspiration. These programs allow users to calculate reference evapotranspiration or crop water requirements by providing the necessary meteorological and plant-related inputs (Desta *et al*., 2017; Rajavel *et al*., 2022; Rao* *et al*., 2020). In addition, machine learning techniques have recently gained prominence as an alternative approach for estimating reference evapotranspiration (da Silva Júnior *et al*., 2019; Gong *et al*., 2021). Despite their potential, using these software tools and methods can be challenging, as they require familiarity with different data formats, computational processes, and access to a variety of meteorological data.

A significant challenge in estimating reference evapotranspiration and agricultural water requirements is the limited availability of meteorological stations in rural and agricultural areas. Most stations are situated in urban regions, which can result in inaccurate assessments of water needs due to their distance from farmlands and the impact of urban factors such as industrial emissions, vehicular pollution, and extensive concrete surfaces. To overcome this limitation, various approaches, including averaging, regression analysis, and geostatistical techniques like kriging, co-kriging, and inverse distance weighting, have been utilized in recent years (Barideh *et al*., 2022; Gentilucci *et al*., 2021; Kamali *et al*., 2015).

Over the past few decades, numerous research efforts have focused on estimating reference evapotranspiration using various datasets, including MERRA (Modern-Era Retrospective analysis for Research and Applications), ECMWF (European Centre for Medium-Range Weather Forecasts), GLDAS (Global Land Data Assimilation System), and others. Among these, the ECMWF database has consistently demonstrated superior accuracy in comparison to other sources (Park & Choi, 2015; Pelosi *et al*., 2021; Veysi *et al*., 2024). ERA5, the fifth-generation reanalysis dataset from the European Centre for Medium-Range Weather Forecasts

(ECMWF), offers hourly data on atmospheric conditions, ocean waves, and land surface variables, covering a period of 4 to 7 decades.

Despite the availability of various methods and software packages for estimating reference evapotranspiration (RET), many existing tools require users to provide complete meteorological data or possess sufficient technical expertise, which may limit their applicability in data-scarce regions. Therefore, there remains a need for a simple and accessible tool capable of estimating RET using minimal user input. To address this need, the present study introduces AgriAide, a desktop application designed to estimate long-term daily RET for any location using only its geographic coordinates. The software integrates long-term meteorological data from global databases with the FAO Penman–Monteith equation to estimate RET without requiring local meteorological observations. In addition, it supports batch processing for multiple locations and enables users to compare RET estimates with calculations based on user-provided meteorological data. The software is freely available at www. rahmanbarideh.blogfa.com

2. Materials and methods

2.1. Study Area

Iran, covering an area of approximately 1.65 million square kilometers, is situated in southwestern Asia between latitudes 24° to 40° N and longitudes 44° to 64° E (Fig. 1). The country exhibits considerable climatic heterogeneity, ranging from hyper-arid and arid conditions in the central and eastern regions to temperate and humid climates in the northern and western parts. The national average annual precipitation is approximately 250 mm, which is less than one-third of the global mean. Nevertheless, spatial and temporal variations in precipitation are pronounced, with values ranging from less than 50 mm in the central desert regions to over 1800 mm in parts of the northern highlands. In parallel with precipitation variability, reference evapotranspiration (ET_0) also displays substantial spatial diversity, fluctuating from about 800 mm in the humid northern areas to more than 3500 mm per year in the southern, central, and southeastern regions. Approximately 12% of the country's land area is classified as agricultural, of which about half is irrigated and the remainder is rainfed (Modaresi & Araghi, 2023; Zolfaghari *et al*., 2025).

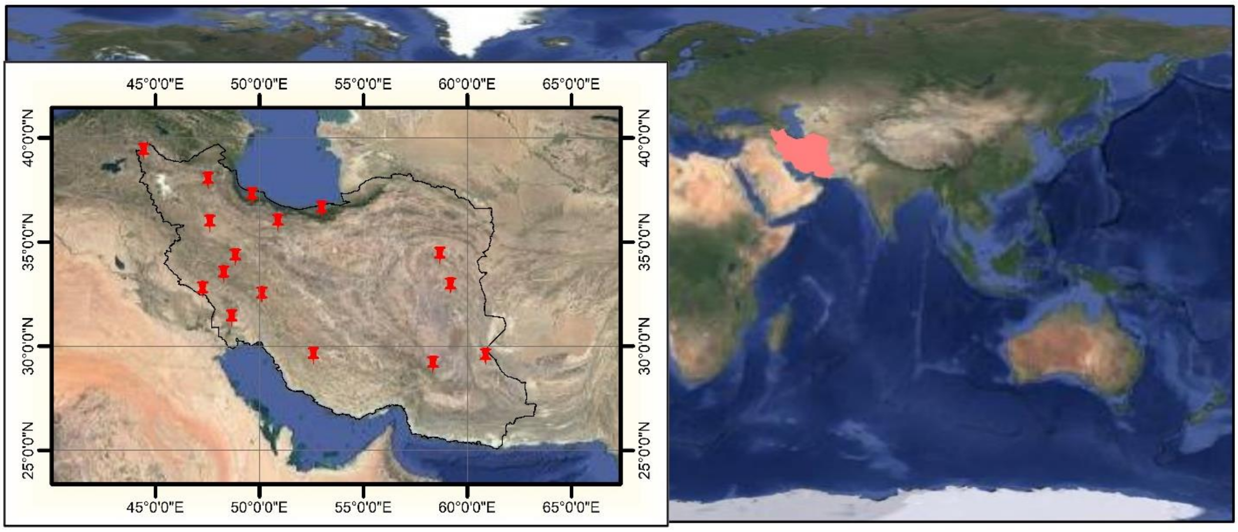

Figure 1. Geographical locations of the study area

2.2. Introduction to AgriAide Software

AgriAide is a portable software (no installation required) developed based on Python (https://www.python.org/). Its current version is designed for extracting and calculating reference evapotranspiration (RET). The primary goal of this software is to simplify the complex steps of calculating RET. Thus, the user can access a 20-year (2004-2024) daily time series of RET by simply entering the coordinates of their desired location. Currently, this software covers Iran with an area of 165 million hectares. In addition to providing a daily RET time series at each point, it allows the user to visualize daily RET (in the software coverage area) as an image for any date. Furthermore, this software can calculate RET based on station data and the FAO Penman-Monteith equation. In other words, if the user has meteorological data, they can calculate reference evapotranspiration and compare it with the values provided by the software on a daily and monthly basis. Another feature of this software is the simultaneous calculation of the RET time series for a large number of points. This means the user can extract the RET time series simultaneously for a large number of locations. The outputs of this software are provided to the user in Excel files. Figure (2) shows an overview of the software and some of its outputs.

