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Determination Of Reference Evapotranspiration For Albania

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Abstract:
In order to make the best possible planning and to get the highest possible production, plants should be provided with the optimal amount of water. This amount depends mainly on the type of plant, pedological characteristics of the soil, hydrological conditions of the area and geographical position.
Before the '90s in Albania, calculations for irrigation rates for different cultures were made by determining the Evapotranspiration with the methods Blaney - Criddle, Thornthwaite and Quijano, with Blaney – Criddle being the most used method.
After '90s, the structure and types of plants that were planted before were changed, but also we have a change in the amount of rainfall during the vegetation period.
This paper consists of the definition of Evapotranspiration using the FAO Penman-Monteith method for Albania for different cultures and soils.
The results of this work serve for a better planning of water resources, given that the trend of atmospheric precipitation is declining.
Keywords*: Evapotranspiration,Evaporation,Transpiration,*

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I. INTRODUCTION

Albania is a country where about 50% of employment is in the agricultural sector and as such, it needs to use the resources it has to develop this sector in the most optimal way. In total, agricultural land occupies an area of 695,000 ha (24% of the total land area), of which about 360,000 ha are estimated to be irrigable, and about 120,000 ha are potentially irrigable. Irrigation of these surfaces is done mainly with gravity flow, and irrigation canals have an efficiency of 30 ÷ 60%, which means that a relatively large part of the water is not used. In order to make a better management of water resources for the development of agriculture, it is first necessary to determine better the amount of water needed for irrigation, because the types and number of plants that are planted now, differ from those planted before the 90s.

Purpose of the study

To determine the Evapotranspiration of the plant, different methods have been used in Albania, this paper will be based on the FAO Penman-Monteith method published by FAO Irrigation and Drainage Paper No. 56 (FAO - 56), as a new standard for calculating potential Evapotranspiration for various plants. This paper aims to draw maps of Albania for:

• Reference evapotranspiration (ETo), on a monthly and annual basis.

General

Evapotranspiration proces

The combination of two separate processes according to which water is lost from the soil surface due to evaporation and from plants due to transpiration is defined as Evapotranspiration (ET).

Evaporation

Evaporation is the process by which liquid water is converted to water vapor (evaporation) and removed from the evaporation surface. Water evaporates from various surfaces, such as lakes, rivers, sidewalks, land and vegetation.

Transpiration

Transpiration consists of the evaporation of liquid water into the plant stems and the removal of vapors into the atmosphere. Plants mostly lose their water through their stomata. These are small openings in the plant leaf through which gases and water vapors pass. Water, along with some nutrients, is taken from the roots and transported through the plant. Evaporation takes place inside the leaf, respectively in the intercellular spaces, and the exchange of steam with the atmosphere is controlled by the opening of the stomatas. Almost all of the water obtained is lost by transpiration and only a small fraction is used inside the plant.

Evapotranspiration

Evaporation and transpiration occur simultaneously and there is no simple way to distinguish between the two processes. In addition to the condition of the water in the upper layer, evaporation from a planted soil is mainly determined by the fraction of solar radiation that reaches the soil surface. This fraction decreases during the growing period as the plant develops and the plant crown emits more and more shadow on the soil surface. When the plant is small, water is mainly lost by evaporation of the soil, but when the plant develops well and manages to completely cover the soil, transpiration becomes the main process. In the first phase of planting almost 100% of evapotranspiration comes from evaporation, while with full plant growth, more than 90% of ET comes from transpiration.

Factors affecting Evapotranspiration

Weather parameters, crop characteristics, management and environmental aspects are factors influencing evaporation and transpiration.

Weather parameters

The main weather parameters that affect evapotranspiration are radiation, air temperature, humidity and wind speed. The evaporating power of the atmosphere is expressed by the evaporation of the reference plant (ETo). Evapotranspiration of the reference plant represents evapotranspiration from a standardized planted area.

Plant type

Plant type, variety and stage of its development should be taken into account when assessing evapotranspiration from plants in large areas. Differences in transpiration resistance, plant height, plant roughness, reflection, soil cover and plant root characteristics lead to different levels of evapotranspiration, in different plant species under the same environmental conditions. Plant evapotranspiration under standard conditions (ETc) refers to the evaporation requirement from plants growing in large areas under optimal soil irrigation, very good management and full production in these climatic conditions.

