APPLICATION TO CALCULATE POTENTIAL EVAPOTRANSPIRATION

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บทคัดย่อ— การคำนวณหาค่าปริมาณการใช้น้ำของพืช เป็นส่วนหนึ่งในการบริหารจัดการปริมาณน้ำต้นทุนกับการเพาะปลูกพืชของเกษตรกร เพื่อคาดการณ์ปริมาณน้ำว่าเพียงพอกับการเพาะปลูกพืชหรือไม่ และช่วยลดความเสียหายของเกษตรกรในการทำแผนรองรับ กรณีเกิดสภาวะภัยแล้งหรือฝนทิ้งช่วงได้ การคำนวณหาค่าปริมาณการใช้น้ำของพืชสามารถทำได้หลากหลายวิธี เช่น การตรวจวัดจากพืชโดยตรงใช้เครื่องมือ การคำนวณจากข้อมูลภูมิอากาศ เป็นต้น ผลลัพธ์ที่ได้มีค่าความถูกต้องใกล้เคียงความเป็นจริง เมื่อเป็นการคำนวณจากข้อมูลภูมิอากาศจะต้องใช้ข้อมูลภูมิอากาศในพื้นที่หลากหลายชนิดข้อมูล และมีต้องการปรับเทียบข้อมูล ดังนั้นในงานวิจัยนี้จึงนำเสนอแอพลิเคชันช่วยในการคำนวณหาค่าปริมาณการใช้น้ำของพืชอ้างอิง โดยใช้ข้อมูลจากสถานีตรวจวัดอากาศของกรมอุตุนิยมวิทยาทั่วประเทศไทย จำนวน 124 สถานี สามารถนำผลลัพธ์ที่ได้ไปใช้ในการคำนวณหาค่าความต้องการน้ำของพืชได้ พร้อมนำเสนอการคาดการณ์ค่าการคายระเหยของพืชในพื้นที่ต่างๆ สามารถทำการปรับค่าข้อมูลภูมิอากาศผ่านแอพลิเคชัน โดยใช้เครื่องมือที่มีการเปิดใช้งานฟรีในปัจจุบัน และมีความสามารถในการแชร์ให้กับผู้ใช้งานได้ง่าย โดยมีเพียงไม่กี่ขั้นตอน

คำสำคัญ: การคายระเหยของพืช, ความต้องการน้ำชลประทาน, สถานีตรวจวัดอากาศ, แอพลิเคชันการเกษตร

Abstract— The calculation of the water consumption of plants is a guideline to manage the amount of water and the cultivation of crops. There is enough water to grow the crop,is reduce damage to farmers can be supported when drought or rain drops. The calculation of water consumption of plants can be done in a variety of method such as plant measurements using a tool the calculation of the weather data, etc. The results have a close approximation of the calculated from the climate data, it will be required to use multi-area climate data and calibrate data. Therefore, this study offers an application for calculating the water consumption of the reference plants. Using 124 weather stations from Thailand's meteorological stations, the results can be used to calculate the water requirements of plants. Proposed evapotranspiration forecasts for different areas. Climate data can be manual update through the application and the evapotranspiration equation was recalculated. We use appsheet tool to create our application and connect our spreadsheet to compute evapotranspiration. It is can be calculate from the complex equation and easily to make application, easily to share the application to user.

Keywords- potential evapotranspiration, application, water management, appsheet

I. INTRODUCTION

The evapotranspiration is commonly used to describe two processes of water loss from land surface to atmosphere, evaporation and transpiration. Evaporation is the process where liquid water is converted to water vapor(vaporization) and removed from sources such as the soil surface, wet vegetation, pavement, water bodies, etc. Transpiration consists of the vaporization of liquid water within a plant and subsequent loss of water as vapor through leaf stomata. Evaporation and transpiration occur simultaneously and both processes depend on solar radiation, air temperature, relative humidity (i.e., vapor pressure deficit) and wind speed.

Z. Chen, et al.,[1] develop decision support system for water irrigation management base on WEBGIS. It solved the water shortage problem, can create the precision irrigation schemes, retrieval of water-saving irrigation mode, optimum irrigation schemes and guiding optimum irrigation for users in irrigation districts.

N. Watchrapong, et al.,[2] estimated potential evaporation by using data mining technique and had 3 climate change scenario: baseline condition 360 ppm, medium term future 540 ppm, long term future 720 ppm. That study was used to create on artificial neural network model and used climatic data from metrological department of Thailand during 1980 to 1989. Using compare Et from paddy fields.

