

The Impact of Climate Change on the Erosion Process in the Albanian Hydrographic River Network

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Abstract

The impact of climate change on the erosion process in the Albanian hydrographic river network is presented in the paper. There are analyzed pale climate changes, present climate changes and the cascade impact of these changes on erosion process in Albanian hydrographic system.

KEYWORDS: climate change, impact, erosion, river

Introduction

The catchment area of Albanian hydrographical network is 43305 km², where 28500 km² is inside the Albanian state territory and the rest outside of it. This area is one of the most complicated natural areas in Europe because of its physic-geographical conditions: a mountainous region, a particular land cover with small vegetation and important flysch formation presence, a typical Mediterranean climatic regime with intensive precipitation, a hydrological regime with intensive surface flow, etc.

Many hydrological studies have been carried out to evaluate the climate change in the Albanian territory, Demiraj E. et al. [2], Frasheri A et al. [3], etc. At the same time other studies have been carried out to evaluate suspended and load sediment discharge of the Albanian river system, Pano N. [5, 6, 8], Saraçi R. [7]. In this paper it is attempted to present the evaluation of this cascade impact of climate change on erosion in the Albanian hydrographic river network.

The general cascade impact of climate change in the erosion process has been analyzed in two principal aspects. Firstly by the evaluation of the global water potential of river system and secondly, by the influence of the multi-annual variation of this potential on the erosion processes in the catchment area of this system.

Impact for two type climatic characteristics years respectively: wet and dry years are analyzed.

Method and Materials

Climate change is analyzed in two directions: firstly by temperature record in the deep wells and shallow boreholes, and secondly by the meteorological observations data. The ground surface temperature reconstruction for long period, about 5 centuries, has been performed by estimation of the ground surface temperature changes at the past, according to the present-day distribution of the temperature at the depth, recorded in the borehole.

The study of geothermal field of Albania has been carried out based on the temperature logging in the wells and boreholes. Six thermo plots were used for inversion of the ground surface temperature history which is located at the plane region in the west of Central Albania and in the mountainous region of the northeast of the Albania Cermak V. et al. [3].

Air and ground temperatures, total annual rainfall quantity, wind speed and wetness, which are analyzed by records in Meteorological Stations. These stations are located in different plane regions (Shkodra, Tirana, Kuçova and Fier) and in mountainous region of Albania (Kukes), where the investigated wells are situated [1, 2].

In the Albanian hydrographical network there are 11 principal rivers together their numerous branches such as Buna River with catchment area of the $F=5\ 750\text{km}^2$, Drini River $-F=14\ 173\text{km}^2$, Vjosa River $-F=6706\ \text{km}^2$, Semani River $-F=5649\ \text{km}^2$, etc. There are 125 other rivers with a small catchment area $F>50\ \text{km}^2$ (Pano N., Avdyli B. [6]).

Water potential evaluation was carried out based on the multi-annual archival data. Albanian monitoring system consists of more than 220 meteorological stations and 175 hydrometric stations in a period of 15-50 years. These stations are located all over the territory.

Water potential of this system has been evaluated by a specific way, because this system is very complicated. This system is generally a mountainous hydrographic network with an average altitude of 785m. Part of the system is Prespa-Ohri and Skutary lakes, with a surface of 270-305 km^2 and with a very intensive karstic phenomenon in the limestone formation. In these conditions the estimation of run-off discharge is carried out for two categories of river basins, with different hydrographical and hydraulically natural conditions:

Firstly, for river systems where the run-off discharge is computed as function of the altitude of water level ($Q'_0=f(H)$). Secondly, for the water system of Skutary Lake- Drini River-Buna River, which is very complicated and is unique in the Mediterranean hydrography? This particularity has made particular modeling for the estimation of the water discharge of Buna River (Q_2) necessary:

$$Q_2 = 0,025 \cdot [H_2 - Q_2^2 / (0,0073 \cdot H_2 \cdot 1.61413)^2]^{1.85} - Q_4 \quad (1)$$

There are their discharge of the Buna river that flows away from the Skutary Lake, have been calculated in dependence of the lake water level (H_2) and the Drini River discharge (Q_1) in to Buna River. Parameters of the water river discharge probability distribution (Q_0, C_V, C_S) for the Albanian river system are calculated. Graphic-analytic relation are also compiled according to these forms: $Q_0=f(x_0)$, $Q_0=(x_0, t_0)$ and $Q_0=f(F)$ where: Q_0 - is water discharge, X_0 -precipitation, t_0 - temperature, F -catchment area surface were determined. Calculating and examining much annual archival data for the period 7-30 years analyze erosion process evaluation in this network. Sediment samples are taken in 70 cross-sections in the river system. After determining respective samples with observed data of the solid discharges, statistical analyze of this samples is made. Parameters of the suspend loads discharge probability distribution (R_0, C_V, C_S) for Albanian river system are calculated. For these rivers graphic-analytic relations are also compiled as forms: $R_0=f(Q_0)$, $R_0, p\% = f(Q_0, p\%)$ and $R_0=f(F)$, (where: R_0 - is solid suspend discharge) were determined.