Management and environmental conditions

Factors such as soil salinity, poor soil fertility, limited fertilizer application, the presence of impermeable soil layers, lack of disease and pest control, and poor soil management can limit plant development and reduce evapotranspirimin. Other factors to consider when evaluating evapotranspiration are soil cover, plant density, and the amount of water in the soil. The effect of the amount of water on land in evapotranspiration is mainly conditioned by the size of the water deficit and the type of soil. On the other hand, too much water will result in large amounts of water in the root zone, it might damage them, and it might restrict water uptake from the roots by impeding respiration.

Methods and data used to estimate irrigation rates.

Some of the methods that were used before the 90s in our country are:

Blaney Method - Criddle

To determine the potential evapotranspiration this method uses day time temperature and air humidity data. This formula has the form:

$$Etc = K\frac{(T+18)}{2.2}p \qquad (1)$$

where Etc – Potential Evapotranspiration(mm)

K –Physiological coefficient of the plant

T – Average monthly temperature in(oC)

p – Average monthly percentage of daylight hours, versus year-round hours

Thornthwaite method

Obtained from Thornthwaite in the years 1944 ÷ 1948 for places with medium rainfall the formula has the form:

$$Etc = 1.6\left(\frac{10\,t}{I}\right) \qquad (2)$$

Where: Etc – Monthly evapotransipration potential (cm)

t – Average monthly temperature (oC)
I – Monhtly heat index
Etc - Potential monthly evapotranspiration (cm)
t - Average monthly temperature in (oC)
I - Monthly heat indicator

Quijano Method
obtained by Quijano in 1960, this formula is similar to that of Blaney - Criddle but does not take into account the coefficient of K cultures and has the form:

$$Etc = F \bullet t \qquad (3)$$

where: Etc –Monthly evapotransipration potential (mm)
t – Temperatura mesatare mujore ne (oC) / Average monthly temperature (oC)
F – Monthly coefficient obtained in tables for different geographical latitudes.

The method used to determine the reference Evapotranspiration
Different methods have been used in Albania to determine the Evapotranspiration of the plant, as already mentioned above. This paper will be based on the FAO Penman-Monteith method published by FAO Irrigation and Drainage Paper No. 56 (FAO - 56), as a new standard for calculating potential Evapotranspiration for various plants.

The Penman-Monteith equation
In 1948, Penman combined energy equilibrium with mass transfer method and derived an equation to calculate evaporation from an open water surface from standard climatic data of sunlight, temperature, humidity, and wind speed. This combination of methods was further developed by many researchers and spread to plant surfaces by introducing resistance factors. Surface resistance parameters are often combined into one parameter, which is the "mass" of surface resistance, which operates in parallel with the aerodynamic resistance.

Surface resistance, s_r ,describes the vapor flow resistance through the stomata openings, the total leaf area, and the soil surface.
Aerodynamic resistance ar,, describes the resistance from the upper part of the plant and includes friction from the movement of air over the surface of the plant. Although the exchange process in a vegetation layer is too complex to be fully described by the two resistance factors, a good correlation can be obtained between measured and calculated evapotranspiration rates, especially for a uniform grass surface, which will be taken as a reference.

The combined Penman-Monteith equation states:

$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_s)}{r_a}}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)} \qquad (4)$$

where: Rn - is the net radiation
G - is the heat flux of the earth
(es - ea) - represents the vapor pressure deficit of air
ρa - is the average density of air at constant pressure
cp - is the specific heat of the air
Δ - represents the slope of vapor pressure saturation
γ - is the psychrometric constant
rs and ra - are surface and aerodynamic measures of resistance.