W. Sarintorn, et al.,[3] create a prototype for of geographic information system based on appropriate irrigation decision.

It was ton solve the problem of water allocation without considering irrigation schedule. That research can computing crops water requirement and irrigation schedule of water allocation.

In the next section, introduce the evapotranspiration and spreadsheet. In section 3 is present proposed evapotranspiration calculation method. In section 4, conclusion and future study

II. RELATED WORK

A. *Evapotranspiration*

Evapotranspirationis the process of evaporation and transpiration from ocean to the atmosphere. Evaporation is rate of water to the air from sources such as the soil, canopy interception and water bodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves. Evapotranspiration is an important part of the water cycle[4]. The evapotranspiration valueuse to calculate water irrigation demand, using soil data, land use and agriculture data and data of weather stations Meteorological Department. Evapotranspiration can be estimated using several method, such as indirect method catchment water balance. The calculation of potential evapotranspiration is climate data at the time and place of experiment. That data is synthesis and divide period time with age plant or time to use. The equation for compute evapotranspiration have several such as modified pennman, Penman monteith, pan method.

The FAO Penman-monteith equation determines the evapotranspiration from the hypothetical grass reference surface and provides a standard to which evapotranspiration in different periods of the year or in other regions can be compared and to which the evapotranspiration from other crops can be related. Transpiration rate is also influenced by crop characteristics, environmental aspects, and cultivation practices. Different kinds of plants may have different transpiration rates. Not only the type of crop, but also the crop development, environment, and management should be considered when assessing transpiration. For example, when the crop is small, water is predominately lost by soil evaporation because little of the soil surface is covered by the plant, but once the crop is well developed and completely covers the soil, transpiration becomes the main process.Reference evapotranspiration (ETo) is defined as the rate at which readily available soil water is vaporized from specified vegetated surfaces. Then reference evapotranspiration is defined as the ET rate from a uniform surface of dense, actively growing vegetation having specified height and surface resistance, not short of soil water, and representing an expanse of at least 100 m. of the same or similar vegetation. The concept of the ETo was introduced to study the evaporative demand of the atmosphere independent of crop type, crop development, and management practices. If water is abundantly available at the reference surface, soil factors do not affect ET; however, ET may decrease overtime as soil water content decreases. Relating ET to a specific surface provides a reference to which ET from other surfaces can be related.

The evapotranspiration is based on the Penman monteith equation. The equation is as follows:

$$ET_p = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}U_2(e_s - e_a)}{\Delta + \gamma(1+0.34U_2)} \quad (1)$$

where

ET_p = evapotranspiration [mm./day],

R_n = net radiation at the crop surface [MJ/m^2/day],

G = soil heat flux density [MJ/m^2/day],

T = air temperature at 2 m. height [°C],

U_2 = wind speed at 2 m. height [m/s],

e_s = saturation vapour pressure [kPa],

e_a = actual vapour pressure [kPa],

Δ = slope vapour pressure curve [kPa/°C],

γ = psychrometric constant [kPa/°C].

$$R_n = R_{ns} - R_{nl} \quad (2)$$

where

R_{ns}=net solar or net shortwave radiation [MJ/m^2/day],

=0.77[0.25+0.50(n/N)]Ra

$R_a = 37.6\ dr(\omega_s*\sin\omega*\sin\delta + \cos\varphi*\cos\delta*\sin\omega_s)$[MJ/m^2/day]

$dr = 1+0.033*\cos(0.0172*J)$ [radian]

$J = int(30.42*M-15.23)$

$\varphi = 0.01745*(LTD+LTL/60)$ [radian]

$\delta = 0.409 \sin(0.0172*J - 1.39)$ [radian]

$\omega_s = \arccos(-\tan\omega * \tan\varphi*\tan\delta)$ [radian]

$N = 7.64\omega_s$ [hr./day]

$e°(T_{max}) = 0.6108 \exp(17.27*T_{max}/(T_{max} + 237.3))$ [kPa]

$e°(T_{min}) = 0.6108 \exp(17.27*T_{min}/(T_{min} + 237.3))$ [kPa]

$e_s = [e°(T_{max})+e°(T_{min})]/2$

R_{nl} = net outgoing long wave solar radiation [MJ/m^2/day]

$=2.45*10^{-9}[0.9*(n/N)+0.1]*(0.34-0.14*\square ea)*[(T_{max}+273)^4 +(T_{min}+273)^4]$

$$G = c_s(T_i+T_{i-1})/dt \approx 0 \quad (3)$$

$$\gamma = c_p P/\varepsilon\lambda = 0.00163P/\lambda \quad (4)$$

where

P = Atmosphere pressure[kPa],

λ = latent heat of vaporization[MJ/kg]

$= 2.501-(2.361*10^{-3})T$

$$U_2 = U(z)[4.87/\ln(67.8z - 5.42)] \quad (5)$$

where

U_z=wind speed at z m. height [m/s],

Z=Height of wind speed [m.]