Analyze of the Results

The ground surface temperature reconstruction of the thermo plots of Kolonja-10, which is located at coastal plane region of western Albania, is shown in Figure 1. As it is seen in this figure, the GST history yielded by tighter inversion of Ko-10, presents a gradual cooling of 0.6 K, before a middle of the 19th century. Later followed by 0.6 K warming, with a gradient 5.4 mK/years, that seems quite reasonable and is consistent with generally accepted ideas about the climate of the last 2-3 centuries.

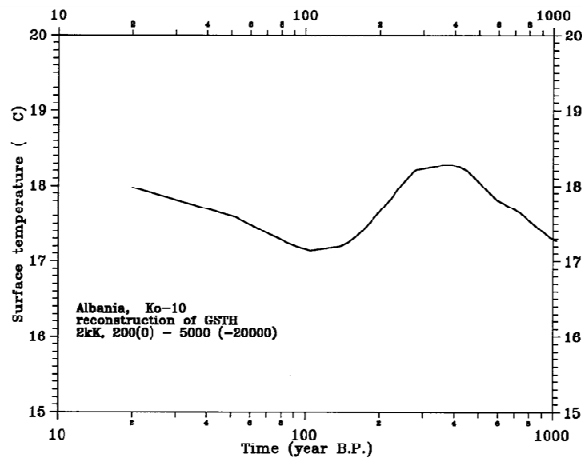


Figure 1. Ground surface temperature history according to thermo plot of Ko-10 deep well (According to the Safanda, J. calculations).

Some changes are observed in the mountainous regions of Northeast Albania as to the cooling of 0.2 K during the 19th century. Later, the warming trend of 0.6 K during the 20th century, by a gradient 6.7 mK/year has been observed. Warming gradient increasing at mountainous regions, in comparison with coastal areas, is caused by intensive deforestation during the last half of 20th century.

Climate changes in Albania are observed also by the hydro meteorological studies (Figure 2).

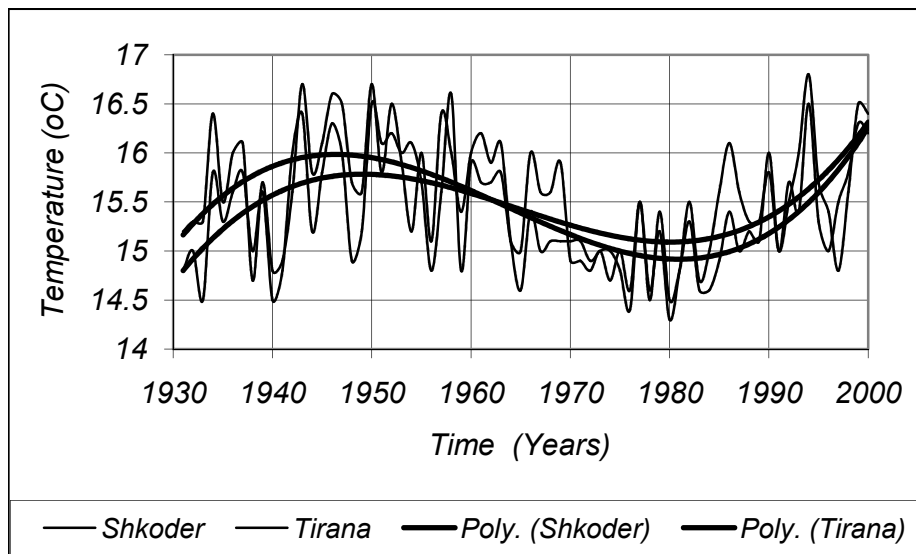


Figure 2. Air Average Annual Temperature Variation at Tirana and Shkoder Meteorological Stations (Period 1931-2000).

