Study on development a tool for computing water equirement satisfaction index of crop and application to warning drought in An Giang province

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● **Abstract:** The report presents the use guidelines for computing crop water requirements of FAO to develop a Water Requirement Satisfaction Index (WRSI) tool for crops. This tool has been developed based on the platform of Microsoft Excel software, the programming language is Visual Basic. The results of applying this tool with meteorological data series in An Giang province shows that the level of water satisfaction of Dong Xuan rice crop is 28%, corn is 16%, while the Mua rice crop is 92%, corn is 98%. Therefore, it can be seen that the role of irrigation in the Dong Xuan crop is important. When using the WRSI tool with meteorological data daily, the need for irrigation to replace the shortage of rainfall can be determined, so drought can be warned. The WRSI tool is not only applicable in An Giang province but it can also be applied to other localities.

● **Key words:** WRSI, drought, Evapotranspiration, Crop

1. Introduntion

In the world, there are many authors studying drought. But due to the complexity of this phenomenon, there is not yet a common method for drought studies. In defining, identifying, monitoring and drought warning, the authors often use the main tool is the drought index.

Tracking change the value of the drought indices will help determine the starting time, duration and intensity of the drought.

In order to monitor and monitor drought, it is necessary to set up a specific process both qualitatively and quantitatively through indicators and indicators to be able to identify if a drought has occurred, drought is still continuing or has expired. And in an uncertain way, it could happen better or worse.

According to WMO, drought is divided into meteorological drought, hydrological drought, and agricultural drought. The Water Requirement Satisfaction Index (WRSI) can be considered an agricultural drought index because it is related to the humidity or water shortage of a crop which is an important feature used in the evaluation and monitoring of plant moisture. WRSI is an indicator of crop status based on the amount of water available to the crop during the growing season.

This report introduces the application of WRSI to the development of a informatics tools for drought warnings as well as the possibility of a good harvest or crop failure

2. Data and Methods

2.1. Data

Meteorological data: data by day of maximum, minimum air temperature, air humidity, sunhours, wind speed at Chau Doc station from 1986 – 2015 (30 years)

Information of soil profile at Cho Moi site (Vietnamese name: Dat phu sa song Cuu Long, glay. FAO-UNESCO name: Umbri-Gleyic FLUVISOLS)

Information on the growing stages and cultivation techniques of rice and maize varieties in An Giang

2.2. Methods

WRSI is the ratio of seasonal actual crop evapotranspiration (AET) to the seasonal crop water requirement

$$WRSI = (AET/WR) \cdot 100 \quad (1)$$

Where: WR is calculated from potential evaporation (PET) using crop factor to adjust according to crop growth stage:

$$WR = Kc \cdot PET \quad (2)$$

Where, Kc is the crop coefficient. Potential evapotranspiration (PET) was calculated by using FAO Penman – Monteith method [2]:

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + (1 + 0.34\ u_2)} \quad (3)$$

Actual crop evapotranspiration (AET) during the whole crop season is the actual evapotranspiration under actual non-standard conditions.

$$ETc = (Ks \cdot Kcb + Ke)\ ETo \quad (4)$$

In equation (4), Ks is the Water stress coefficient that represents the water shortage in the soil, it also represents the saline soil condition, which making soil water less available for plant root extraction. Kcb is basal crop coefficient that represents the transpiration component. Ke is soil evaporation coefficient that represents the evaporation component. The coefficients have a maximum value of 1 and are described in detail in FAO documents [2].

Table 1: Drought level classification and good harvest level according to the WRSI index.

Level	WRSI (%)	Decentralized term	Classification levels are seasonal
1	100	Water demand completely satisfied	Get the big harvest
2	95-99	Normal	Good harvest
3	81-94	Drought	Medium
4	61-80	Moderate Drought	Fair enough
5	51-60	Severe drought	Poor
6	< 50	Extreme Drought	Crop failure

In Vietnam, the WRSI was first applied in 2008 at the Viet Nam Institute of Meteorology, Hydrology and Climate Change, drought and the possibility of a good harvest are classified in Table 1

2.3. Technical

This tool is built on Microsoft Excel software to create interfaces and interact with the tool. The programming language is Visual Basic.