The Penman-Monteith calculation model as formulated above includes all the parameters that regulate the energy exchange and heat flux (evapotranspiration) from the uniform vegetation extent. Most parameters are measurable or can be easily calculated from meteorological data. The equation can be used to directly calculate crop evapotranspiration, as surface and aerodynamic resistances are specific to each crop. Formula (4) calculates the value of the total Evapotranspiration for any plant. To facilitate calculations and to have a formula that can be used in any place regardless of climatic conditions, formula (4) was derived as a reference plant taking the plant height 0.12 m, surface resistance 70 s / m and albedon 0.23 corresponding to the grass plant, as a widely studied plant. Given the data for the reference plant equation (4) takes the form:

$$ET_0 = \frac{0.408\Delta\,(R_n - G) + \gamma\,\frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)} \qquad (5)$$

where: ETo - Reference evapotranspiration (mm / day)
Rn - is the net radiation on the plant surface (MJ / m2 / day)
G - is the heat flux density (MJ / m2 / day)
T - average daily air temperature at 2 m altitude (° C)
u2 - wind speed at 2 m altitude (m / s)
es - saturated vapor pressure (kPa)
ea - current vapor pressure (kPa)
(es - ea) - vapor pressure saturation deficit (kPa)
Δ - slope of the vapor pressure curve (kPa / ° C)
γ - is the psychrometric constant
The equation uses standard measured climatic data of solar radiation (sunlight), air temperature, humidity and wind speed. To ensure the integrity of the calculations, weather measurements should be made at 2 m (or converted to that height) over a large area planted with grass shading the soil and irrigation as per standard.

Climate Division of Albania

The climatic division of a country represents the synthesis of the perennial regime of meteorological elements. It expresses the real characteristics derived from the unity of interaction of a number of factors. In the context of the European climate, the territory of Albania, together with the Iberian and Apennine peninsulas, is part of the subtropical climate belt. This belt includes areas or regions with climatic features that differ significantly from each other. The classification of climates, based on the genesis of air masses, also gives a general idea of the climatic characteristics of areas in the broadest sense of the word. The large area of several hundred thousand km², which have air masses highlights precisely the fact that based on them can be judged only on the general characteristics in terms of macro-regions.

The path followed by cyclones in their displacement is taken as an important indicator of climatic divisions. The northern parts of the territories, which remain to the north of these roads, are subject to cold air masses coming from the interior of the continent, while the southern parts are subject to warm air masses. In other words, the position of the polar front should also determine the climatic boundary between the zones.

The Albanian territory remains entirely south of the summer position of the polar front over Europe. In accordance with this position of the polar front during the winter, Albania is affected by cold air masses. The changes observed from one province to another are the result of local factors of climate formation. The center of the moving cyclone and together with it the warm sector or the position of the front, during their displacement, do not always maintain the same path. They can cross further north or south of our territory. This instability means that not always the same part remains north or south of the polar front. Consequently, the climatic characteristics of different provinces in relation to the polar front do not constitute a stable feature. The size of the territory compared to those of a cyclone allows the whole of Albania to be traversed in a short time by a single air mass. In this way the possibility of the dominance of different air masses in different parts of the country is significantly limited. The changes observed in climatic characteristics are primarily the result of the influence of physical-geographical factors on air masses, ie the result of local factors.

The percentage ratio of the amount of rainfall of the driest season to the wettest one, also shows us that our territory presents a satisfactory uniformity. As noted for the annual amplitude, the Ionian coast is an exception from other regions of the country. Here the percentage is smaller than anywhere. This indicator shows that in the highlands (where there are observations, the percentage of rainfall of the driest to the wettest season increases regardless of whether we are in the southern part of the country, in the middle, northeast or north. indicates that rainfall during the summer is more the result of vertical development clouds, which are more frequent in mountainous areas.
The territory of Albania is divided into 4 climatic zones and 13 sub-zones named as follows:

- Mediterranean plain area with three sub-areas: North,Central,South.
- Mediterranean hilly area with four sub-areas:North,Central,Southeast,South-west.
- Mediterranean front mountainous area with two sub-areas:North,South
- Mediterranean mountainous area with four sub-areas:North,East,Southeast ,South.

