SPECIFIC ROLES OF SOIL IN AGROECOSYSTEMS OF NERETVA AND TREBIŠNJICA RIVER BASIN

Ferdo BAŠIĆ[1]*, Nevenko HERCEG[2], Darija BILANDŽIJA[3], Ana ŠLJIVIĆ[2]

Original scientific paper UDK 631.4(497.6)

ABSTRACT

The diversity of soils and climate in the Neretva and Trebišnjica River Basin spreads from the lower, higher, high to very high zone over 2,000 meters above sea level. The most important agricultural land is in river valleys and karst poljes of belonging zones. Ameliorative systems are mostly out of function while actual systems are comprised of very intensive farming; vegetable growing, modern fruit plantations on the open field and protected areas (greenhouses), but also of the low-intensity farming system in a mountainous area. The current climate changes obviously are not a temporary phenomenon, but are a specific one; there are no more "dry" or "rainy years" as it was in the past -now we have both in the same year. In spring, the soil needs quick and efficient drainage of the sufficient water by drainage system, but in dry – vegetation period, compensation of water deficiency by irrigation is needed. Therefore, today's generation of decision-makers and users of soil as a public treasure cannot avoid the question as to which soil/land areas and at which way to focus investments. We propose the construction of multi-purpose water accumulation, to collect (excess) precipitation in autumn-winter season for irrigation in dry summer vegetation period, but it is necessary to focus land management on (pedo) biological properties and activity.

Keywords: *Neretva and Trebišnjica River Basin, changing climate conditions, karst polje*

INTRODUCTION AND OBJECTIVE OF RESEARCH

Important territory of agro sphere of Bosnia and Herzegovina (B&H) is the Neretva and Trebišnjica River Basin with associated karst poljes. The Neretva River is the longest (230 km) and the most water abundant river with annually discharge of 11,900 km^3 of high quality fresh water into the Adriatic Sea. Water springs of this river is in Zelengora and Lebršnik Mountains on 1,095 m.a.s.l., at first it flow as alpine river with deep, wild

[1] Croatian Academy of Sciences and Arts, Trg Nikole Šubića Zrinskog 11, 10000 Zagreb, Croatia

[2] University of Mostar, Faculty of Science and Education, Matice Hrvatske b.b., 88000 Mostar, Bosnia and Herzegovina

[2] ana.sljivic@gmail.com

[3] University of Zagreb, Faculty of Agriculture, Svetošimunska 25, 10000 Zagreb, Croatia

*Corresponding author: fbasic@hazu.hr; www.ferdobasic.info

canyon, than wide water valley and is 203 km long in B&H, but the last 22 km of Neretva River is in Croatia, forming a wide picturesque delta on the mouth. Longer and water-richer tributary stream of Mediterranean Sea is only Nile River. The second largest watercourse of B&H is the Trebišnjica River 96.5 km long, having the spring on the foot of Vlajinja mountain near Bileća on 392 m.a.s.l., naturally sinks in ponor of Popovo polje and flows into the Adriatic Sea, but also partly flows underground to Hutovo blato and Neretva River.

The objective of research was to define and explain two specific soil-related services in environmentally sensitive area of Neretva and Trebišnjica River Basin: much more known food- and less known non-food or ecosystem-regulatory roles or services of soil. Because of these, soil-related services going to be more and more important in the light of predicted and expected climate changes. The other objective was to analyse tendencies of climate changes. The special aim was to define water balance and requirements tendencies of requirements of water for irrigation in conditions of intensive agriculture of low (5-100 m.a.s.l.), higher (100-300 m.a.s.l.) and high karst *poljes* (300-700 m.a.s.l.), as well as low intensity farming systems of very high *poljes* (more than 700 m.a.s.l.) and surrounding area.

MATERIAL AND METHODS

For general analyse and evaluation of climate, soils and biological resources, the results obtained in the study of Mišetić *et al*. (2005) for this territory were used.

Characterization of climatic conditions was made according to the data of Meteorological stations Mostar (h = 99 m.a.s.l.), φ = 43°20´53˝ N,λ = 17°47´38˝E) and Ivan Sedlo (h = 967 m.a.s.l. φ = 43°45´04˝ N,λ = 18°02´10˝E) of Federal Hydro meteorological Institute of Federation of B&H in Sarajevo, both for the same series of meteorological data; past series (1961-1990) and recent series of data (2000-2015).

Based on these data, the *Lang's* rain factor (KF) and *Gračanin's* monthly rain factor (KFm) was calculated. Water balance was calculated according to Thorntwhite method and drought conditions were described by monthly index of aridity by UNEP. For the same usable were also published data on this topic of Vlahinić *et al*. (2013), as well as the data from neighbouring county (Mesić, 2009). For characterization of soil, the data of own research in protected areas of Hutovo blato (Bašić, 2012) and Blidinje (Bašić, 2012; Bašić, Herceg 2015), as well as data on soil genesis and evolution on limestone and dolomite (Resulović *et al*. 2008, Bašić 2013, Husnjak, S., 2014) were used. Soil taxonomy was made using the criteria of International soil classification system IUSS Working Group WRB (2015), as well as soil classification according to criteria of Husnjak (2014). For agro ecological valorisation, the own experiences of neighbouring county (Poljak *et al*., 2009; Kisić 2009) were used. Very useful were also results obtained in research of Livanjsko polje (Čustović, Bašić, 2009; Čustović, Herceg, 2013), and data on policy of nature protection in B&H (Herceg *et al*., 2010).