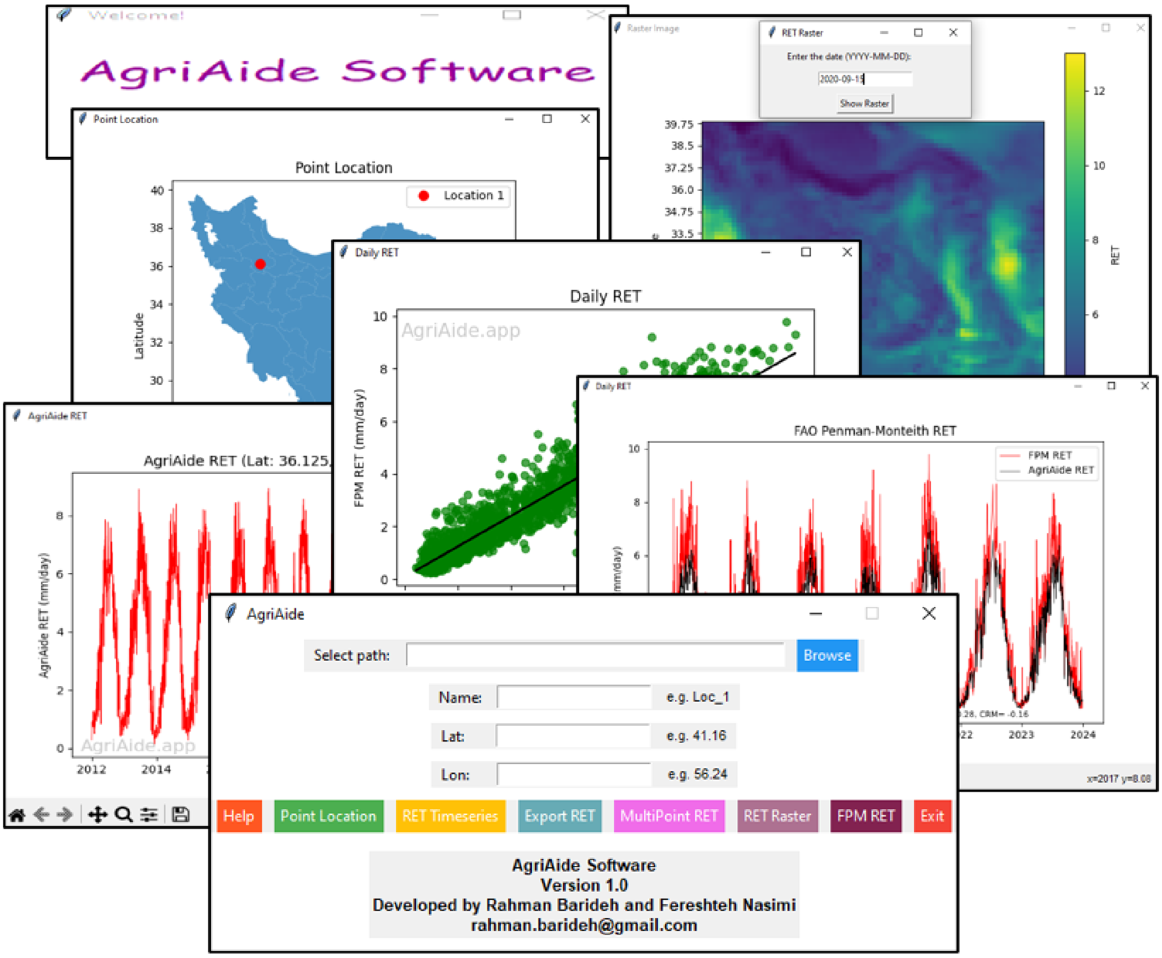

Figure 2. AgriAide Software Interface and Some of Its Outputs

2.3. Reference Evapotranspiration

In the AgriAide software, the FAO Penman-Monteith equation (Equation 1) and ERA5 dataset are utilized to generate reference evapotranspiration. The necessary data for calculating RET over 20 years were extracted hourly for Iran, and then daily RET was computed. The ERA5 reanalysis data have a spatial resolution of 0.25 degrees.

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

Where RET is the reference evapotranspiration [mm day^{-1}], G is the soil heat flux density [MJ m^{-2} day^{-1}], Rn is the net radiation at the crop surface [MJ m^{-2} day^{-1}], u_2 is the wind speed at 2 m height [m s^{-1}], e_s is the saturation vapor pressure [kPa], T is the mean daily air temperature at 2 m height [°C], e_a is the actual vapor pressure [kPa], γ is the psychrometric constant [kPa °C^{-1}], Δ is the slope of vapor pressure curve [kPa °C^{-1}], Ra is the daily extraterrestrial radiation [mm d^{-1}] and Rs is the total solar radiation [MJ m^{-2} day^{-1}].