3. Results

3.1 WRSI tool

The main interface of the tool is presented in Figure 2. Users need to choose:The main interface of the tool is shown in Figure 1. The user can choose:

Station: each station needs a meteorological data series to calculate. The data series is updated regularly according to monitoring data or forecast data

Load and calculate: this is the main function of WRSI tool, it is only used when changing the data of the meteorological station and changing year.

Day, month, year: time to start planting. Or average data of many years to determine the time of the year is suitable for start planting

Type tree: In this study, initially only allows selection of 2 crops are rice and corn that have short to long growing period. When crops and other growing times are needed, the user needs to enter the crop type and the basic growth characteristics in another interface, which is related to the evaporation coefficient of the crop.

Land: selected soils suitable for local area

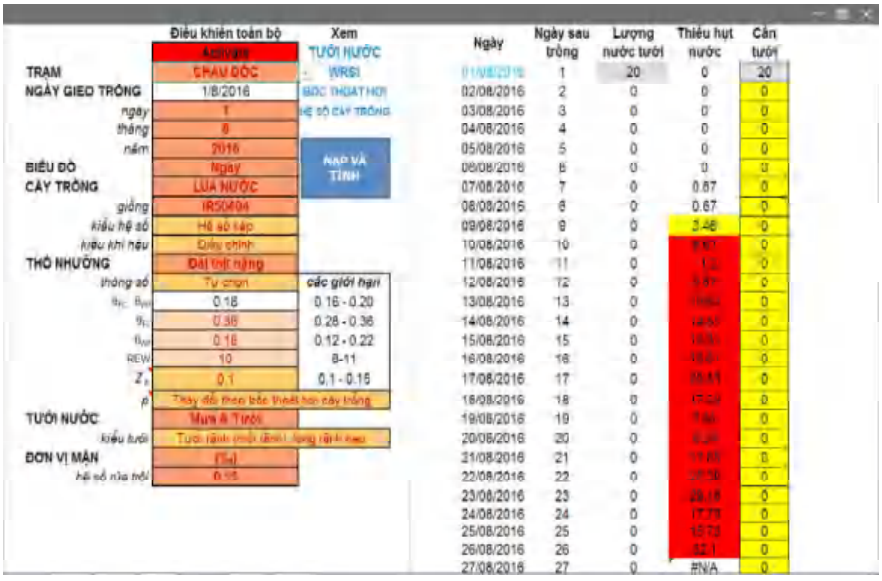

Figure 1: The interface of the WRSI tool on Excel

Sprinklers: Soil surface wetting by options such as absolutely dependent on rainfall or irrigation methods or rain and irrigation methods. If the rain and irrigation option is selected, the user can use "CC tưưs" column to add the amount of water (corresponding to the amount of rainfall) that crops need to grow normally.

Need irrigation: if an equal or greater amount of water is added to the "Thiin hhi" column, the result of the WRSI chart will change.

Salty unit: Unit for measuring salinity in soil. There are 2 options (dS/m) or (‰). If the soil is saline, enter the time of salinity and concentration at another interface.

The results of the WRSI tool are the following charts:

Chart of crop coefficients by growth stages (Figure 2). Crop coefficient according to the growth stage is provided by FAO, was experimental in standard conditions. When using coefficients at a specific local, it is necessary to adjust them to suit the climate in that region