RESULTS AND DISCUSSION

Climate of basin

On entire area two types of climate meet collide, chaotic intertwined and mixed influences of the Mediterranean in the south and the continental climate of the north. Warm, maritime air masses from Adriatic crosses Neretva valley and penetrates by numerous canyons penetrate into the interior. Southern slopes of all mountains in the Basin are exposed to its direct impact As consequence, for example, on Čvrsnica Mountain the Mediterranean flora penetrates very high (Bjelčić, Šilić, 1971; Šilić 2003; Martinić *et al*., 2010; Šaravanja *et al*., 2010). Collision and mixing of air masses cause the sudden change of weather and abundance of snow in winter.

Area of Mostar is located in the circulation zone of mid-latitude during the most of the year. It is under the influence of the subtropical high pressure zone during summer, with dry and warm weather. According to the Köppen climate classification, the location of Mostar has Cfsa climate.

In contrast to the Neretva River valley, the location of Ivan Sedlo in the central mountain region has a sub mountainous climate with maritime characteristics, which are primarily reflected in the annual rainfall regime and moderating air temperature extremes. According to the Köppen climate classification, the location of Ivan Sedlo has Cfsb climate.

Air temperature

According to the data of the past (1961-1990) series at Mostar meteorological station in the Neretva River valley, the annual cycle of air temperature monthly averages has maritime characteristics with autumn being warmer than spring by 1.6°C on average.

In the recent series all analysed indicators of monthly and annual temperatures increased in relation to series from past century (Table 1).

Table 1. Basic statistics of air temperature (°C) for Mostar

	1961-1990						2000-2015					
	MAM	**JJA**	**SON**	**DJF**	**VEG**	**ANN**	**MAM**	**JJA**	**SON**	**DJF**	**VEG**	**ANN**
avg	13.7	23.5	15.3	5.9	20.4	14.6	14.9	25.6	15.9	6.6	21.9	15.7
sd	1.0	0.8	1.0	1.0	0.7	0.4	0.7	1.2	0.8	1.0	0.9	0.5
max	15.2	25.0	17.2	7.6	21.5	15.6	16.4	27.8	17.6	8.8	23.3	16.2
min	11.4	21.7	13.0	3.3	18.8	13.6	13.8	23.4	14.0	4.8	20.3	14.6

**MAM: March, April, May; JJA: June, July, August; SON: September, October, November; DJF: December, January, February; VEG: vegetation period; ANN: annually; avg-average; sd-standard deviation; cv-coefficient of variation; max-maximum; min-minimum*

Considering the ten warmest years and warmest growing seasons in past and recent, all of them (both years and growing seasons) are recorded in the 21st century (Figure 1).

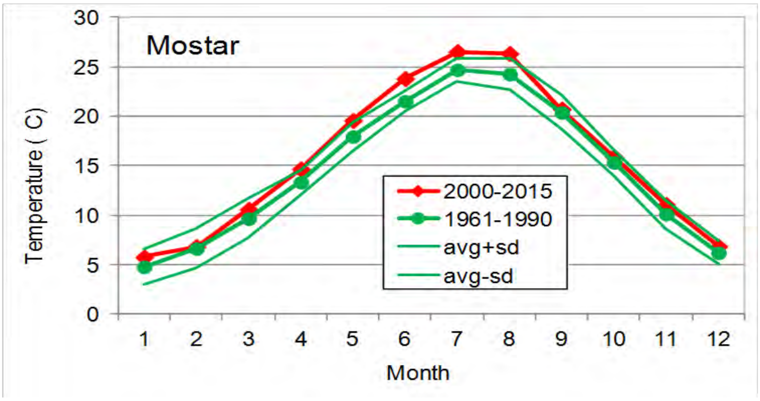

Figure 1. Monthly air temperature of series 2000-2015 and 1961-1990 - Mostar meteorological station

Considering the ten warmest years and warmest growing seasons in both series (46 years), all of them (both years and growing seasons) are recorded in the 21st century. Similar results were obtained by Majstorović (2015), which show an increase of average annual air temperature in B&H in last 100 years for 0.6°C.

According to the data of the Ivan Sedlo during the recent series summer months were warmer and consequently mean summer temperature and mean temperature of the growing period year were higher than in past series of last century (Table 2, Figure 2).

Table 2. Basic statistics of air temperature (°C) for the Ivan Sedlo

Indicators	Past series of data 1961-1990*						Recent series of data 2000-2015					
	MAM	JJA	SON	DJF	VEG	ANN	MAM	JJA	SON	DJF	VEG	ANN
avg	6.8	15.6	8.2	-1.6	13.0	7.2	7.7	16.9	8.9	-0.9	13.9	8.1
sd	1.2	0.8	1.2	1.6	0.6	0.5	0.7	1.1	1.1	1.7	0.8	0.6
max	8.8	17.3	10.1	1.2	14.0	8.3	8.9	19.2	10.8	2.8	15.2	9.0
min	4.0	13.8	6.0	-5.5	11.6	6.4	6.5	15.3	6.0	-3.2	12.9	6.8

**MAM: March, April, May; JJA: June, July, August; SON: September, October, November; DJF: December, January, February; VEG: vegetation period; ANN: annually; avg-average; sd-standard deviation; cv-coefficient of variation; max-maximum; min-minimum*

Of ten warmest years in both - past and recent series means 46 years, nine of them are recorded in the 21st century and of ten warmest vegetation periods of both series, eight of them are recorded in the recent - 21st century, indicated climate warming.

Maritime influence in the annual cycle is reflected in the warmer autumn than spring for 1.4°C. During the year, average monthly temperature begins to decline from mid-summer to the coldest month in the annual cycle (January, -2.7°C) and then increase to the warmest, means July with 16.4°C. It can be expected August as the hottest month as frequently.