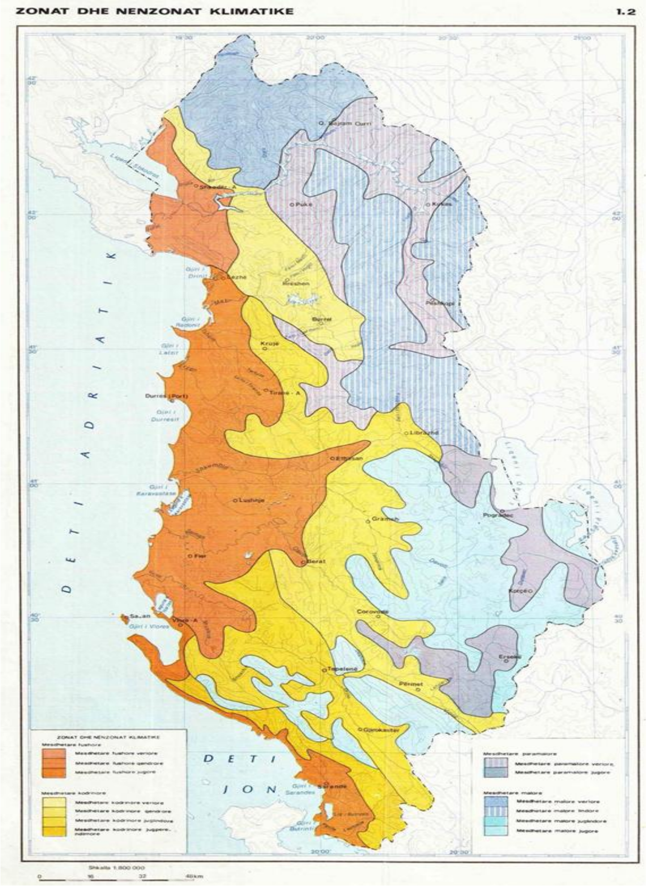


Figure 1: Climatic zones of Albania (Climate Atlas of Albania 1988

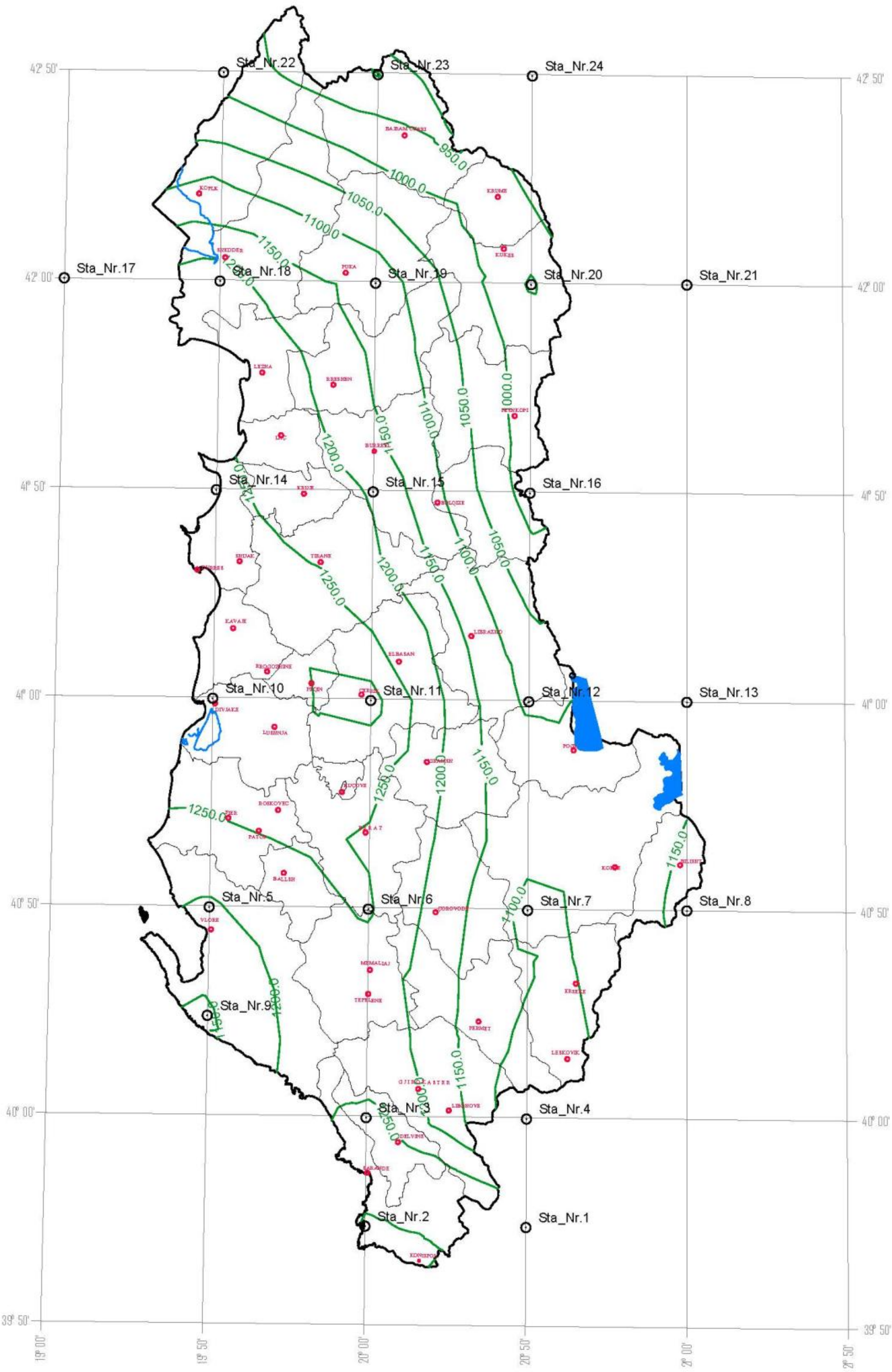
Evapotranspiration Map for Albania

According to the procedure recommended by FAO, the reference Evapotranspiration (ETo) calculations were made with the FAO Penman-Monteith method published by FAO Irrigation and Drainage Paper No. 56 (FAO - 56). Given that the available data are daily, and Evapotranspiration (ETo) was done on a daily basis for each of the stations under review. With the results from the calculations and in this case the Reference Evapotranspiration Map (ETo) was drafted for each of the months and the annual one for Albania.

Nr.	Geographic coordinates		Coor. UTM		Amount
	With	Length	North	South	
1	39.74	20.50	4,399,019.92	457,158.62	1297.44
2	39.74	20.00	4,399,378.46	414,316.64	1303.83
3	40.00	20.00	4,428,236.06	414,639.54	1271.12
4	40.00	20.50	4,427,876.92	457,320.05	1060.06
5	40.50	19.50	4,484,335.40	372,896.91	1192.79