MJ/m^2/day

$\Delta = 4098*e_s/(T+237.3)^2$ [kPa/° C]

$P = 101.3[(273+T_{mean})-(0.0065*Z)/(273+T_{mean})]^{5.26}$

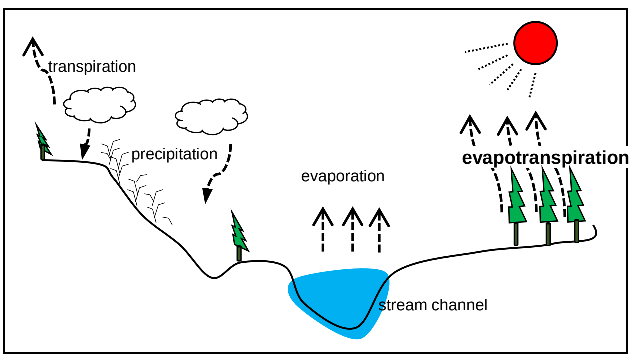


Figure 1. Water cycle showed evapotranspiration process.

Location: Altitude above sea level (m) and latitude (degrees north or south) of the location should be specified. These data are needed to adjust some weather parameters for the local average value of atmospheric pressure (a function of the site elevation above mean sea level) and to compute extraterrestrial radiation (Ra) and, in some cases, daylight hours (N). In the calculation procedures for Ra and N, the latitude is expressed in radian (i.e., decimal degrees times p /180).

The input data can be found in The Thai Meteorological Department [6], The Department of Water Resources [7] and The Royal Irrigation Department [8]

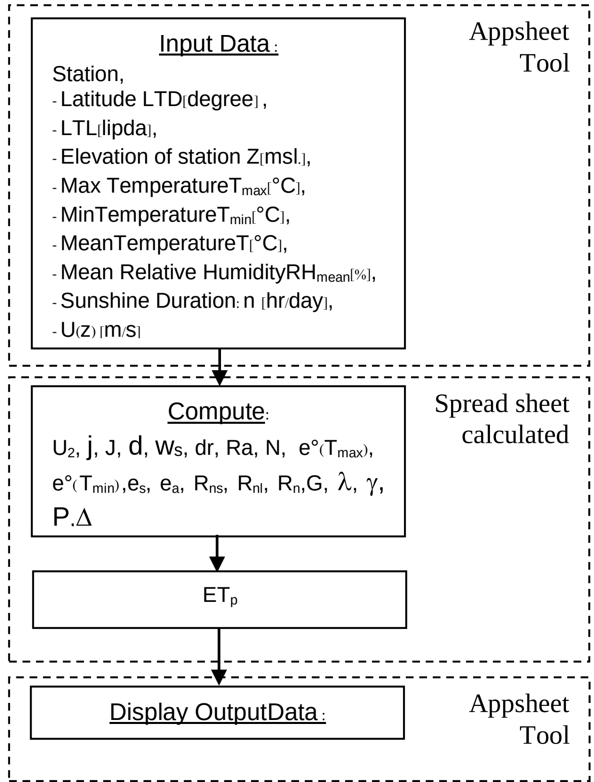


Figure 2. Evapotranspiration by Penman Monteith equation calculated process.

Temperature: The (average) daily maximum and minimum air temperatures in degrees Celsius (°C) are required. Where only (average) mean daily temperatures are available, the calculations can still be executed but some underestimation of ETo will probably occur due to the non-linearity of the saturation vapour pressure - temperature relationship. Using mean air temperature instead of maximum and minimum air temperatures yields a lower saturation vapour pressure e_s, and hence a lower vapour pressure difference (e_s - e_a), and a lower reference evapotranspiration estimate.

Humidity :Theaveragedaily actual vapour pressure, ea, in kilopascals (kPa) is required. The actual vapour pressure, where not available, can be derived from maximum and minimum relative humidity (%), psychrometric data (dry and wet bulb temperatures in °C) or dewpoint temperature (°C).