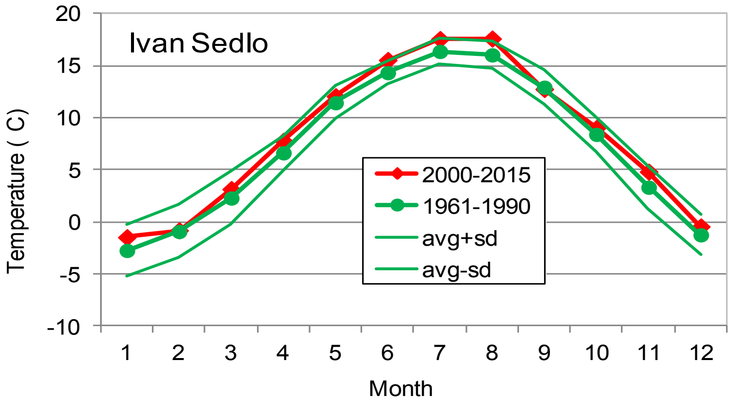

Figure 2. Monthly air temperature of series 2000-2015 and 1961-1990 –Ivan Sedlo meteorological station

Mean temperatures of July ranged 14.7°C - 19.7°C, both are warm (w) and mean January temperatures from -7.8°C - 0.9°C, means from nival (n) to cold (c). Temperature conditions are more stable in the warm part of the year (April to October) than in the cold one (November-March). This is evident from the annual course of temperature variability, expressed by standard deviation, which is the smallest in June and July (1.1°C namely 1.2°C), and the biggest one from January to March (1.8°C, 1.9°C, 2.0°C respectively). During the recent 16-year series 2000-2015, summer months were warmer than long term average, and consequently mean summer temperature and mean temperature of the growing (vegetation) period, as well as for the year were higher than long term average.

In support of theory of "climate warming" are data that of ten warmest years in both of series (46 years), nine of them are recorded in the 21st century and of ten warmest growing seasons eight of them are recorded in the 21st century.

Precipitation – quantity and distribution

According to the 30-year past series of climatic data, Mostar in the Neretva River valley has the maritime annual cycle of mean monthly precipitation. During the cold half-year receives in average 66% more precipitation than in the warm half (Table 3). This water is useful for irrigation in dry and hot summer season, as precondition of vegetable growing in a reasonable intensive farming system on the open field and/or in plastic houses.

Table 3. Basic statistics of precipitation regime for Mostar

Indica-tors	Past series 1961-1990*						Recent series 2000-2015					
	MAM	JJA	SON	DJF	VEG	ANN	MAM	JJA	SON	DJF	VEG	ANN
avg	379.4	196.5	449.8	495.3	522.2	1522.5	343.6	182.6	466.0	529.0	530.3	1494.5
sd	116.7	77.4	156.8	200.3	143.8	287.4	157.7	88.5	163.1	189.8	186.6	425.0
cv	0.31	0.39	0.35	0.40	0.28	0.19	0.46	0.48	0.35	0.36	0.35	0.28
max	748.1	384.9	747.9	873.7	915.6	1987.2	802.1	388.7	873.0	948.3	871.1	2490.7
min	213.0	76.2	172.1	114.1	315.8	840.5	137.4	77.9	168.1	187.3	289.6	872.5

**MAM: March, April, May; JJA: June, July, August; SON: September, October, November; DJF: December, January, February; VEG: vegetation period; ANN: annually; avg-average; sd-standard deviation; cv-coefficient of variation; max-maximum; min-minimum*

Precipitations are in the form of rain, snow is rare and short-lived. There is no clear tendency in precipitation regime, but the tendency of increase of maximal rainfall (more torrential rains). Analysis of precipitation regime shows that there is no clear grouping of “dry” and “wet – rainy” years in the 21st century. Of ten driest years and vegetation periods in the both series (46 years), five of them (both years and growing seasons), are recorded in the 21st century.

According to the past series 1961-1990, mountain meteorological station Ivan Sedlo on average receives 1,469 mm of precipitation (Table 4, Figure 5).

Table 4. Basic statistics of precipitation regime - Ivan Sedlo station

Indica-tors	Past series 1961-1990*						Recent series 2000-2015					
	MAM	JJA	SON	DJF	VEG	ANN	MAM	JJA	SON	DJF	VEG	ANN
avg	370.8	287.7	412.0	402.4	633.6	1469.0	348.4	275.3	482.2	439.6	653.9	1527.0
sd	105.1	106.1	120.5	152.7	144.3	237.3	94.9	96.8	139.0	170.9	198.5	333.9
cv	0.28	0.37	0.29	0.38	0.23	0.16	0.27	0.35	0.29	0.39	0.30	0.22
max	627.8	561.8	691.0	657.3	957.5	1781.5	493.4	402.2	779.1	827.4	1020.6	2510.2
min	205.4	150.9	181.8	80.5	393	976.4	182.6	90.7	210.5	154.2	313.5	1041.1

**MAM: March, April, May; JJA: June, July, August; SON: September, October, November; DJF: December, January, February; VEG: vegetation period; ANN: annually; avg-average; sd-standard deviation; cv-coefficient of variation; max-maximum; min-minimum*

The distribution of rainfall during the year is under the maritime influence, having the primary maximum in late autumn (November, 169 mm), but from February to April a spreading secondary maximum of about 135 mm. In the recent series small changes in mean annual and seasonal regime has occurred in relation to series of data of past century (from 6% to 9%) except in autumn when an increase of 17% is recorded.

Our analyse shows that of ten driest years and growing seasons in analysed 46 years, such a three years and growing seasons are recorded in this century as well as two of ten rainy years and five of ten growing seasons are also recorded in the 21st century. Speaking on precipitation tendency, truth to say, there is no humidity increasing tendency of climate.