6	40.50	20.00	4,483,734.99	415,265.46	1255.63
7	40.50	20.50	4,483,374.79	457,632.99	1081.22
8	40.50	21.00	4,483,254.73	500,000.00	1162.43
9	40.24	19.50	4,455,474.48	372,407.40	1138.25
10	41.00	19.50	4,539,840.58	373,845.67	1290.92
11	41.00	20.00	4,539,238.59	415,897.87	1319.37
12	41.00	20.50	4,538,877.44	457,949.16	1088.44
13	41.00	21.00	4,538,757.06	500,000.00	1133.86
14	41.50	19.50	4,595,350.26	374,804.07	1262.42
15	41.50	20.00	4,594,746.87	416,536.70	1195.23
16	41.50	20.50	4,594,384.88	458,268.55	976.93
17	42.00	19.00	4,651,711.06	334,361.18	1174.11
18	42.00	19.50	4,650,864.46	375,772.06	1235.70
19	42.00	20.00	4,650,259.85	417,181.93	1140.00
20	42.00	20.50	4,649,897.12	458,591.13	942.92
21	42.00	21.00	4,649,776.22	500,000.00	1117.56
22	42.50	19.50	4,706,383.17	376,749.55	973.03
23	42.50	20.00	4,705,777.53	417,833.50	897.43

24	42.50	20.5	4,705,414.19	458,916.89	1092.99

Table 1: Table of Annual Reference Evaporation (ETo) layer per station (mm / year)



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