Evapotranspiration and its evaluation on the Albanian territory

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Abstract

Evaluation of evapotranspiration it's a very important problem, because of natural specific conditions of Albanian territory (mountainous regions, lake system present, Mediterranean climate, etc.)
Many particular studies are made in Albania to evaluate the evapotraspiration. Jaho S et al. (1984), Laska A. (2007). This paper is an attempt to present a general evaluation of the evapotranspiration in Albanian territory,
It is evaluated using multi-annual archival information of the Institute for Energy, Water and Environment.
Evapotranspiration is evaluated by computing its principal components, such as: potential evapotranspiration – E_0*, real evapotranspiration –* E_R*, evapotranspiration deficit –* ΔE*, pluviometric deficit –* Δx*, and water flow deficit –* Z_0*.*
Evapotranspiration evaluation in the Albanian territory is calculated by different ways, such as: direct observed method, indirect calculating method using empiric formulas and water balance method.
Division scheme of Albanian territory in homogeneous regions based on evaluation and determination of the natural factors that influence on evapotranspiration process is presented in this paper. Analyzing and dividing the Albanian territory, in homogeneous, region is accepted as the smallest tacsionometric unit. As the result of the specific physicogeographical conditions of Albanian territory, the principal nature factors that influence on the evapotranspiration processes are: a) climate regime and b) morphometric conditions of the territory.
Evapotranspiration and territory altitude dependence subdues the vertical zone law, having e typical regional character. Using these dependences, the evapotranspiration maps are made for the Albanian territory.

Keywords: Reference evapotranspiration, real evapotranspiration, deficit evapotranspiration, pluviometric deficit, water flow deficit.

Introduction

Evapotranspiration is one of the major problems of soil water balance and is a question of great interest for a wide community of specialists like meteorologist, agronomist, hydrologists, managers of irrigation etc.
Many particular researches are carried out in Albania to evaluate evapotraspiration. This paper is an attempt to introduce a general evaluation of the evapotranspiration in Albanian territory,
Evaluation of evapotranspiration in the Albanian territory plays a major role because Albania is a complicated and complex natural area in Europe as a result of its specific physical-geographical conditions: a mountainous region, typical Mediterranean climate, a particular hydrographical system, etc.
There are various methods applied: direct measurement or observed method; indirect calculating method using empiric formulas, based on meteorological data; water balance method. It is evaluated by using multi-annual archival hydrometeorological information of the Institute for Energy, Water and Environment such as temperature, rainfall, solar radiation, vapour pressure, wind speed.
Evapotranspiration evaluation is based on the observed period of 1961-1990 years and 6 experimental stations GGJ with an observed period of about 10 years.

Description of the region

The Republic of Albania, borders in the North and North-East with Kosovo and Montenegro, on the East with the Former Yugoslav Republic of Macedonia, and in the South and South-East with the Republic of Greece

The main characteristics of weather system are comparatively short winters and relatively hot summers. The climate in Albania registers large differences between various locations: significant contrasts regarding air temperature, yearly rainfall, sunlight, air humidity, etc. are present.
For example, sunlight exposure changes from 2731 hours a year in Xare by Saranda to 2722 hours a year in Vlora, 2560 hours a year in Tirana, 2246 hours a year in Peshkopi and 2046 hours a year in Kukës.
Furthermore, the level of rainfall is 1430 mm a year and reduces from west to east. Albania is complicated natural area as a result of its specific physicogeographical conditions: mountainous region, typical Mediterranean climate, particular hydrographical system etc.
Evaluation of evapotranspiration in Albania plays e major role. There are various methods applied: direct measurement or observed method; indirect calculating method using empiric formulas, based on meteorological data; water balance method. It is evaluated by using multi-annual archival hydrometeorological information of the Institute for Energy, Water and Environment such as temperature, rainfall, solar radiation, vapour pressure, wind speed