Δ was calculated using Equation 2, which used the daily mean temperature. Additionally, Equations 3 through 6 were utilized to compute actual and saturated vapor pressures. In these equations, the minimum and maximum relative humidity as well as the minimum and maximum temperature were used.

$$\Delta = \frac{4098\left(0.6108\, e^{\left(\frac{17.27T}{T + 237.3}\right)}\right)}{(T\ +\ 237.3)^2} \quad (2)$$

$$e_a = \frac{e^0(T_{min})\frac{RH_{max}}{100} + e^0(T_{max})\frac{RH_{min}}{100}}{2} \quad (3)$$

$$e_s = \frac{e^0(T_{min}) + e^0(T_{max})}{2} \quad (4)$$

$$e^0(T_{min}) = 0.6108\, e^{\left(\frac{17.27T_{min}}{T_{\,min} + 237.3}\right)} \quad (5)$$

$$e^0(T_{max}) = 0.6108\, e^{\left(\frac{17.27T_{max}}{T_{\,max} + 237.3}\right)} \quad (6)$$

γ was determined using Equation 7, which considers atmospheric pressure. The calculation of Rn was carried out using Equations 8 through 10, which used solar radiation (Rs), clear-sky solar radiation (Rso), and albedo.

$$\gamma = 0.665 \times 10^{-3} P \quad (7)$$

$$Rn\ =\ Rns\ -\ Rnl \quad (8)$$

$$Rns\ =\ (1\ -\ \alpha)\ Rs \quad (9)$$

$$Rnl = \sigma\left[\frac{T_{maxK^4} + T_{minK^4}}{2}\right]\left(0.34 - 0.14\sqrt{e_a}\right)\left(1.35\frac{R_s}{R_{so}} - 0.35\right) \tag{10}$$

2.4. Database Selection

Barideh *et al.* (2022) investigated how meteorological variables influence reference evapotranspiration (RET)(Barideh *et al.*, 2022). Their research highlighted that the maximum temperature plays the most critical role in affecting RET, with a 20% variation in maximum temperature leading to an 8% change in RET. Other significant factors included sunshine hours, wind speed, and minimum temperature. In contrast, minimum and maximum relative humidity showed the least impact on RET fluctuations. The study's results are summarized in Figure 3.

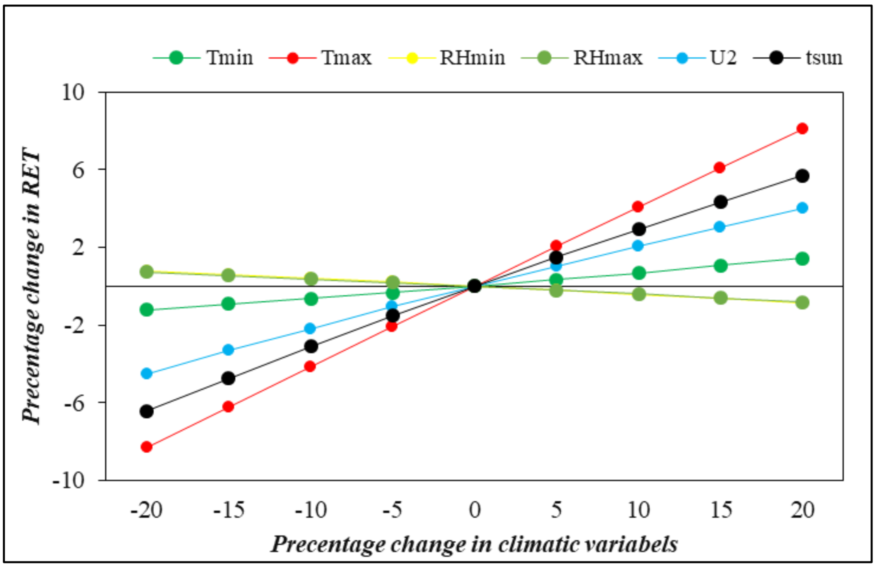

Figure 3. Percentage of Changes in Reference Evapotranspiration Relative to Changes in Meteorological Variables within the Range of ±20% (Barideh *et al.*, 2022)

To improve the precision of RET estimations, it is essential to use a dataset with the highest accuracy for these variables. Accordingly, Barideh and Nasimi (2024) selected three datasets (including CFSv2 (Climate Forecast System Version 2), developed by NCEP (NOAA's National Centers for Environmental Prediction), is a fully integrated model capturing interactions among the Earth's oceans, land, and atmosphere. This model generates four daily control runs. CFSv2 data have been available since April 1, 2011, with a spatial resolution of 0.2 degrees[1], ERA5, the fifth-generation reanalysis dataset from the ECMWF (European Centre for Medium-Range Weather Forecasts), offers comprehensive hourly estimates of atmospheric, oceanic, and land surface variables. ERA5 features a spatial resolution of 0.25 degrees and a temporal resolution of one hour[2], and NASA's Goddard Space Flight Center provides the second version of the MERRA reanalysis dataset, known as MERRA2. Built upon the GEOS-5 model and the DAS (Data Assimilation System), MERRA2 delivers precise long-term analyses of weather conditions. By integrating irregular spatial and temporal observations,

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[1] www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ncdc:C00877
[2] https://cds.climate.copernicus.eu/datasets

MERRA2 offers gridded datasets with a spatial resolution of 0.5° x 0.625°, updated daily[3]) containing the required variables and assessed their reliability in providing the meteorological factors influencing RET (Barideh & Nasimi, 2024). To identify the most suitable dataset, they utilized a ranking system based on evaluation indices. Long-term data from 24 synoptic stations were collected and analyzed for this purpose. The overall rankings for ERA5, CFSv2, and MERRA2 were 19, 25, and 37, respectively. Based on these results, they concluded that ERA5 is the most accurate dataset among the three and this dataset could be used with confidence (Barideh & Nasimi, 2024). Consequently, the AgriAide software utilized this dataset for its calculations. Other research has also validated the reliability of this dataset (Fatolahzadeh Gheysari *et al*., 2024; Hou *et al*., 2023; Pelosi *et al*., 2020, 2021; Veysi *et al*., 2024).