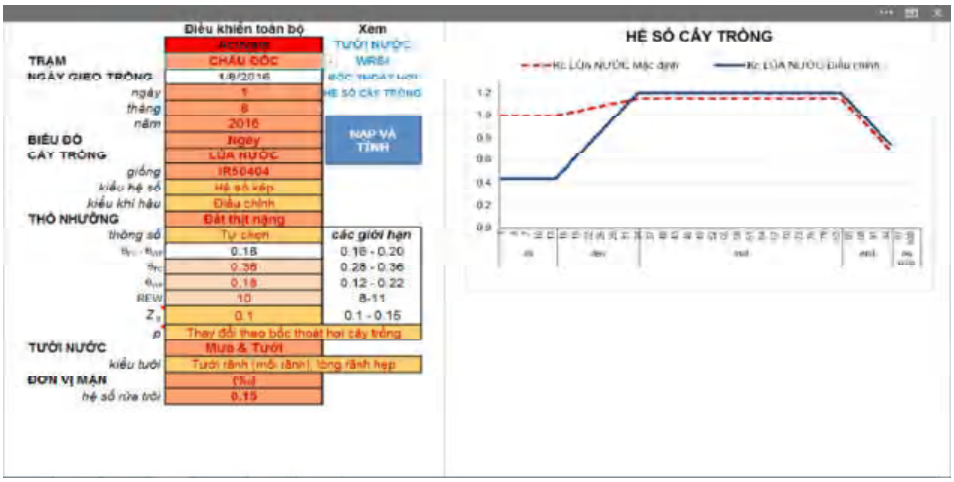

Figure 2: Crop coefficient (Rice) in Chau Doc station area

Chart of crop evapotranspiration includes: evapotranspiration and actual evapotranspiration, potential evaporation (Figure 3).

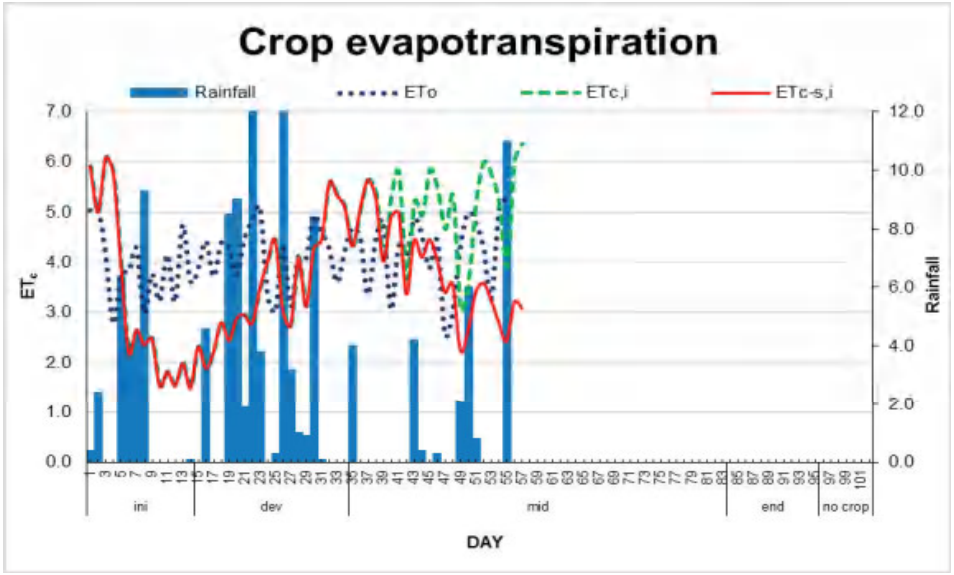

Figure 3: Crop evapotranspiration and rainfall during growing period

Chart of WRSI and rainfall by plant growth time (Figure 4). The WRSI index is getting smaller, the water demand of the crop not meeting the requirements in. According to Table 1 and the resulting graph can warn of water shortage due to drought and the possibility of crop yields falling. If there is no rain or not watering enough, there is a chance that the crop will fail.