Methods and Analyses

The evapotranspiration process
Evapotranspiration in Albania is determined by the correlation of different geographical factors like: climate, relief, territory litological structure, vegetation, etc. As a result the influence of all these factors in territory is different not only during the months, seasons and different periods of the years, but also in the multi-annual cycle.
The evaluation of potential evapotranspiration, otherwise recognised nowadays as the referential area evapotranspiration has been performed with reference to diverse climatic zones in Albania. Therefore, to this end, the Albanian territory subjected to our research has been classified into three areas.
I-Field areas situated on the Western Lowlands in Lushnje, Durres;
II-Hilly areas Peshkopi, Burrel and
III-Mountainous areas Korce, Erseke.
In this paper Evapotranspiration is evaluated by computing its principal components, such as: Potential Evapotranspiration or reference evapotranspiration – ET_0, Real Evapotranspiration – ET_R, Evaporation Deficit –ΔE, Pluviometric Deficit – ΔX_0 and Water flow deficit – Z_0.
It is calculated by some different methods, such as: Direct observed method, indirect methods using empiric formulas and Water balance
Reference (Potential) Evapotranspiration – ET_0 is calculated by various methods such as: Turc, Penman, Thornthweit, Penman Monteith, Equation FAO56 Penman-Monteith. In 1990 the experts and researches of FAO in collaboration by International Commission for Irrigation and Drainage of OBM is choose the FAO Penman Monteith that correct method for evaluated of ET_0.
The values of $ET_{0,}$ calculated by different ways, result similar with one on other. At the same time, these values are relatively similar, to the results of the direct observed method by GGJ experimental stations (difference about – $\delta ET_0 = \pm 5 \div 10\%$).
The average monthly Reference Evapotranspiration on the Albanian territory differs from about $ET_0 = 10 \div 40$mm in January, the coldest month of the year, to about $ET_0 = 120 \div 170$mm in June, the hottest month, refers FAO Pennman-Monteith. (fig.1)
The average annual potential evapotranspiration for the multi-annual period is about $ET_0 = 800 \div 1100$mm**.** The average annual ET_0 in the plains varies from $ET_0 = 1000 \div 1100$mm and on the mountains about $ET_0 = 800 \div 850$mm. (refers FAO Pennman-Monteith)

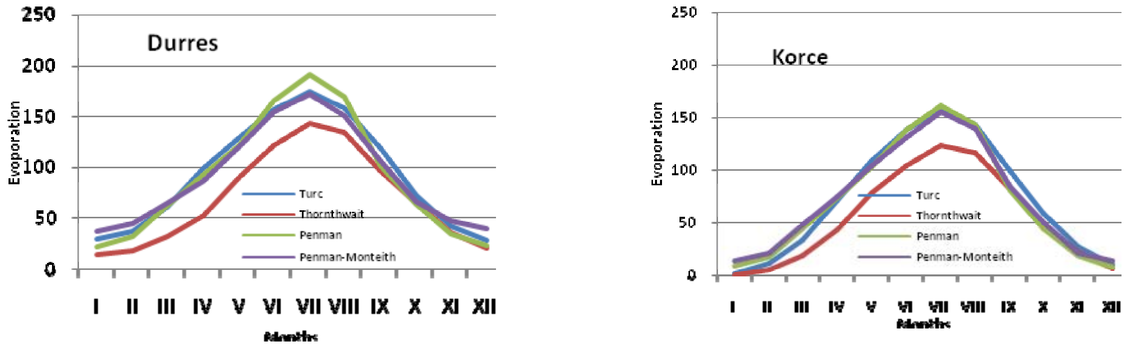

Figure 1. Distribution of months values of ET_0 for two diverse regions

Table 1 Reference evapotranspiration ET_0 (mm) in Albania

N	Area	Methods	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Yearly
I	Lushnje	Turc	31	39	62	95	134	164	179	162	112	76	44	29	1132
		PThornthwait	16	19	32	52	90	126	147	139	99	62	29	20	893
		Penman	23	30	57	83	120	170	193	171	99	62	29	20	1057
		FAO56 Penman-Monteith	28	32	60	80	116	130	166	159	100	70	32	30	1003
	Durres	Turc	30	38	62	100	130	158	175	159	119	73	43	29	1121
		Penman	22	32	62	92	122	166	191	169	102	64	35	23	1080
		Thornthwait	15	19	32	53	90	122	143	134	97	65	36	21	827
		FAO56 Penman-Monteith	37	45	65	86	120	154	172	150	107	66	47	39	1088
II	Peshkoip	Turc	0	11	35	71	109	137	156	142	97	58	25	8	849
		Penman	7	15	41	70	101	139	161	142	76	39	15	6	812
		Thornthwait	0	5	20	47	84	112	129	121	83	47	21	5	674
		FAO56 Penman-Monteith	10	21	45	71	103	125	136	146	81	48	21	12	819
	Burrel	Turc	26	33	55	86	126	155	173	157	114	73	39	26	1063
		Thornthweit	13	17	30	51	89	123	144	135	94	59	31	17	924
		Penman	14	23	49	73	109	152	178	157	88	49	21	11	803
		FAO56 Penman-Monteith	18	26	51	74	110	146	168	141	90	55	24	17	920
III	Erseke	Turc	3	20	32	65	104	134	153	138	96	58	28	11	833
		Thornthwait	2	6	19	41	75	98	115	106	77	47	24	9	619
		Penman	11	20	46	70	98	134	152	134	74	44	11	12	816
		FAO56 Penman-Monteith	14	22	48	72	100	130	145	122	78	48	25	16	820
	Korce	Turc	2	12	34	71	109	138	158	143	100	59	28	10	864
		Penman	9	18	45	74	103	139	162	144	81	45	19	8	847
		Thornthwait	1	6	19	44	79	105	124	117	82	48	23	7	655
		FAO56 Penman-Monteith	14	22	48	75	104	131	156	140	85	51	22	14	862
		ASCE Panman-Monteith	14	22	48	75	104	131	156	140	85	51	22	14	862