2.5. Software Evaluation

To evaluate the software outputs, the data required for calculating reference evapotranspiration were collected from 16 synoptic stations within the study area (Figure 1). Then, the RET was calculated using the FAO Penman-Monteith (Equation 1). Additionally, the time series of RET generated by the software for these stations was prepared. Finally, the outputs were compared, and the accuracy of the generated data was assessed using statistical indicators.

2.6. Evaluation indexes

The results were evaluated using the following statistical indices

$$\mathrm{R}^2 = 1 - \frac{\sum_{\mathrm{i=1}}^{\mathrm{n}} (\mathrm{O_i} - \mathrm{P_i})^2}{\sum_{\mathrm{i=1}}^{\mathrm{n}} \left(\mathrm{O_i} - \overline{\mathrm{O}}\right)^2} \tag{11}$$

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{\mathrm{i=1}}^{\mathrm{n}} (\mathrm{O_i}\text{-}\mathrm{P_i})^2}{\mathrm{n}}} \tag{12}$$

$$\mathrm{nRMSE} = \frac{\mathrm{RMSE}}{\overline{\mathrm{O}}} \tag{13}$$

$$CRM = \frac{\sum_{\mathrm{i=1}}^{\mathrm{n}} P_i - \sum_{\mathrm{i=1}}^{\mathrm{n}} O_i}{\sum_{\mathrm{i=1}}^{\mathrm{n}} O_i} \tag{14}$$

In this context, n denotes the total number of data points, Oi represents observed values, Pi indicates predicted values, and Ō is the average of the observed data. The root mean square error (RMSE (L T^{-1})); measures the divergence between observed and predicted values. The coefficient of determination (R^2 (-)) evaluates how well the data trend is represented, with values closer to one indicating higher accuracy in capturing the variable trends of the database. The coefficient of residual mass (CRM (-)) assesses whether the model overestimates or underestimates the data. A CRM value of zero implies perfect agreement between the database and observed values, while positive values suggest overestimation, and negative values indicate underestimation. The normalized RMSE (nRMSE (-)) reflects the quality of the database variables. An nRMSE value below 0.1 is ideal, while values ranging from 0.1 to 0.2 and 0.2 to 0.3 signify good and moderate reliability, respectively. Values exceeding 0.3 indicate significant uncertainty in the model (Andarzian *et al*., 2011; Barideh *et al*., 2022; Geshnigani *et al*., 2021).

[3] https://gmao.gsfc.nasa.gov/gmao-products/merra-2/

3. Results and Discussion

3.1. Software Guide

The main window of AgriAide software is shown in Figure 4. The descriptions of each object in this window are as follows.

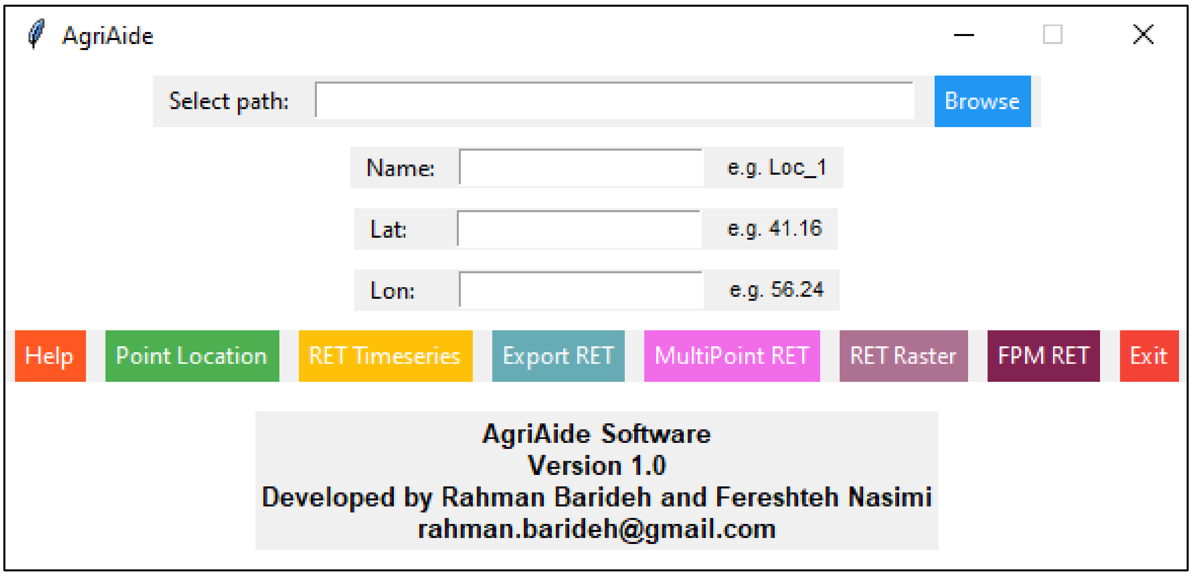


Figure 4. Main Window of AgriAide Software

Select path: To use this software, you must use the browse button to select the desired data folder. Currently, there are one data folder named IR_Data, corresponding to Iran.

Name: This field is optional and is used to specify the name of the desired location in the outputs.

Lat: In this field, the geographical latitude coordinates of the desired point are entered in decimal degrees.

Lon: In this field, the geographical longitude coordinates of the desired point are entered in decimal degrees.

Help Button: Clicking on this button opens the user guide for using this software.

Point Location: This button helps the user ensure the accuracy of the entered coordinates in the two fields of latitude and longitude. It does so by displaying the entered coordinates as a point on the border of the selected area.

RET Tim series Button: Clicking on this button displays the daily reference evapotranspiration time series for a 20-year period for the entered coordinates.

Export RET Button: Clicking on this button saves the daily reference evapotranspiration for a 20-year period for the entered coordinates as an Excel file for the user.