Radiation: The (average) daily net radiation expressed in megajoules per square metre per day (MJ m-2 day-1) is required. These data are not commonly available but can be derived from the (average) shortwave radiation measured with a pyranometer or from the (average) daily actual duration of bright sunshine (hours per day) measured with a sunshine recorder.

Wind speed: The (average) daily wind speed in metres per second (m/s) measured at 2 m above the ground level is required. It is important to verify the height at which wind speed is measured, as wind speeds measured at different heights above the soil surface differ. The calculation procedure to adjust wind speed to the standard height of 2 m.

Example input data to compute the evapotranspiration, TheMae Hong Son meteorological station data showed that below:

- Latitude	degree, LTD	19.00
	lipda, LTL	18.00
- Elevation of station above MSL.,(Z)		267.00
- Height of wind vane above ground,(z)		11.30

Date dd/mm/yy	Max Temperature ° C	Min Temperature ° C	Mean Temperature ° C	Sunshine Duration hr./day	Mean Relative Humidity %	Wind Speed m./sec
01/01/15	29.50	17.00	21.60	6.88	78.00	0.88
02/01/15	28.30	15.40	20.80	6.68	77.00	0.00
03/01/15	29.20	15.30	21.20	7.66	78.00	1.00
04/01/15	29.90	17.20	22.30	7.81	80.00	0.00
05/01/15	30.40	18.20	23.20	7.30	80.00	1.13
06/01/15	30.40	18.70	23.20	7.96	80.00	0.00
07/01/15	30.80	16.20	21.80	7.25	79.00	0.00
08/01/15	28.50	17.00	21.90	6.98	84.00	1.00
09/01/15	24.20	21.20	22.30	7.29	92.00	0.38
10/01/15	27.50	19.30	22.00	6.79	79.00	1.38
11/01/15	28.20	16.50	20.60	7.10	78.00	0.00
12/01/15	28.30	14.60	20.00	7.26	75.00	1.13
13/01/15	27.50	11.40	18.60	7.33	73.00	0.00
14/01/15	27.60	14.40	19.80	7.15	74.00	0.50
15/01/15	27.00	14.60	20.20	7.57	79.00	0.00
16/01/15	29.90	18.40	22.90	7.54	73.00	1.50
17/01/15	29.40	19.30	23.10	7.62	74.00	0.00
18/01/15	29.10	16.90	22.20	8.04	75.00	0.63
19/01/15	28.50	17.00	22.10	8.23	76.00	0.38
20/01/15	29.50	16.30	21.80	8.28	78.00	0.50
21/01/15	30.30	17.80	22.20	8.03	74.00	0.00
22/01/15	29.70	14.20	21.00	7.88	71.00	0.00
23/01/15	29.50	13.20	19.80	8.29	74.00	0.38
24/01/15	29.50	12.90	20.20	7.70	73.00	0.38
25/01/15	30.00	13.50	20.20	8.02	74.00	0.38
26/01/15	29.90	14.20	20.40	7.78	75.00	0.75
27/01/15	30.20	13.50	20.30	8.03	75.00	0.63
28/01/15	30.50	13.90	20.50	6.78	75.00	0.38
29/01/15	31.50	13.60	21.20	7.72	74.00	0.00
30/01/15	31.70	14.00	21.40	7.66	72.00	0.50
30/01/15	31.80	14.00	21.30	7.00	72.00	0.50

Next calculation the evapotranspiration (ETo) from the Penman Monteith equation. The result show that:

$U_2=U(z)*[4.87/\ln(67.8*z - 5.42)]$	m./sec	0.330
$\varphi = 0.01745*(LTD+LTL/60)$	radian	0.337
$J = int(30.42*M-15.23)$		15
$\delta = 0.409 \sin(0.0172*J - 1.39)$	radian	-0.370
$\omega_s= \arccos(- \tan\varphi * \tan\delta)$	radian	1.434
$dr = 1+0.033*\cos(0.0172*J)$	radian	1.032
$R_a = 37.6\ dr(\omega_s*\sin\varphi \sin\delta + \cos\varphi \cos\delta \sin\omega_s)$	MJ/m²/day	27.167
$N = 7.64\omega_s$	hr./day	10.959
n/N		0.628
$e°(T_{max}) = 0.6108 \exp [17.27*T_{max}/(T_{max} + 237.3)]$	kPa	4.123
$e°(T_{min}) = 0.6108 \exp [17.27*T_{min}/(T_{min} + 237.3)]$	kPa	1.938
$e_s = [e°(T_{max})+e°(T_{min})]/2$	kPa	3.030
$e_a = (RH_{mean}/100)*e_s$	kPa	2.364
$e_s - e_a$	kPa	0.667
$\sqrt{e_a}$	kPa	1.537
$R_{ns} = 0.77[0.25+0.50(n/N)]R_a$	MJ/m²/day	11.796
$R_{nl} = 2.45*10^{-9}[0.9*(n/N)+0.1]*(0.34-0.14*\sqrt{e_a}) *[(T_{max}+273)^4+(T_{min}+273)^4]$	MJ/m²/day	3.140
$R_n = R_{ns} - R_{nl}$	MJ/m²/day	8.656
G = 0 when daily soil heat flux over 10-30 day periods		0
$\lambda= 2.501-(2.361*10^{-3})T$	MJ/Kg.	2.450
$\Delta = 4098*e_s/(T+237.3)^2$	kPa/° C	0.185
$P = 101.3[(273+T_{mean})-(0.0065*Z)/(273+T_{mean})]^{5.26}$	kPa	98.200
$\gamma= 0.00163(P/\lambda)$	kPa/° C	0.065
ETo= $[0.408*\Delta*(R_n-G)+(900*\gamma*U_2*(e_s-e_a)/(T+273))]$	mm./day	2.71
$/[\Delta+\gamma*(1+0.34*U_2)]$	mm./month	83.9

B. *Application by Appsheet Tools*

Appsheet[9],[10] is tools to create applications for business, professional or personal needs. It generally takes complex programming to build useful applications. However, Appsheet enables a limited but important subset of apps, those that follow a simple data-driven pattern. The behavior of an Appsheet app is almost completely determined by the structure of your data. It can build apps for project management, field operations, customer service, team collaboration, task management, staffing, and so much more. Appsheet apps are designed to work offline, can control and enable various aspects of online behavior.

The step for work :

1) start with a online spreadsheet

2) create application from website, design UI, testing

3) publish the application

4) deploy by user

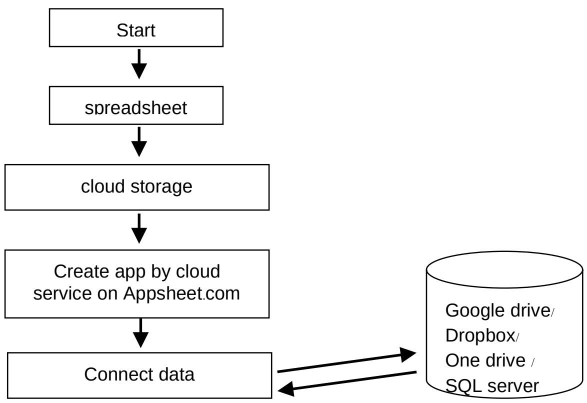


Figure 3. Application creator by Appsheet Tool.

III. PROPOSED EVAPOTRANSPIRATION VAPCALCULATION METHOD

In this section, showed my approaches for computing the evapotranspiration algorithm. The application based on spreadsheet application, computed evapotranspiration each Meteorological Department station. Therefore, my approach use a FAO Penman monteith equation, to simplifying equation and used widely.

Step1: select the Meteorological Department station.

Step 2: get data: Latitude degree,LTD, lipda,LTL, Elevation of station above MSL.,(Z), Height of wind vane above ground,(z) , Max Temperature, T_{max}(°C) Min Temperature, T_{min}(°C), Mean Temperature, T (°C) Mean Relative Humidity, RH_{mean}(%) Sunshine Duration, (hr./day) Wind Speed U(z), (m./sec).

Step3:calculate all variable from equation 1:R_n,G,T,U_2,es,ea,Δ andγ

Step 4: calculate evapotranspiration from equation 1 and the variable calculate in step 3.

Step 5: update and check the inputdata, if changed, application is recalculated and showed the new evapotranspiration value.

The application is designed with simple data by Appsheet tool.These tool is app creator and used worldwide.