Results of hydrological analyse of Brilly *et al*. (2015) suggest the frequent flood as indicator of precipitation regime.

According to Lang's rain factor, as visible in Table 5, area of Mostar is characterised by humid climate (H) in both studied series, but with lower rain factor – KF in recent series.

Table 5. Rain factors as indicator of humidity – Mostar station

Analysed series	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
1961-1990	34.3	23.1	15.5	9.5	5.7	3.6	1.8	3.0	4.7	10.0	19.8	28.8	104.3 – H
	ph	ph	ph	h	sh	sa	a	a	sa	h	ph	ph	-
2000-2015	30.8	21.7	13.0	8.3	4.3	3.0	1.8	2.3	6.8	9.8	15.2	25.6	95.0 - H
	ph	ph	h	h	sa	a	a	a	h	h	ph	ph	-

Abbreviations: ph-per humid; h-humid; sh-semi humid; sa-semiarid, a-arid

Comparing the *Gračanin's* monthly rain factors (KFm) in studied series, it is visible that KFm of all months is lower in recent serie compared to past serie June became arid and along with July and August there are three months with arid characteristics. Contrary, September is the only month more humid in the recent serie compared to past one.

Contrary of situation in Mostar according to *Gračanin's* monthly rain factors (KFm), area of Ivan Sedlo has per humid climate in both of studied series of data (Table 6).

Table 6. Rain factors as indicator of humidity – Ivan Sedlo station

Analysed series	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
1961-1990	-	-	58.5	20.0	9.1	7.4	5.0	6.2	8.5	15.9	51.0	-	204.0 - PH
	-	-	ph	ph	h	h	sh	sh	h	ph	ph	-	-
2000-2015	-	-	37.9	14.9	9.3	7.1	5.1	4.2	11.8	18.7	33.8	-	187.6 - PH
	-	-	ph	ph	h	h	sh	sa	h	ph	ph	-	-

Abbreviations: ph-per humid; h-humid; sh-semi humid; sa-semiarid, a-arid

Comparing the monthly rain factors in studied periods, it's visible that one month (August) only has become more arid and September more humid in the recent serie.

Thresholds of cardinal temperatures and vegetation period

Minimal temperature by which starts the biological activity of continental crops/plants, in the spring and stops in autumn is 5°C, for thermophilic plants vegetation starts at 10°C, but for Mediterranean cultures the threshold is 15°C (Mesić, 2009).

Table 7 presents the start, end and duration of periods with selected cardinal temperatures of 5, 10, and 15°C in Mostar.

Table 7. Thresholds and duration of cardinal temperatures in Mostar

Analysed series	Thresholds of temperatures, °C								
	5°C - vegetation period of continental cultures, date of:			10°C - vegetation period of termophilic cultures, date of:			15°C - vegetation period of Mediterranean cultures, date of:		
	Start	End	Duration	Start	End	Duration	Start	End	Duration
1961-1990	18.I	8.I	355 days	18.III	16.XI	244 days	26.IV	17.X	175 days
2000-2015	01.I	31.XII	365 days	11.III	23.XI	258 days	17.IV	21.X	188 days

The mentioned indicates that vegetation periods with temperatures above 5, 10, and 15°C in Mostar prolonged respectively by 10, 14, and 13 days in the recent period compared to past century.

Table 8 presents the start and end of vegetation periods for plants with cardinal temperatures of 5, 10, and 15°C of area of Ivan Sedlo meteorological station.

Table 8. Thresholds and duration of cardinal temperatures in Ivan Sedlo

Period	Thresholds of temperatures, °C								
	5°C - vegetation period of continental cultures, date of:			10°C - vegetation period of termophilic cultures, date of:			15°C - vegetation period of Mediterranean cultures, date of:		
	Start	End	Duration	Start	End	Duration	Start	End	Duration
1961-1990	3.IV	4.XI	216 days	6.V	4.X	152 days	25.VI	25.VIII	62 days
2000-2015	27.III	13.XI	232 days	1.V	7.X	160 days	10.VI	31.VIII	83 days

The period with temperatures above 5, 10 and 15°C in Ivan Sedlo prolonged by 16, 8 days and 21 days respectively in recent series compared to the past one. Means in the area of Ivan Sedlo there are thermic conditions for grass, some cryophilic plants, like rye, potato, cabbage and some shorter FAO groups of maize, but “late frost” is permanent risk for spring crops.

Water balance by Thornthwaite method

Calculation of water balance by Thornthwaite method of Mostar area during the series 1961-1990, shows the average actual evapotranspiration of 679 mm, total annual water surplus 844 mm, while deficiency is 126 mm and occurs in vegetation period during July and August (Figure 3 left).

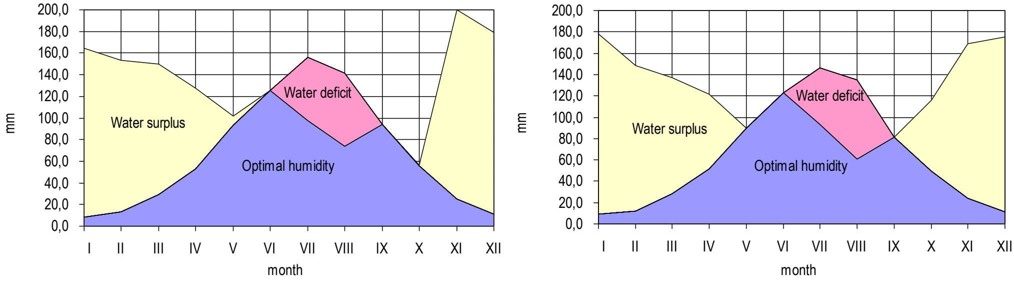

Figure 3. Water balance by Thornthwaite for Mostar 1961-1990 (left) and 2000-2015 (right)

Comparing the surpluses and deficiencies it is visible that there is no significant difference.