MultiPoint RET Button: This button allows the user to obtain the daily reference evapotranspiration time series as an Excel file for a large number of coordinates. To use this button, the coordinates of the desired points must be entered in the multiPoint.csv file. This file is available in all folders accompanying this software.

RET Raster Button: Clicking on this button opens a window and prompts the user to enter a date, then displays the image of reference evapotranspiration for the selected area on the entered date.

FPM RET Button: This button is specifically designed to compute RET using meteorological data acquired from weather stations. The calculations are performed using the FAO Penman-Monteith equation. To utilize this button, it's necessary to input the required data into the RET_Data.csv file, which is included in all folders alongside this software. Additionally, this button provides a comparison between the RET calculated by the user and obtained from the software.

3.2. Example

Figure 5 shows the selection of the IR_Data folder related to Iran, along with the entry of coordinates for a specific point as an example. Clicking on the "Point Location" button brings up a window where users can verify the accuracy of the entered coordinates. Additionally, the bottom toolbar in the Point Location window provides tools for editing and saving the image.

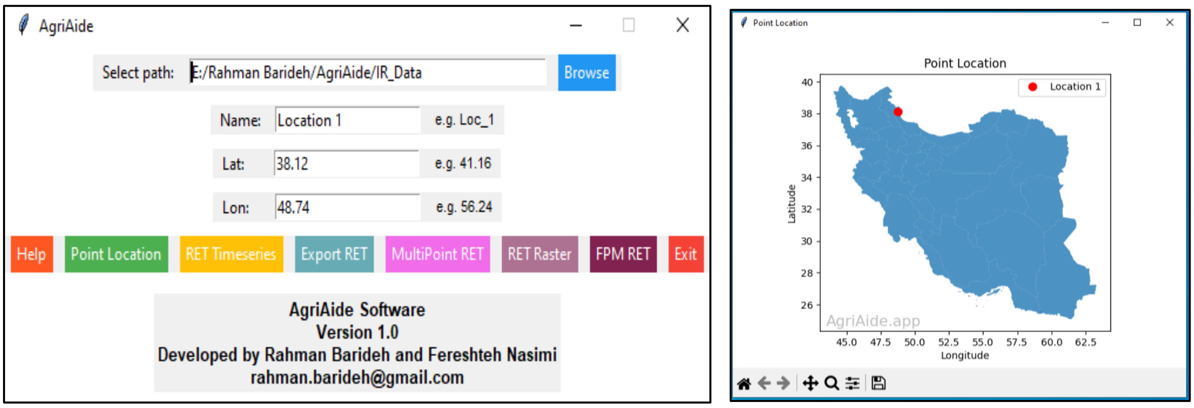


Figure 5. Data Entry and Display of the Point Location Window

In the next step, by clicking on the RET Timeseries button, a daily time series of reference evapotranspiration over a 20-year period for the entered coordinates will be displayed. The user can adjust the time range using the tools at the bottom of the window and then save it. Additionally, by hovering over the chart, the values of reference evapotranspiration and time are visible on the bottom right corner of the window (Figure 6). Furthermore, clicking on the Export RET button will save the reference evapotranspiration Excel file in the same folder with the name entered in the Name field.

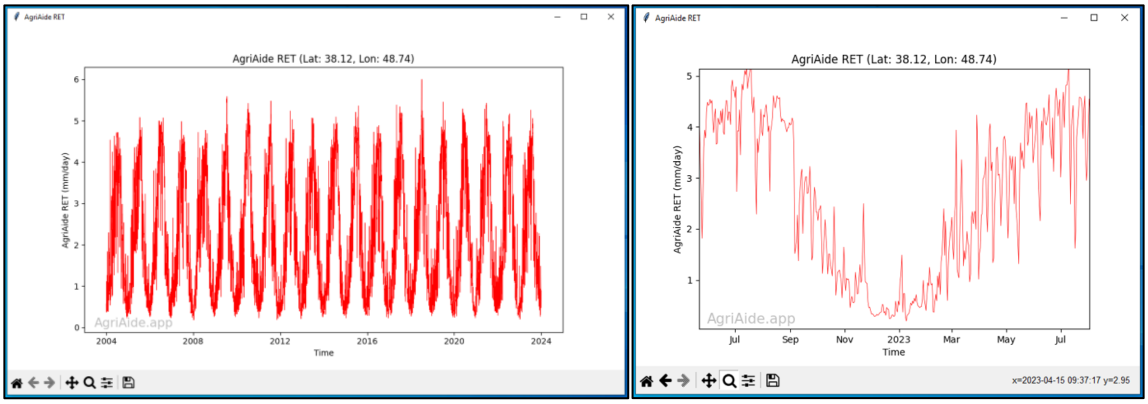


Figure 6. RET Time Series Window

To use the MultiPoint RET button, you first need to enter the coordinates of the desired points in the multiPoint.csv file. Then, by clicking on this button, the time series for all points will be saved as an Excel file in the same folder. Figure 7 illustrates how to enter the data and the software output. As can be seen, only the output for three points is saved because the coordinates for the fourth point were not entered completely.