Another component of evapotranspiration is the Real Evapotranspiration – ET_r It is calculated by the methods: Thornthwait, Turc, water balance, Cotagne and Costandinov. The values of ET_r calculated by different methods result relatively similar with each other. At the same time, these are relatively similar to the results of the deficit water flow-Z_0 calculated by the water balance method (difference about –δ ETr = ±5-10%).

ET_r in Albania varies from about 650 ÷ 700mm in the Coastal area to 300 ÷ 400mm in the mountains, having an average of ET_R = 500 ÷ 600mm all over the Albanian territory.

Real Evaporation – ET_R is presented on Tab.2.for the same regions like of ET_0

The values obtained following the calculations according to the above-mentioned methods have been provided in table 2, wherein there have been represented the monthly values according to the Thornthwait method, as well as the annual values according to Turc, Water balance, Coutagne and Constandinov monogram.

The monthly distribution of the real evapotranspiration values according to the Thornthwait method haven bee graphically represented in Figure 2.

Table 2 The annual of Real evapotranspiration ET_r (mm) in Albania

N	Area	Months distribution of ETr (Thornthwait method)												Annual some of ETr				
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Aaccording to Thornwa	Aaccording to Turc	Aaccording to Coutagne	Aaccording to Costandinov	Aaccording to Water balance
I	Lushnje	23	30	57	83	120	170	34	33	57	62	29	20	718	679	789	650	670
	Durres	22	32	62	92	122	150	23	31	60	64	35	23	716	676	784	600	700
II	Burrel	12	21	48	72	102	140	146	47	78	45	18	12	741	651	694	500	640
	Peshkopi	7	15	41	70	101	139	102	36	58	39	15	6	629	546	617	450	480
III	Korce	9	18	45	74	103	100	32	31	48	45	19	8	532	499	606	400	450
	Erseke	11	20	46	70	98	134	136	35	58	44	21	12	685	513	576	400	575