For Ivan Sedlo, during the past series actual evapotranspiration amounts 560 mm and the soil water reserves decrease during July and August. The total average annual water surplus is 909 mm while water deficiency is not registered (Figure 4 left).

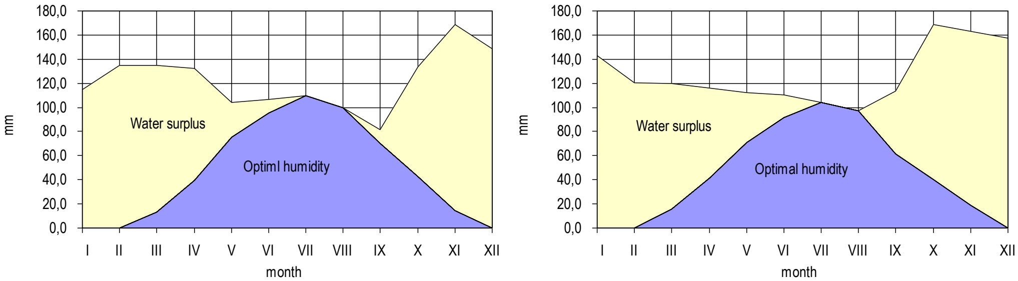

Figure 4. Water balance by Thornthwaite for Ivan Sedlo 1961-1990 (left) and 2000-2015 (right)

In recent series actual evapotranspiration is 542 mm and soil water reserves decrease during July and August. The total average annual water surplus is 985 mm while water deficiency is not registered (Figure 7 right).

Index of aridity according UNEP

We used monthly index of aridity - IA_U = rainfall (mm)/potential evapotranspiration created by FAO/UNEP for numerical identification of desertification (Tsakiris, Vangelis 2005).

Table 9. Indicators of water balance - Mostar

Series of meteorological data		Month $AI_U = P^*/PET$						Annually mm		
		IV	V	VI	VII	VIII	IX	P*	D	S
Past series 1961-1990.	Average	-	-	0.62	0.29	0.52	-	1,522.0	126	843.7
	Dry 1983	-		0.33	0.13	0.44	-	840.5	265	308.5
	Rainy 1979	-	0.44	0.55	-	-	-	1,987.2	81	1,271.0
Recent series 2000-2015.	Average	-	-	0.59	0.33	0.45	-	1,494.5	127	861.1
	Dry 2011	0.58	0.91	0.25	-	0.16	0.35	872.5	187.0	318.7
	Rainy 2010	-	-	0.17	0.34	-	-	2,490.7	156	1,865.2

**P – Precipitations in mm, PET - potential evapotranspiration in mm D – water deficiency in mm S – water surplus in mm*

sub humid (0.50< AI_U <0.65)	*semiarid (0.20< AI_U <0.50*	*arid (0.05< AI_U<0.20)*

In dry years of recent series dry period begins in April and ends in September, July were not dry but August was the driest. In rainy year June was the driest. Problem is surplus from 18,650 m^3 water, causing soil erosion and floods on one, but drought on the other side.

Situation in Ivan Sedlo (Table 10), compared with long-term average, has surprisingly been changed. Usually humid area has become arid in dry, but semiarid in July and sub humid in in August in rainy year.

Table 10. Indicators of water balance – Ivan Sedlo

Series of meteorological data		Month $AI_U = P^*/PET$			Annually mm		
		VI	VII	VIII	P	D	S
Past series 1961-1990.	Average	-	-	-	1,469.0	0	909.3
	Dry 1990	0.60	0.58	0.61	976.4	25	441.2
	Rainy 1984	-	0.50	-	1,781.5	0	1,205.5
Recent series 2000-2015.	Average	-	-	-	1,527.0	0	985.2
	Dry 2011	-	-	0.10	1,041.1	0	506.1
	Rainy 2010	-	0.27	0.71	2,510.2	9	1,976.4

**P – Precipitations in mm, PET - potential evapotranspiration in mm; D – water deficiency in mm, S – water surplus in mm*

sub humid (0.50< AI_U <0.65)	*semiarid (0.20< AI_U <0.50*	*arid (0.05< AI_U<0.20)*

Water surplus in recent series is higher than in past one, even extremely high.

Climatic conditions of the of Neretva and Trebišnjica River Basin are strongly influenced by winds, especially in autumn, winter and early spring. The most frequent winds are bura and jugo. Bura is northern and north-eastern, but jugo is the southern wind. Citing the other authors Ćorić (2009) states that winds decrease the temperature, quickly dries the soil and significantly decrease air saturation with water Which means that the area is much drier than it express analysed and presented indicators of climate.

The unfavourable distribution of precipitation during the year, with a large surplus in the cooler and deficiency in the warmer part of the year is the main characteristic of precipitation regime and water balance in the Basin. The rational and reasonable solution is to collect water surplus in (mini)multi-purpose accumulation and use this water for irrigation in dry period. Agriculture should be protected of both extremes - drought and floods.

SOILS OF NERETVA AND TREBIŠNJICA RIVER BASIN

Specifics of soil genesis and evolution

Dominant parent rocks generating mineral component of soil in Neretva – Trebišnjica Basin are hard Mesozoic, on southern part dominantly cretaceous but in northern older - Triassic and Jurassic) limestone and dolomites, typical for B&H karst. Loose parent materials are localy widespread (Ljubuški, Dubrave) as flysh (layers of marl in change with thin layers of sandstones), soft Miocene limestones, marly limestones and marl.