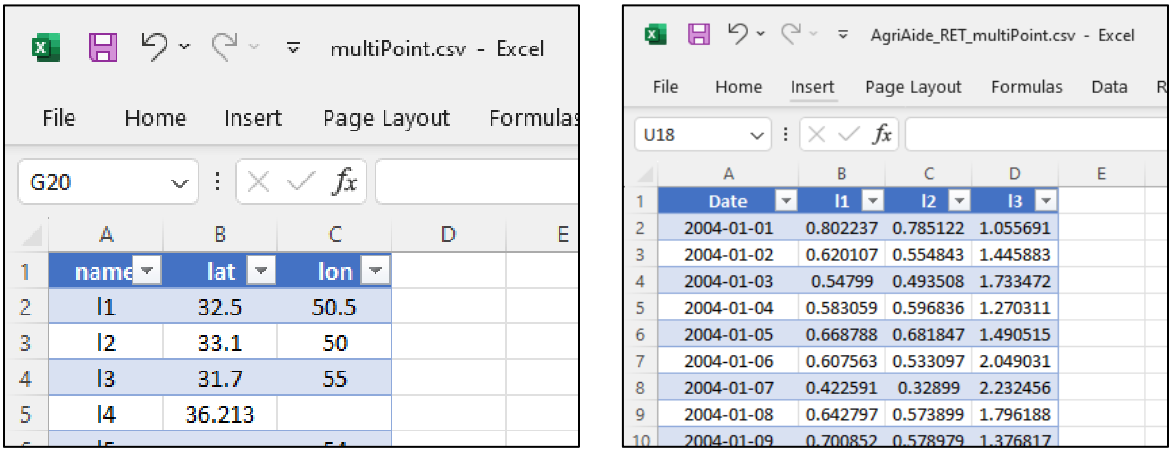


Figure 7. How to Enter Data and Output of the MultiPoint RET Button

By clicking on the RET Raster button, a window opens and prompts the user to enter the desired date. Then, it displays the image of the changes in reference evapotranspiration for the selected date across the entire chosen area (Figure 8). The user can select multiple dates simultaneously and view all the images at once.

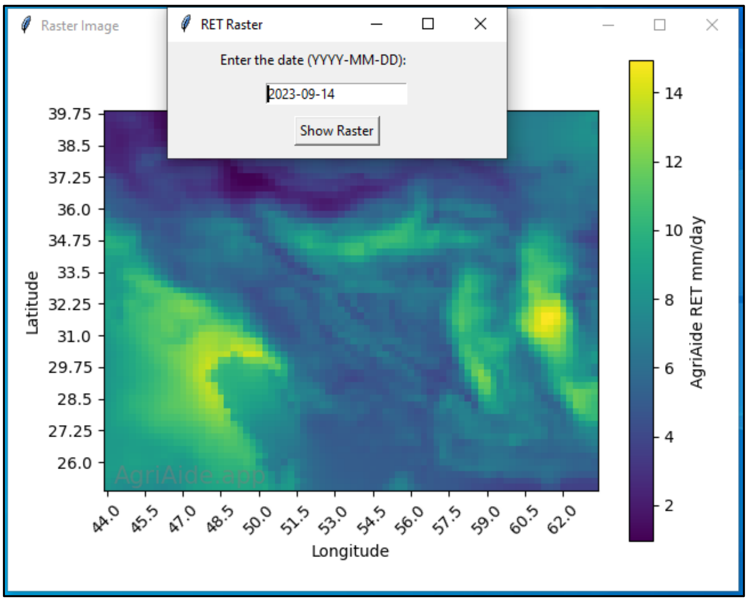
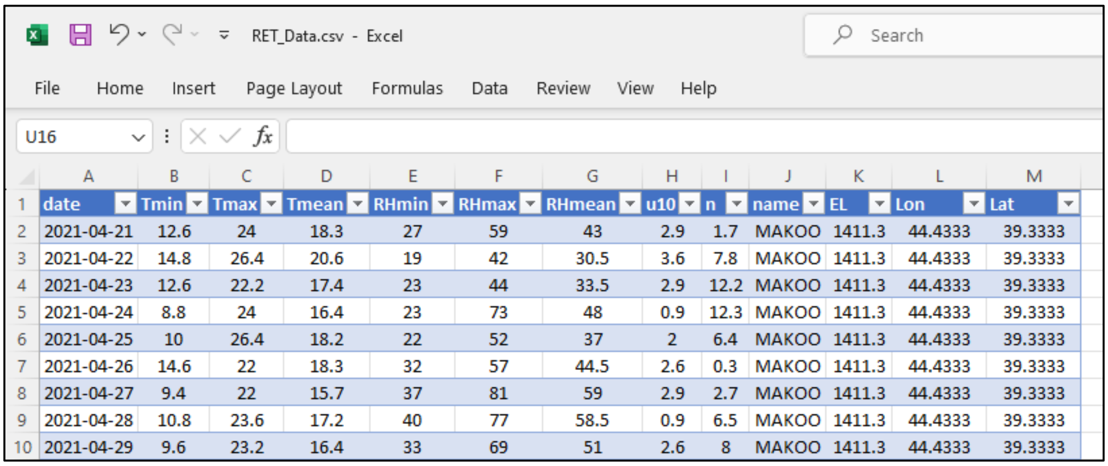


Figure 8. Display of the RET Raster Button Output

As mentioned, the FPM RET button is designed to calculate reference evapotranspiration based on meteorological data. To use this tool, first, the required information must be entered into the RET_Data.csv file. Then, by clicking on this button, reference evapotranspiration is calculated and saved in the same folder for the user (Figure 9).

The necessary meteorological data includes maximum, minimum, and average temperatures in degrees Celsius, maximum, minimum, and average relative humidity in percentage, wind speed at a height of 10 meters in meters per second, sunshine hours in hours, elevation in meters, and latitude and longitude in decimal degrees.



date	Tmin	Tmax	Tmean	RHmin	RHmax	RHmean	u10	n	name	EL	Lon	Lat
2021-04-21	12.6	24	18.3	27	59	43	2.9	1.7	MAKOO	1411.3	44.4333	39.3333
2021-04-22	14.8	26.4	20.6	19	42	30.5	3.6	7.8	MAKOO	1411.3	44.4333	39.3333
2021-04-23	12.6	22.2	17.4	23	44	33.5	2.9	12.2	MAKOO	1411.3	44.4333	39.3333
2021-04-24	8.8	24	16.4	23	73	48	0.9	12.3	MAKOO	1411.3	44.4333	39.3333
2021-04-25	10	26.4	18.2	22	52	37	2	6.4	MAKOO	1411.3	44.4333	39.3333
2021-04-26	14.6	22	18.3	32	57	44.5	2.6	0.3	MAKOO	1411.3	44.4333	39.3333
2021-04-27	9.4	22	15.7	37	81	59	2.9	2.7	MAKOO	1411.3	44.4333	39.3333
2021-04-28	10.8	23.6	17.2	40	77	58.5	0.9	6.5	MAKOO	1411.3	44.4333	39.3333
2021-04-29	9.6	23.2	16.4	33	69	51	2.6	8	MAKOO	1411.3	44.4333	39.3333

Figure 9. How to Enter Meteorological Data for Using the FPM RET Button

Additionally, the FPM RET button provides various windows for exploration in calculations. In the FAO Penman-Monteith RET window, it displays the time series of calculated reference evapotranspiration based on user data and generated by AgriAide, allowing the user to apply their desired corrective operations on it (Figure 10).