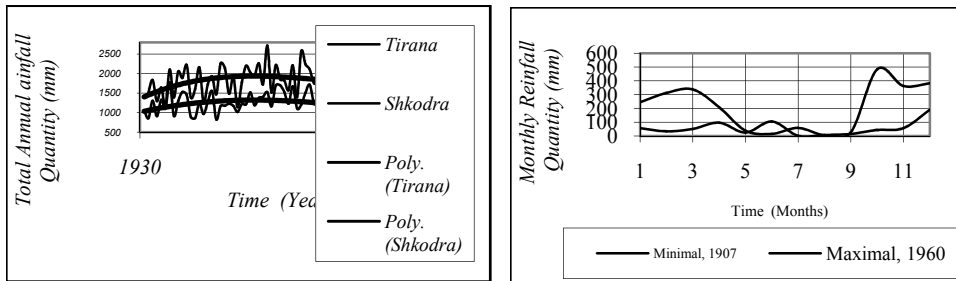


Figure 3. Total year rainfall quantity of the Tirana in the most and Shkodra Meteorological Station. (Period 1930-2000)

Figure 4. Total Year Rainfall Quantity dry and wet year, respectively, of the Shkodra Meteorological Station (respectively 1907 and 1960 years).

In general, at the end of first observes half 20th century, a warming of climate, about 1°C. Third quarter of 20th century is characterized by a cooling of 0.6°C, and later, up to present a warming of 1.2°C. Warming trend of maximum 1.2°C, in particular after seventy years, is observed in all Albanian territory. The meteorological data shows that the warming trend is not a monotone one. In short intervals are observed cooling and warming. The meteorological studies have verified warming of the climate during the last quarter of the XXth century, too. It has been consisted that: “Around the 1980’s a warming trend is observed” Demiraj E. et al [2].

The warming period in Albania is accompanied with changes of the rainfall regime, wind speed and wetness (Figure 3). Figure 4 is presented the difference of the total year rainfall quantity in the most dry and wet years, respectively 1907 and 1960. The warming have accompanied with decreasing of the wind speed about 1.5 m/sec and 5% increasing of the wetness.

This warming is part of the global Earth warming during the second half of XX century. Its impact has been observed on some directions:

- Country climate,
- Water systems and water resources. The rainfall regime changes have their consequences in the fresh water resources of the country, of surface’s and underground waters.
- Inland water resources changes have their impact on the hydrographic regime of the Adriatic Sea.
- Soil erosion intensively, forestry etc.

Water potential of Albania is $W_0=41,249.10^9 \text{ m}^3$ that corresponds to a discharge of $Q_0=1304 \text{ m}^3/\text{sec}$, and a module of $q_0=30.1 \text{ l}/\text{sec}.\text{km}^2$. So Albania is one of the countries of a high specific water potential in Europe.

The hydrographical features of the Albanian principal rivers in a Table 1 are presented.

In the Albanian hydrographic network the annual flow distribution is generally characterized by a typical Mediterranean nature with strong flow in winter and weak one in summer. The two characteristics periods are: a) dry water period of the year (VII—IX) and b) wet water period of the year (X-XI). About 20% of the annual flow passes during the dry period, while 80% of it passes during the wet one. Erosion processes in this territory is very intensive especially during the water period.

Water flow of the hydrographic network of Albanian rivers differs in wide limits, not only in different periods of the year, but also in the multi annual cycle because of the of the physic-geographical conditions of the network and especially of the atmospheric precipitation and evotranpiration regime.

To explain the cyclical fluctuations of annual flow of the Albanian river system, have constructed standardized difference-integral curves of module coefficients. The presence of cycles of different duration is characteristic in the fluctuation of river flow.

The value of the coefficient of the water discharge variation is $C_v=0.25$ of the Drini River, $C_v=0.27$ of the Mati River, $C_v =0.27$ of the Ishmi River, $C_v=0.32$ of the Vjosa River, etc.

Evaluation of the yearly flow fluctuation of the Albanian rivers was carried for multi annual period. So, during the multi annual cycle the discharge in the Mediterranean Sea varies in very wide limits, from 700-800 m³/sec for the hydrological years of a low precipitation and from 1800-2200 m³/sec for the hydrological years of a high precipitation.

Albanian rivers are the most turbid in the Europe. The average suspended load discharge concentration of these rivers is $r_0=1260$ gr/m³, the suspended load discharge is $R_0=1650$ kg/sec (in Table 1). One of the important respective indicators to estimate the integral impact of the natural factors in the erosion process is the specific module of the suspended load discharges- η (in ton/km².years). In the Albanian territory hydrographical catchment area, the average specific module of the suspended load discharges is $r_0= 1489$ ton/km².year.