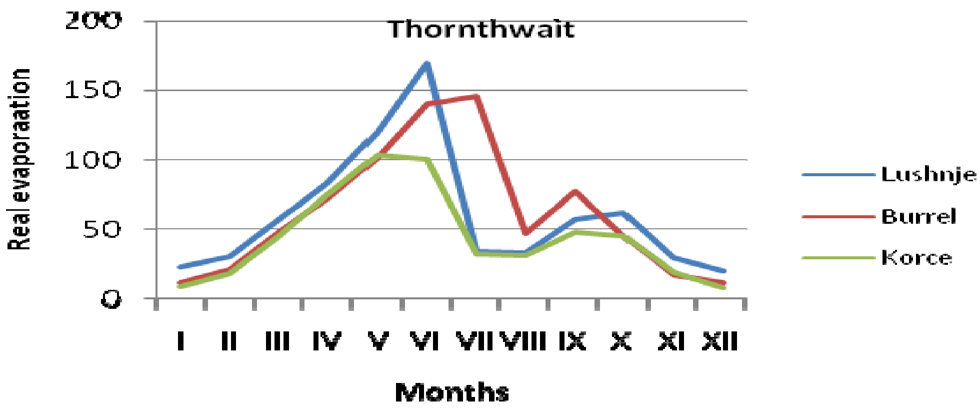

Figure 2. Distribution of months values of ET_r, by Thornthwait method

Deficit evapotranspiration – ΔE is computed as the difference $\Delta E = (ET_0 - ET_R)$. ΔE in Albanian varies about ΔE = 425 ÷ 450mm on the coastal area to ΔE = 150 ÷ 200mm in the mountains.
Having already recognised the ET_0 values, it is possible to determine the pluviometric deficit ΔE referring to every period of the year, as a difference of reference evapotranspiration with the respective rainfalls corresponding to this period.
It is in this way that the water balance-sheet for every month of the year is calculated, likewise the pluviometric deficit is later determined during the dry months, whereas the superfluous water-supply is determined during the wet months.
The pluviometric deficit in Albania is represented in fig.3, wherein it is evident that during the June-September period Et_0 is greater than the rainfalls, consequently there is shortage of water-supply. The opposite happens during the October-May period when the rainfalls are greater than ET_0, consequently there are excessive rainfalls.

Annual distribution of reference evaporation – ET_0, Real evaporation – ET_R and pluviometric deficit – ΔE in Albania is represented in Fig.3.

Table 3 The monthly and annual values for evapotranspiration components ET_0, ET_r and ΔE

Nr.	Elements	Months												Yearly
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1	Potential Evoapotranspiration – ET_0	22	32	62	90	121	172	191	168	93	63	34	23	1084
2	Real Evapotranspiration – ET_R	22	32	62	90	121	136	17	29	58	63	34	23	687
3	Evapotranspiration deficit– ΔE	-	-	-	-	-	36	174	139	35	-	-	-	397

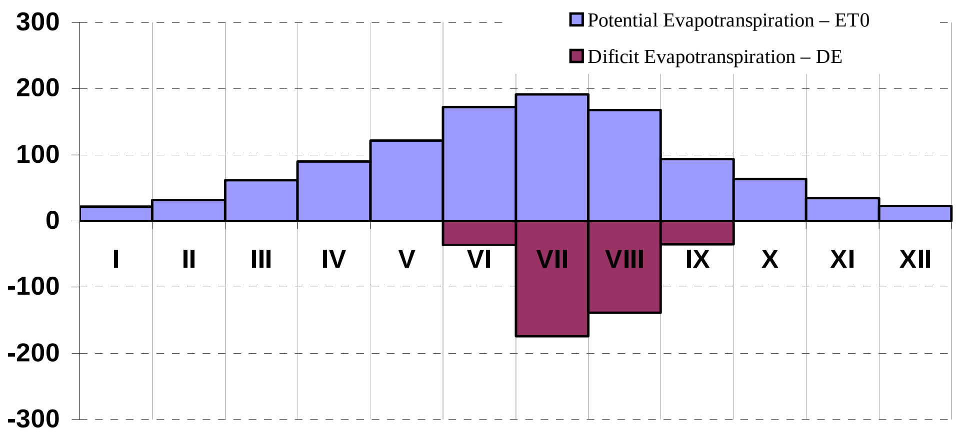

Figure 3. Annual distribution of Evapotranspiration potential – ET_0; Real evapotranspiration – ET_R and evapotranspiration deficit - ΔE in Albania

Results

Albanian territory division scheme in homogeneous regions, based on evaluation and determination of the natural factors, influencing the intensity of the evapotranspiration process, is presented in this paper.

Many important indicators to evaluate the integral impact of the natural conditions of the territory on the evapotranspiration process are respectively: Reference Evapotranspiration – ET_0, Real Evapotranspiration – ET_R and evapotranspiration deficit – ΔE.

In the general scheme of evapotranspiration intensity process, the natural conditions of the Albanian territory are grouped as the following:

a. Territory morphometric parameters. Morphometric factors are determined by the topographical characteristics of the Albanian territory. The main parameters considered are: (h) – territory average altitude, and (l) – distance from the Sea.
b. Territory climatic parameters. Climatic parameters are: Sun radiation (J), Air temperature (t_a), precipitation (X_0), Air humidity (I_0), wind (v), etc.
c. Computation principal parameters of the water balance of the territory. Water balance parameters are: pluviometric deficit (ΔX_0) and water flow deficit – (Z_0).

Analyzing and dividing the Albanian territory in homogeneous areas, region is accepted as the smallest tecsinometric unit.

Classification is made for the following evapotranspiration categories: high, low and mean.