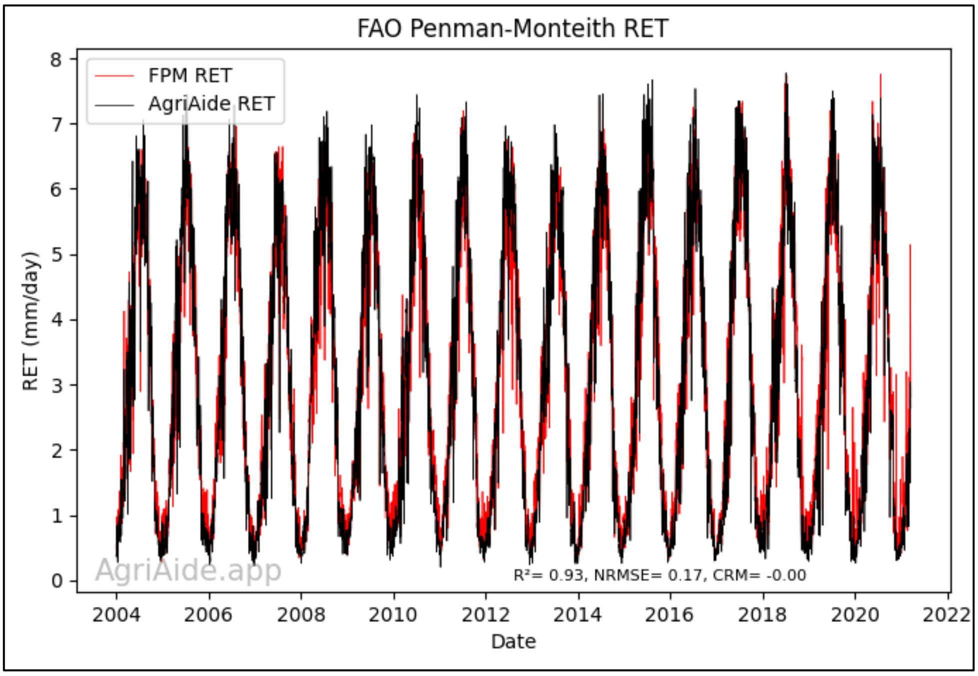


Figure 10. FAO Penman-Monteith RET Window

In the Daily RET and Monthly RET windows, statistical comparisons are made between the calculated reference evapotranspiration from user data and that generated by the software, and the statistical index values are displayed on the figure (Figure 11). It is worth mentioning that if user data falls outside the software's dataset time range, calculations will still be performed, but only the windows related to statistical indices will be displayed.

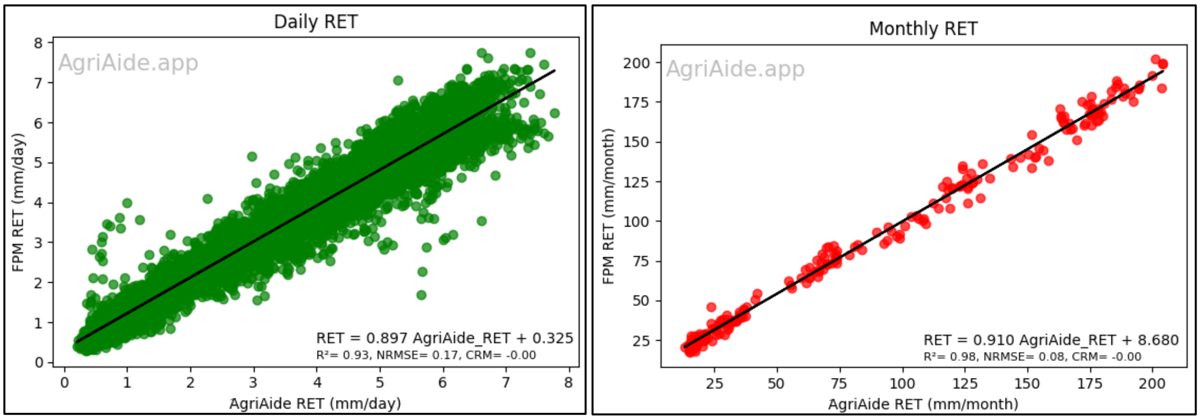


Figure 11. Daily RET and Monthly RET Windows

3.3. Software RET Evaluation

In Figure 12, the violin plot illustrates the distribution of daily reference evapotranspiration values (FPM RET) across the 16 stations under study. Ahvaz and Bam stations exhibit the highest evapotranspiration values due to their hot and arid climate, while Rasht and Sari stations display the lowest values, attributed to their humid climate and higher moisture levels. Data dispersion is more pronounced in stations such as Ahvaz and Dehloran, whereas a more uniform distribution is observed in stations like Rasht and Sari. The median values for most stations fall within the range of 3 to 6 mm per day.