Table 1. The hydrological characteristics of the Albanian principal rivers

Nr	Rivers	F	H	Q	R	r_0	D	W_p	W_f	W_t
1	Drini	11756	971	352	438	1250	1176	13825	2770	16594
2	Mati	2441	746	103	60.0	590	828	2021	505	2526
3	Ishmi	673	357	20.9	45.3	2161	2122	2020	510	2530
4	Erzeni	760	435	18.1	102	5635	4184	3180	795	3975
5	Shkum	2244	753	61.5	187	3040	2373	5800	1450	7250
6	Seman	5649	863	95.7	418	4367	2367	13200	3300	16500
7	Vjosa	6704	855	195	212	1087	997	6710	1680	8390
8	Other	53061	735	105.8	206	1962	1224	6497	1500	7997
9	with out	53737	775	977	-	-	-	-	-	-
10	lakes with lakes	43306	789	1303	1669.1	1707	1489	53252	12510	65763

F-Catchment km²; H-Average altitude m; Q-Water discharge m³/s; R-Suspend load discharge kg/s; r₀-Turbidity gr/m³; D-Module of solid discharge Ton/km²; W_p-Suspend load volume 10³.ton; W_f-Bead load volume 10³.ton; W_τ-Total aluvion volume 10³.ton.

The average annual sediment discharge into Adriatic and Ionian seas is W_T= 65,763.10⁶ ton, from which W = 52,240.10⁶ ton are suspend sediment and W_F⁰= 12,510.10⁶ ton are load sediment (Table 1).

The value of the coefficient of the suspended discharges variation coefficient for the Drini River is C_vR₀= 0.46, for Shkumbini River C_vR₀= 0.66, for Vjosa River C_vR₀= 0.69, etc.

According to the multi annual data the total suspend discharge of the Albanian river system in the Mediterranean Sea varies in very wide limits. Minimal suspend discharge is W_p= 30.10⁶ ton that correspond a specific module of r₀= 967 ton/km² for the hydrological dry years up to maximal values W_F=120.10⁶ ton that correspond a specific module of r₀= 3558 ton/km²for the hydrological wet years.

The relation coefficient η₀=C_v^{R₀}/C_v^{Q₀} in the Albanian river system varies from 1.24 to 2.16. In these conditions, the intensity variation of erosion process depends mainly on the variation of the water discharge variation as well as on other general factors such as evotranspiration and temperature that are linked with climate regime intensity. The relation coefficient η₀ values are presented in the Table 2.

The correlation between annual suspended discharges R_{0,p%} (in ton) and annual water discharge Q_{0,p%} (in m³/sec), (where: p% is probability 1, 2, 5, 10, 20, 50, 75 and 99%) for the Albanian river system are as follows (Figure 5):

$$R_{0,p\%} = 118. \ln Q_{0,p\%} - 322; r=0.96$$

(2)

Table 2. The relation coefficient η₀=C_v^{R₀}/C_v^{Q₀} in the Albanian river system

River s	F Catchment area surfac e km ²	H Avera ge altitud e of the basin m	Q ₀ Wat er dis- char ge m ³ /s	C _v ^{Q₀} Coeffice nt of variation of the water discharg e	R ₀ suspen d load dis- charge kg/s	C _v ^{R₀} is coeffice nt of variation of the suspend load discharg e	η = C _v ^{R₀} /C _v ^{Q₀}
Drini	11756	971	352	0.25	438	0.46	1.84
Mati	2441	746	103	0.27	60	0.33	1.24
Ishmi	673	357	20.9	0.27	45.3	0.61	2.25
Erzen i	760	435	18.1	0.35	102	0.62	1.77
Shku m	2244	753	61.5	0.35	167	0.66	1.88
Sema	5649	863	95.7	0.34	418	0.48	1.54

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Vjosa	6706	855	195	0.32	212	0.69	2.16
Other Rivers	53061	735	109.8	0.35	206	0.50	1.42
without lake	35735	770	977	-	-	-	-
with lake	43304	789	1303	0,35	1669.1	0,58	1.54

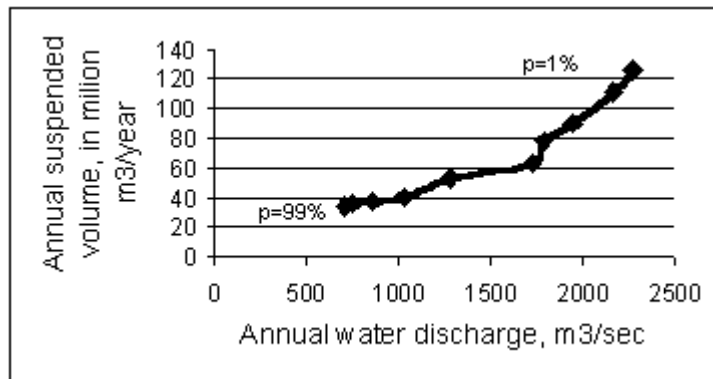


Figure 5. The correlation between annual suspended discharge $R_{o,p\%}$ (in ton) and annual water discharge $Q_{o,p\%}$, of the same probability ($p\%$) in the Albanian river system

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