Soils are formed in complex long-lasting processes of soil genesis as interaction of climate (atmosphere), rock (lithosphere) fauna, flora - vegetation and living macro and microorganisms (biosphere) described in numerous references of B&H famous older and active soil scientists (Resulović, Vlahinić 1972; Resulović 1999; Resulović *et al*., 2008; Ćorić 2009). The duration of soil genesis depends mainly on the characteristics of the parent rock or substrate from which originate mineral component of soil. On the limestone, as the most widespread rock in the Basin, soil formation takes a long time as process of dissolution of limestone and accumulation of non-soluble residue. Time that is necessary for formation of a 1 cm thick soil layer (in the absence of wind/water erosion) is at least 8 000 years. Mentioned above means that for formation of a 100 cm thick soil layer, which would to be a good agricultural soil, approximately is necessery one million, but for Feralsol $_{\mathbf{rhodic}}$ - Tera rossa, according to Durn (1996*)* even two millions years!!!

If there is no interruption, soil genesis and evolution on hard limestones and dolomites shows the sequence of soil types and subtypes, as members of soil evolution series as follows:

LITHOSOL$_{\mathbf{calcaric/dolomitic}}$ (starting - initial accumulation of humus) →**LEPTOSOL** $_{\mathbf{calcaric/dolomitic}}$, **UMBRISOL**$_{\mathbf{leptic/skeletic}}$ - **MELANOSOL**$_{\mathbf{calcaric}}$ – humus-accumulative soils**;**

organogenic (humus accumulation with small mineral component – insoluble residue of limestone or dolomite) →**organomineral** (along with humus accumulation of mineral component – insoluble residue) →**cambic** (increased mineralization of humus and the accumulation of mineral component in residual horizon)→**CAMBISOL**$_{\mathbf{calcaric/dolomitic}}$ or – **FERRALSOL**$_{\mathbf{rhodic}}$ **(**or **TERRA ROSSA** according of Resulović *et al*. 2008, and Husnjak 2014 classification**)** (increased depth of mineral component, decreased humus content because of intensive mineralization) →**LUVISOL on limestone** (along with decreased humus content, elluvial-illuvial migration of clay and differentiation of clay content in soil profile).

All members of series are described in cited literature we could find for territory of Neretva-Trebišnjica Basin, but with different distribution in concrete zone. Because of geomorphological condition, soil genesis can be interrupted mostly by wind and/or water erosion, soil material can be removed to stable topographic position and settled to the foothill or in karst *poljes,* as multi-layers Colluvium. Soil genesis on the parent rock starts again – till the new interruption or till vegetation covers and protects from erosion.

In regularly recently flooded valleys of Neretva, Trebišnjica and tributaries there are Fluvisols, as multilayer soils transported by river water and deposited in floodplain. These soils are in rule very favourable and fertile, but with limited choice of crops – exclusive spring crops sown after regularly winter-spring floods, but on protected and drained land this type of soil is very favourable. Under influence of permanent stagnation of shallow water, as in Hutovo blato there are formed soils reach by organic matter accumulated in anaerobic – water condition – Histosol, with luxuriant specific hydrophilic plant cover. In wider valleys under influence of underground and/or flood water - Gleysols, with typical horizon of bluish colour.

Colluvial soil is a heterogeneous mixture of different soil material that, as a result of gravitation has moved down a slope and settled at its base, in depressions or above a barrier on a low-grade slope (natural or human-made, like hedge walls) or in karst *polje*. It has been transported across and redeposited on slopes as a result of erosional wash but may also be translocated by ploughing. It has been formed in relatively recent times (mostly Holocene), may show some stratification but it is not a typical feature due to the diffuse or chaotic nature of the deposition process.

SOIL-ORIGINATED TERRESTRIAL ECOSYSTEM EFFECTS

Soil is an essential part of all terrestrial ecosystems and milieu whence life (plant) originates and ends, or "an active biochemical factory fundamental for the Earth's food chain" (Arnalds, 2009), means agriculture and forestry as branches of economy crucial for sustainable development. The "Soil-originated terrestrial Ecosystem Effects - SOTEE" arise from soil functions affect the quality of life as the basis of FFFT effects (Food, Fibre, Fuel, Timber, means food security, food safety, source of fiber, biofuels and timber), determine the regional characteristics of the Multifunctional Character of Agriculture and Land

(MFCAL), on which the modern civilization bases sustainable development and formulates its attitude to soil as a natural resource (Bašić 2012, 2013). Concept of MFCAL places equal importance on the productive and ecological regulatory effects-roles of soil. On some areas (agricultural and forest land of high quality) prevalent would be organic matter (FFFT)-productive SOTEE, maximal respected in creation of land management system. On other areas, like protected one (national parks, parks of nature, water protecting area) prevalent SOTEE would be environment regulatory functions - services. The first one is known from very beginning of Soil science, rising within agricultural/forestry sciences, but environment regulatory is of recent origin.

SOTEE arise from interaction of members of so known ecological triad: soil-water-air, as components of terrestrial ecosystems (Varallyay, 2005). In spite of its importance as a unique natural body soil is in a special position in this triad. Namely, air and water are undoubtedly protected as “public properties”, but soil (land) is traditionally one of basically private property. “Demand of the time” is protection of soil and ecosystems by regulation and direction of all practices on land and other resources management on a sustainable way. International, regional, state and local agreements, declarations, regulations, directions, rules and acts are so numerous that property rights of land owners and/or users are reduced on »rights« to work and be responsible for own work according to obligation arise from “out-farm” created decisions. It means; public regulation and legislation but private ownership and responsibility, or; own risk and responsibility for public interest and regulations! Our generation is on global level, on certain crossway where is necessary to find new – better and sustainable relation of land-owners on one, and public interest on the other side, which would reconcile profitability and sustainability in land management. Of course, with awareness of decision makers (politician) and public that there is no sustainable development without sustainable land management on the way which guarantee long-term SOTEE on desired level, including the awareness that tomorrow can be (too) late!