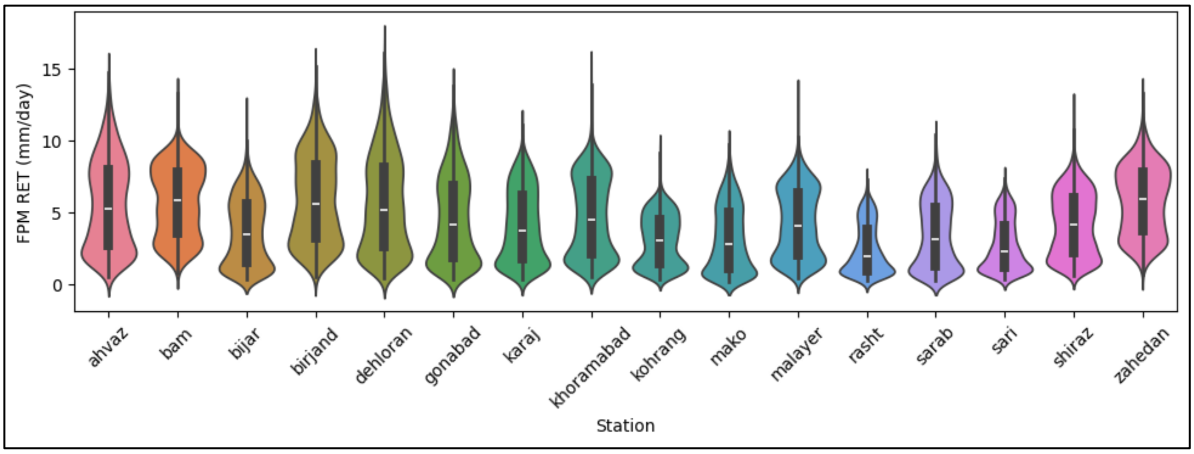


Figure 12. The violin plot of daily reference evapotranspiration (FPM RET) across the 16 stations under study

Table 1 presents the statistical evaluation of the reference evapotranspiration (RET) estimates obtained from the AgriAide across 16 synoptic stations in Iran, using R^2, RMSE, nRMSE, and CRM as performance metrics. The R^2 values indicate a strong agreement between the station and AgriAide RET for most stations, with Bijar, Dehloran, Kohrang, and Rasht showing the highest correlation ($R^2 > 0.95$), suggesting reliable AgriAide outputs in these regions. On the other hand, Bam and Khoramabad present relatively lower R^2 values (0.74 and 0.72, respectively), which could be attributed to local climatic variations. RMSE and nRMSE provide insights into the accuracy of the AgriAide RET, with the lowest errors observed in Dehloran (RMSE = 0.35 mm/day, nRMSE = 0.08) and the highest in Bijar and Khoramabad (RMSE = 1.35 mm/day, nRMSE = 0.28). The CRM highlights slight overestimation in Ahvaz (CRM = 0.15) and an underestimation in Khoramabad (-0.25). Overall, the AgriAide RET shows strong performance across a variety of climatic conditions, with observed differences due to regional environmental and climatic factors.

Barideh and Naseemi (2024) stated that underestimation or overestimation, as well as high nRMSE values, do not indicate incorrect RET calculated from ERA5 data. These discrepancies could be related to the pixel size of ERA5 data, as most weather stations are located in urban areas, where meteorological data is measured for a single point. In contrast, ERA5 provides the average meteorological information for an area of 900 square kilometres (Barideh & Nasimi, 2024). Therefore, it can be concluded that ERA5 data can be used with a high degree of confidence.

Table 1. The statistical evaluation of the reference evapotranspiration (RET) estimates obtained from the AgriAide across 16 synoptic stations in Iran

	ahvaz	bam	bijar	birjand	dehloran	gonabad	karaj	khoramabad	kohrang	mako	malayer	rasht	sarab	sari	shiraz	zahedan
R^2	0.86	0.74	0.97	0.75	0.96	0.98	0.74	0.72	0.97	0.91	0.91	0.98	0.85	0.98	0.96	0.90
RMSE	1.06	1.14	0.34	1.35	0.59	0.35	1.18	1.35	0.27	0.62	0.64	0.19	0.82	0.21	0.38	0.66
nRMSE	0.19	0.20	0.09	0.23	0.10	0.08	0.29	0.28	0.09	0.20	0.15	0.08	0.24	0.08	0.09	0.11
CRM	0.15	-0.19	0.01	-0.22	-0.07	-0.01	-0.26	-0.25	-0.03	-0.16	-0.14	0.03	-0.20	0.00	-0.05	-0.10

4. Conclusion

This study introduces software designed to generate long-term reference evapotranspiration (RET) without requiring input data. The primary goals of this research were to simplify the intricate process of RET calculation, provide access to long-term RET in the absence of meteorological data, and enable RET generation for regions lacking weather stations. The software utilizes ERA5 datasets to calculate RET for the period between 2004 and 2023, allowing users to obtain RET values by simply entering the coordinates of their desired location. Additionally, the software offers the flexibility to calculate RET based on user-provided data. AgriAide features a straightforward and user-friendly interface, streamlining the complexities associated with input data preparation and computational methods. The software’s outputs are applicable to drought monitoring, irrigation planning, hydrological studies, and water resource management. This software is available for free on (www. rahmanbarideh.blogfa.com).

Acknowledgments

The authors would like to thank all participants of the present study.

Authors Contribution

Conceptualization, R.B., F.N.; methodology, R.B., F.N.; software, R.B., F.N.; validation, R.B., F.N.; formal analysis, R.B.; investigation, R.B., F.N.; resources, R.B., F.N; data curation, R.B., F.N.; writing—original draft preparation, R.B.; writing—review and editing, R.B., F.N.; visualization, R.B.; supervision, R.B.; project administration, R.B., F.N.; funding acquisition, R.B. All authors have read and agreed to the published version of the manuscript.

Ethics approval and Consent to participate

The authors avoided from data fabrication and falsification.

Competing Interests

The authors declare no conflicts of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Consent for Publication

Not applicable.

Data Availability

The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials.

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