Computation deficit – ΔX_0 as the difference $\Delta E = \left(ET_0 - ET_R\right)$

DX_0 in Albania varies about 200mm on the coastal area to 2500 ÷ 3000mm on the mountain.

Water flow deficit – Z_0 as the difference $Z_0 = \left(X_0 - Y_0\right)$ where the Y_0 – is water flow (in mm).

For the natural specific conditions of the Albanian territory, particularly, for mountainous areas, values of both evapotranspiration components were computed based on their vertical gradients and their altitude above sea level.

Composition methodology of the distribution for annual evapotranspiration components (ET_0, ET_R, ΔE, ΔX_0 and Z_0) used in the paper consist in classification of the Albanian territory by respectively gradient $P_M = X_0/h$.

Evapotranspiration components and territory altitude subdues the vertical zone low, having a typical regional character. Using these dependences, in the table 4 are made their components for the Albanian territory.

As a conclusion, in the following we are representing in the following the values of the respective Evapotranspiration components (ET_0, ET_R and ΔX_0) according to the various climatic regions and various altitudes of the Albanian territory.

Table 4 The evapotranspiration components (ET_0, ET_r and ΔX_0) in the Albanian territory

Nr	ELEMENTS	Region I_1 – Low ET_0 (in mm)	Region II_1 – Mean ET_0 (in mm)	Region III_1 – High ET_0 (in mm)
I	Reference Evapotranspiration (ET_0)	$\begin{cases} A_1 = 500 \div 700mm \\ B_1 = 701 \div 800mm \end{cases}$	$\begin{cases} C_1 = 801 \div 900mm \\ D_1 = 901 \div 1000mm \end{cases}$	$\begin{cases} E_1 = 1001 \div 1100mm \\ F_1 = 1101 \div 1200mm \end{cases}$
II	Real Evapotranspiration (ET_R)	$\begin{cases} A_2 = 300 \div 400mm \\ B_2 = 401 \div 500mm \end{cases}$	$\begin{cases} C_2 = 501 \div 550mm \\ D_2 = 551 \div 600mm \end{cases}$	$\begin{cases} E_2 = 601 \div 700mm \\ F_2 = 701 \div 800mm \end{cases}$
III	Deficit Pluviometric $\Delta E = \left(ET_0 - ET_R\right)$	$\begin{cases} A_3 = -200 \div 000mm \\ B_3 = 001 \div 200mm \end{cases}$	$\begin{cases} C_3 = 201 \div 400mm \\ D_3 = 401 \div 1000mm \end{cases}$	$\begin{cases} E_3 = 1001 \div 1500mm \\ F_3 = 1501 \div 3000mm \end{cases}$

Conclusion

Evapotranspiration is an important phenomena and representative element of the water balance of the Albanian territory.

The principal results of the evapotranspiration evaluation of the Albanian territory are:

- Annual Evapotranspiration distribution is generally characterized by a typical Mediterranean nature.
- The scheme of classification and division into homogenous sectors based on evaluation and determination of the natural factors participating in the evapotranspiration process.
- Region is accepted as the smallest tacsinometric unit.
- Classification was made for the following indicators: low, mean and high.

I. The region with relatively Low evapotranspiration values respectively:
   - Reference Evapotranspiration - $ET_{0,1} = 500 \div 800mm$
   - Real Evapotranspiration - $ET_{R1} = 300 \div 500mm$
   - Deficit Evapotranspiration - $\Delta E_1 = 100 \div 250mm$
   - Deficit Pluviometric - $\Delta X_{0,1} = -200 \div 200mm$

II. The region with relatively Mean evapotranspiration values respectively:
   - Reference Evapotranspiration - $ET_{0,2} = 801 \div 1000mm$
   - Real Evapotranspiration - $ET_{R2} = 501 \div 600mm$
   - Deficit Evapotranspiration - $\Delta E_2 = 251 \div 400mm$
   - Deficit Pluviometric - $\Delta X_{0,2} = 201 \div 1000mm$

III. The region with relatively High evapotranspiration values respectively:
   - Reference Evapotranspiration - $ET_{0,3} = 1001 \div 1250mm$
   - Real Evapotranspiration - $ET_{R3} = 601 \div 800mm$
   - Deficit Evapotranspiration - $\Delta E_3 = 401 \div 550mm$
   - Deficit Pluviometric - $\Delta X_{0,3} = 1001 \div 3000mm$

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