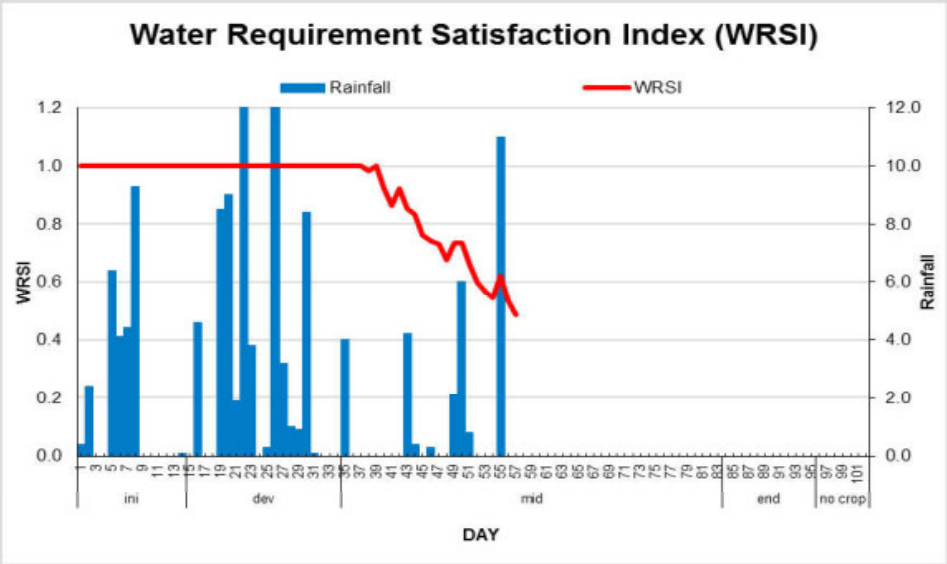

Figure 4: WRSI process results up to the date of the latest meteorological monitoring data

3.2. Application to warn of rice crop failure due to water shortage in An Giang

The calculation results of WRSI are based on actual evapotranspiration and annual evapotranspiration for weeks in 5 months per crop. The selected crop is rice and corn with a 150-day growth period.

In the Winter-Spring crop, sown from the first week of November (from 1 – 10 of November), harvested in the 15th week (21 – 31 of March), in 50% of the years (1 in 2 years), WRSI of rice and maize varieties group changed as follows:

- In the first 3 weeks of the crop (November), due to abundant

- Rainfall, the water demand of rice and corn are satisfied, from 100 – 93%.

- Starting from December onwards, due to the decrease of weekly rainfall towards the end of the crop, in the three weeks of December onwards, the satisfaction of water demand of rice and maize decreases, from 54 to 20%.

- In February the level of satisfaction of water demand of rice and corn is lowest, from 0 to 6% only.

- In March, the water satisfaction level of crop is better than in February.

- On average, in the whole crop, in 50% of the years, the satisfaction level of water demand of winter-spring rice is 28%, very low compared to the demand of rice, while that of corn is 16%. Therefore, the role of irrigation and desalination in the winter-spring crop is very important.

- In Summer-Autumn crop, the same group of rice and maize varieties, sown from first week of May (from 1 – 10 May) harvested in 15th week (from 21 – 30 of Septemper), WRSI of rice and maize varieties group changed as follows:

- In the first 3 weeks of the crop (May), due to abundant rainfall, the water demand of rice is satisfied, from 100 – 82%, of corn from 100 – 95%.

- In June, the satisfaction level of water demand of rice crop decreases, from 84% to 66%, of maize also decreases from 100% to 83%. In the 2nd week, it increased and increased to 83% in the 3rd week of the month.

- In the three main months of the rain season and whole of the Summer-Autumn rice crop, from July to September, the satisfaction level of water demand of rice is very high and quite stable, from 83 to 100%, while maize is almost is 100%.

- On average, in the whole season, in 50% of the years, the water demand satisfaction level of the rice group is 92%, of maize is 98% much higher and more stable than the weeks in the winter-spring crop.

4. Conclusion

Through a drought study in An Giang, the project has created the Water Requirement Satisfaction Index tool of crops. This is a tool that can be used by regulators to warn against drought as well as the possibility of good harvest or crop failure due to due to crop water shortages, particularly in the study of rice.

The use of this tool in An Giang shows that the water satisfaction level of Winter-Spring crop of rice is 28%, of maize is 16%. While that of Summer-Autumn crop of rice is 92%, of maize is 98%. The role of irrigation and desalination in the Winter-Spring crop is very important.

The WRSI tool is not only applied in An Giang province but it can also be applied to other provinces.

The tool was created to meet the purpose of research in An Giang. However, this tool is built on Excel software, so it has many limitations such as rudimentary interface, slow calculation speed. In the future, this tool will be developed into a separate software to better serve the needs of warnings

REFEREENCES

[1] Verdin, J., and R. Klaver, 2002: Grid-cell-based crop water accounting for the famine early warning system. Hydrol. Processes, 16, 1617–1630

[2] Allen R.G, L.S. Pereira, Dirk Raes and D and Smith.M (1998), Crop Evapotranspiration. Guidelines for computing crop water requirements FAO Irrigation and Drainage Paper No. 56. FAO, ROME.