SOTEE in organic matter (Food) production – FFFT

Agriculture, forestry and land management directly affect the appearance of the landscape, the possibility of tourism development and the use of natural resources of the Basin. As stressed by Čustović (2012) and Vlahinić *et al*. (2003) karst *poljes* are with an area of 123,556 ha crucial for agriculture in Herzegovina, divided on the base of latitude:

Low karst *poljes* (19,299 ha)

This category includes karst *poljes* of the altitude 5 to 100 m.a.s.l.: Ljubuški (6,362 ha), Hutovo Blato (4,357 ha), Gabela (1,070 ha), Stolac - Vidovo polje (320 ha) and Mostar polje (4,000 ha). Ameliorative and flood protection systems are more or less in poor condition, some are totally destroyed and of any function (Ćorić 2009; Ćorić *et al*. 2013).

Higher karst *poljes* (25,865 ha)

Tthis category includes karst *poljes* of the altitude zone 100 – 300 m above sea level: Mostar blato (4,140 ha), Imotsko-Bekija *polje* (5,100 ha), Plateau Brotnjo (3,745 ha), Mokro (260 ha), Popovo (4,415 ha) - Construction of HPP, Trebišnjica river-bed trough the *polje* is regulated. Done complex reclamation of soil with irrigation on about 900 ha of land, described by Lučić (2012) Dubrave (7,000 ha), Trebinje-Dživar (1,205 ha).

Generally, land reclamation and floods protection systems are in-complete. The land is threatened by frequent floods and lack of water in dry summer. Existing facilities are unable to protect against the floods.

High karst *poljes* (10,689 ha)

In this category we can find karst *poljes* of the altitude zone 300 - 700 m above sea level: Kočerin (685 ha), Vir – Posušje (3,840 ha), Dabar (3,300 ha), Fatničko (564 ha), Bileća (640 ha), Ljubomir (810 ha) and Ljubinje (850 ha).

The predominant is an extensive crop - animal production as a consequence of unregulated water regime. In spite of water deficiency in soil, especially in summer, irrigation is not practice. According of criteria of EU this area can be designated as “less-favoured area” because of natural handicaps, e.g. unfavourable climatic conditions, short growing season due to the high altitude, steep slopes in mountain areas, and/or low soil productivity. Due to these handicaps there is a significant risk of agricultural land abandonment and thus a possibility of loss of biodiversity, desertification, forest fires and the loss of highly valuable rural landscape. To mitigate these risks, the Less Favoured Areas (LFA) payment is an important tool. Payments should contribute to continued use of agricultural land, maintaining the countryside, maintaining and promoting sustainable farming systems (Bašić, Herceg 2013; Kisić 2009).

Very high karst *poljes* (67,703 ha)

Very high are karst *poljes* of the fourth altitude – over 700 m above of sea level: Gatačko (3,183 ha), Nevesinje (17,000 ha), Livno (34,810 ha) and Duvno (12,710 ha).

Irrigation system was built. Completed flood protection to approximately 3000 ha of land, without irrigation in the building is a system for 900 ha system for basic and detailed drainage. There is a requirement for irrigation, basic and detailed surface drainage pipe drainage. And this zone can be designated as LFA.

Generally, all karst fields in Basin need investment in flood protection, drainage and irrigation system. The main limited factor in plant growing on the whole territory is unfavourable distribution of water, with deficiency in vegetation period but surplus in rest of the year. Building of multipurpose water accumulation offers rational solution (Tomić *et al*. 2013).

Environment regulatory (Non-food) SOTEE - Soil is a regulator!

Soil as a receptor and collector (accumulator) of different substances

With regard to position "between" the lithosphere and atmosphere, direct contact with the hydrosphere and anthrophosphere - biosphere, soil is acceptor of substances falling on it (acid rain and dry deposition - dust) or residues of pesticides, nitrates used in agriculture, that are environmentally relevant for all members of the biosphere and environmental components, especially water.

Soil as natural transformator!

All organic substances in the soil are exposed to (micro) biological destruction, transformation, and synthesis of new compounds, or degraded and immobilized to substances with which photosynthesis begin, means CO_2 and water, as the first and last link in the cycle of small or biological cycling of matter and energy. Similarly, in a harmless form, soil is transforming all organic pollutants such as polycyclic aromatic hydrocarbons (PAH), residues of pesticides and petrochemicals. Soils immobilize organic pollutants.

Soil as natural filter of water – Soil preserves drinking water!

The function of soil as universal cleaner (filter) is to filter rainwater and protects underground drinking (potable) water from pollution. Practically all waters in Neretva and Trebišnjica basin are drinking waters, protection of which is of extremely high importance (Bašić, 2013; Bogunović, Ćorić, 2014; Čustović, 2012; Herceg ,2013).

Climate regulatory SOTEE – Soil is source and sink of glasshouse gases!