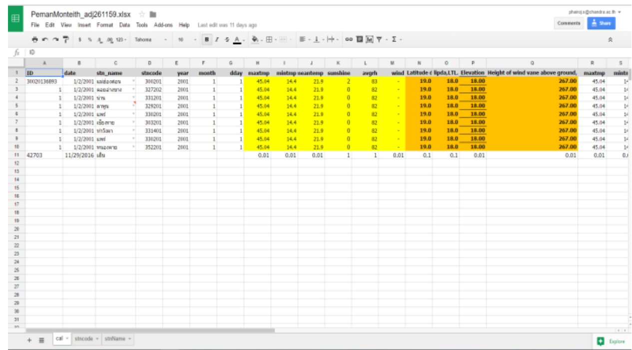


Figure 4. Spread sheet for calculation evapotranspiration. [11]

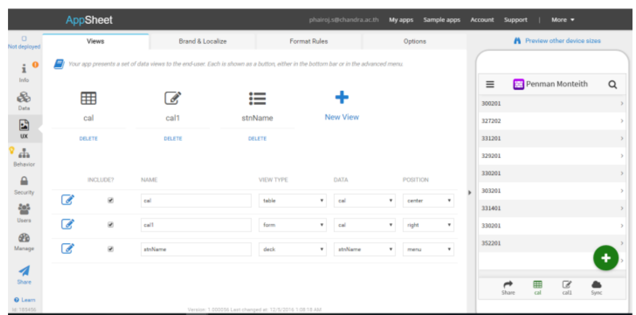
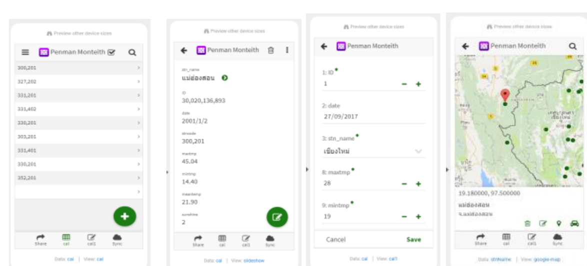


Figure 5. Application by Appsheet Tool.

The spreadsheet for calculate the potential evapotranspiration show in Figure. 4, used googlesheet. tool for creator is Appsheet shown in Figure 5, input data each metrological data station.



(a) Start application (b) select station and edit (c) metrological department station data (d) metrological department station

Figure 6. Application for calculation evapotranspiration.

Our application user interface(UI) for app is show in figure 6.

(a) Start application

(b) Select station

(c) Show metrological department

(d) Map metrological department station data

Our application, The URL launcher is https://www.appsheet.com/start/ae52b0a8-1692-4d5e-9903-ab86d89311ee

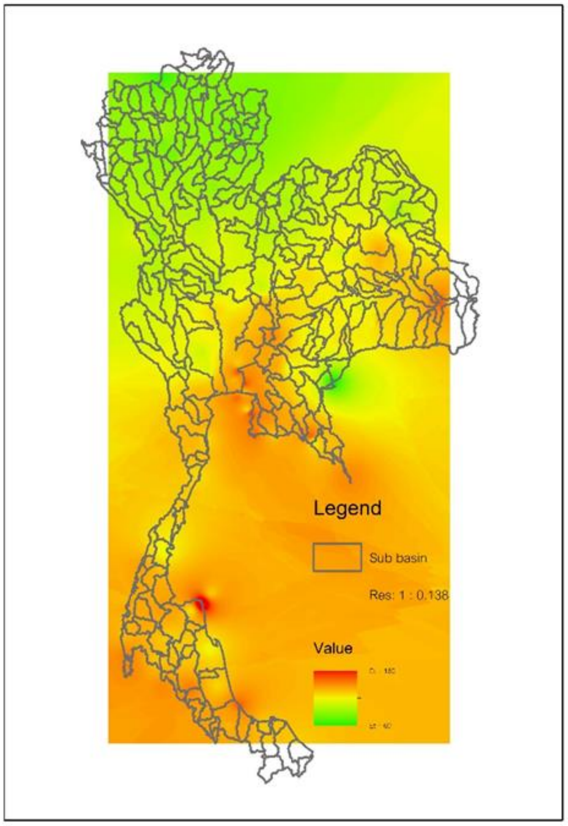


Figure 7. Map evapotranspiration in the Thailand .

The evapotranspiration in Thailand Map create by each metrological station data and QGis[12] to generate map. Next to add position and ET, interpolate ET data, showed map between 60-180 mm./day.

IV. CONCLUSION AND FUTURE STUDY

In this paper, presented the evapotranspiration calculation by Pennman monteith equation, used many data and complex calculated. Our propose used the free open source to create spreadsheet and application: googlesheet and appsheet tool creator. Our application can get past data from Meteorological Department station, adjust data and recalculate show map value of evapotranspiration in Thailand average data since 2004- 2014.

For the future study, my interested in researching for developing the application to compute the water demand irrigation.

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