Soil is a source of emissions of greenhouse gases, primarily CO_2. Namely, soil is the final link in the chain of biotransformation of organic carbon, which results is CO_2 and water as final products – the same one which starts in process of plant photosynthesis. It means that soil is also the sink of CO_2! Layers of the soil completely saturated with water in the absence of oxygen, carbon transformations finished with formation of methane – CH_4, as greenhouse gas more effective than CO_2. Although the total content of organic matter – humus in the soil (humosphere) is low – negligible (1-3%) humus is a public treasure of the most importance. Humus regulates chemical and biological processes, the food and energy source of soil microorganisms or “fuel” for “biologically fire”, as the basic factor of sustainable agriculture intensification. Its positive impact on soil structure strongly influences the water-air relation and hydrothermical conditions of soil, with high influence on soil fertility (Bašić, 2013).

Soil as buffer system

Working as a powerful buffer system, soil inactivates all substances that rapidly enters its mass or were released by mineralization of organic matter and prevent the stress of change in the soil, shocks to the biosphere.

Soil (land) as the space of natural and anthropogenic structures

Pedosphere provides space for agriculture, forestry, expansion of settlements, urban areas, roads, recreational area, and finally space for waste management. When making decisions on trace of roads – highways in Neretva and Trebišnjica Basin, solution should be the shortest possible route intersect karst *poljes* or river valleys with fertile soils. Faulty decisions on location can cause permanent and far-reaching consequences for the use of these facilities.

Soil as medium for waste disposal – On/in soil terminates all wastes!

Waste disposal is one of the spatial functions of soil**.** The choice of location is very delicate and absolutely highly professional matter. Regarding the soil, the basic requirement for good accommodation is the location of the landfill in Neretva and Trebišnjica river basin which excludes the possibility of pollutant emissions into the environment, especially water, but also air or biosphere - the plant life at the landfill or around it. Landfills take space - an agricultural land, a discharge from the landfill can be a source of contamination of soil, water and air pollution, which threatens human health, livestock and wildlife (Bašić, 2013).

SOTEE as foothold of biodiversity!

Soil is a habitat and gene reserve of number of micro-and macro-organisms, starting and ending points of the biological cycling, gene reserve and the foundation of biological diversity one of the major factors in the balance of nature. Means: soil diversity – biodiversity!

The number of living organisms below the surface is many times higher than on the soil surface, which is eloquently illustrated by the fact that good, fertile soil in the arable layer contains about 25 tones/ha of living organisms, including a number of extremely useful, such as symbiotic (genus *Rhizobium*) and non-symbiotic nitrogen fixing bacteria (*Azotobacter, Clostridium pastorianum*) that are using elemental nitrogen from the air and transforming it into a plant available form. What is more fertile soil, the total number of organisms and their diversity increases. Biotechnology is seeking the way to manage beneficial soil biological processes in the desired direction.

SOTEE in landscape shaping – the base of natural beauties!

The man in the natural landscape "impressed" their "messages". Changing the natural vegetation, and entering into the space created by agriculture is the "cultural landscape" due to natural conditions and enriches the space and makes it even more beautiful, affordable and attractive for rural tourism. Anthropogenic influence may be so radical (for example terracing of surface) that natural landscape completely changes in anthroscape.

Soil as a source of raw materials

Soil is an important source of raw materials, especially for the construction industry, such as the excavation of stone, soil for brick, then digging clay for ceramic crafts and industry, the use of sand and gravel as building materials, bauxite from Terra rossa, or the use of peat as a raw material for the production of substrates for closed spaces (greenhouses).

The archival SOTEE – Soil is conservator of natural and human heritages!

Conserving various geogenic and soil genesis shaping, soil keeps information on the conditions during the soil genesis that are useful for interpretation of soil evolution. Means; soil is containing the archaeological evidence of the history of humanity and is an information source for the reconstruction of human life and its activities witnessed by the archaeological remains covered by soil and protected from devastation and destruction.

Taking all in account, shortly described food- and non-food effects of soil-generated terrestrial ecosystems it can be understandable at first that soil as indeed the most complex system known to science is the medium which supports life in its broadest sense. Soil is more than (public) good; it is heritage of past generations, which obligate us ahead of coming generations. Soil science is a Life-science! The frame of agricultural and forest sciences within which Soil science started and developed is going to be (to) narrow!

CONCLUSIONS

The Neretva and Trebišnjica River Bain is a kind of "arena" in which two contrast types of climate meet collide, chaotic intertwined and mixed influences of the Mediterranean in the south and the continental climate in the north.

The durations of vegetation periods in Mostar prolonged respectively by 10-14 days in the recent compared to past century.

As these changes are chaotic and unpredictable, irrigation should be obligate practice in the new climatic conditions, in spite of water surplus from 318 mm in dry year to 1865 mm in rainy one, which means 18,650 m^3/ha/year of water causes soil erosion and floods, but also drought is a regular event on the other side.

The vegetation periods with temperatures above 5, 10, and 15°C in Mostar prolonged respectively by 10, 14, and 13 days in the recent period compared to past century.

The unfavourable distribution of precipitation during the year, with a large surplus in the cooler and deficiency in the warmer parts of the year is the main characteristic of precipitation regime and water balance in the Basin. The rational and reasonable solution is collection of water surplus in (mini)multi-purpose accumulation and use of mentioned water for irrigation in dry periods. Agriculture should be protected of both extremes - droughts and floods.

On hard limestones and dolomites there is soil evolution series: Lithosol→ Leptosol, Umbrisol, Melanosol→ Cambisol, Ferralsol, Terra rossa → Luvisol.

On global level our generation is on certain crossway where is necessary to find new – better and sustainable relation of land-owners on one, and public interest on the other side, which will reconcile profitability and sustainability in land management.

Taking all into account, shortly described food- and non-food effects of soil-generated terrestrial ecosystems we can say; soil is more than (public) good; it is heritage of past generations which obligate us ahead for coming generations.

Soil science is a Life-science! The frame of agricultural and forest sciences within which Soil science started and developed is going to be (to) narrow!

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