

**EWA Green Capital Event: Sustainable Urban Drainage Solutions (SUDS)**

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**Sustainable Urban Hydrological Systems in Sarajevo**

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- Sarajevo is the largest and at the same time the capital city of Bosnia and Herzegovina
- 275,524 inhabitants in the city itself (4 municipalities, P= 141,7 km<sup>2</sup>).
- In the wider area of the city, including the Sarajevo Canton (1276.9 km<sup>2</sup>), East Sarajevo and the suburbs, the home found 555,210 inhabitants.
- The city is surrounded by the Dinaric Alps along the Miljacka River in the heart of the Balkans.



Grad Sarajevo  
City of Sarajevo

From top, left to right: Sarajevo panorama, Emperor's Mosque, Sarajevo Cathedral, Orthodox Cathedral, Sarajevo Library, Latin Bridge, and Sebilj.

Flag

Seal

Nickname(s): "Jerusalem of Europe"<sup>TM</sup>  
"Jerusalem of the Balkans"<sup>TM</sup>; "Saber, Rajevica"<sup>TM</sup>

Sarajevo has a **humid continental climate**.

The average yearly temperature is 10 °C (50 °F):  
-January (-0.5 °C (31.1 °F) on average) being the coldest month of the year and  
- July (19.7 °C (67.5 °F) on average) the warmest.

Sarajevo is surrounded by five great mountains (Treskavica, Bješnica, Jahorina, Trebević, Igman) which have a big influences on the climate.



Olympic mountain Bješnica's tallest peak, by which the whole mountain group got its name, rises to an elevation of 2067 meters (6782 feet).  
Olympic mountain Jahorina highest peak Gogorjica, has a summit elevation of 1 916 meters (6,286 ft)  
- Treskavica at 2.088  
- Trebević at 1.627 meters  
Territorial Position of Sarajevo: Situated in the area called Sarajevsko Polje. The average altitude of urban center of Sarajevo is 518 m.

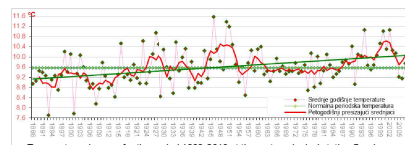
In 2011 Sarajevo was the first city outside the European Union to be nominated for the European Capital of the Culture

**(1961-2014)**

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	18.2 (64.8)	21.4 (70.5)	26.6 (79.9)	30.2 (86.4)	33.2 (91.8)	35.9 (96.6)	38.2 (100.8)	40.0 (104.0)	37.7 (99.9)	32.2 (90.0)	24.7 (76.5)	18.0 (64.4)	40.0 (104.0)
Average high °C (°F)	3.7 (38.7)	6.0 (42.8)	10.9 (51.6)	15.8 (60.4)	21.4 (70.5)	24.3 (75.7)	27.0 (80.6)	27.2 (81.0)	22.0 (71.6)	17.0 (62.6)	9.7 (49.5)	4.2 (39.6)	15.8 (60.4)
Daily mean °C (°F)	-0.5 (31.1)	1.4 (34.5)	5.7 (42.3)	10.0 (50.0)	14.8 (58.6)	17.7 (63.9)	19.7 (67.5)	19.7 (67.5)	15.3 (59.5)	11.0 (51.8)	5.4 (41.7)	0.9 (33.6)	10.1 (50.2)
Average low °C (°F)	-3.3 (28.1)	-2.5 (27.5)	1.1 (34.0)	4.8 (40.6)	9.0 (48.2)	11.9 (53.4)	13.7 (56.7)	13.7 (56.7)	10.8 (50.0)	6.4 (43.5)	1.9 (35.4)	-1.8 (28.8)	5.4 (41.7)
Record low °C (°F)	-26.8 (-16.2)	-23.4 (-10.1)	-16.4 (-7.9)	-13.2 (-8.8)	-9.0 (-15.8)	-3.2 (26.2)	-2.7 (27.1)	-1.0 (30.2)	-4.0 (24.8)	-10.9 (12.4)	-19.3 (-2.7)	-22.4 (-8.3)	-16.2 (-16.2)
Average precipitation mm (inches)	68 (2.7)	64 (2.5)	70 (2.8)	77 (3.0)	72 (2.8)	80 (3.1)	72 (2.8)	66 (2.6)	91 (3.6)	88 (3.5)	85 (3.3)	86 (3.4)	92.8 (36.5)
Average rainy days	8	10	13	17	17	16	14	13	15	13	12	11	15.9
Average snowy days	10	12	9	2	0.2	0	0	0	0	2	6	12	53
Average relative humidity (%)	79	74	68	67	68	70	69	69	75	77	76	81	73
Mean monthly sunshine hours	57.1	83.8	125.6	152.3	191.7	207.1	256.3	238.2	186.6	140.8	81.2	40.7	1,769.4

The **highest** recorded temperature was 40,7 °C (105 °F) on 19 August 1946, and on 23 August 2008 (41.0).  
The **lowest** recorded temperature was -26.2 °C (-15.2 °F) on 25 January 1942.

On average, Sarajevo has 7 days where the temperature exceeds 32 °C (89.6 °F) and 4 days where the temperature drops below -15 °C (5 °F) per year.



Temperature changes for the period 1888-2010 at the meteorological station Sarajevo - Bješnica

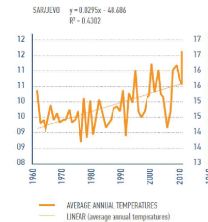


Chart 23: Trends of air temperature changes in Bosnia and Herzegovina

- Studies of temperature change for the period 1961-2010 indicate that temperatures have increased in all areas of the country.
- In the analysis of multi-year series of data (1961 – 2014) by years, a positive linear trend was observed in mean annual temperature, which is especially pronounced in the past 30 years, since 1982.

**Changes in air temperature**

Sarajevo	Year	Vegetation period	Spring	Summer	Autumn	Winter	
	1961-1990	9.7	15.7	9.7	16.3	10.4	0.4
	1961-2010	10.1	16.2	10.0	19.1	10.5	0.7
	Deviation	0.4	0.5	0.3	2.8	0.1	0.3
	2001-2010	10.4	16.5	10.3	19.6	10.6	1.1

The increase in annual air temperature are about 0.4 °C,

However, increases in air temperature over the last fourteen years are even more pronounced.

## PRECIPITATION

- In recent years there has been a pronounced impact of climate change on rainfall regime with the consequences on water resources
- The consequences of these changes are reflected in the distribution of rainfall during the year.

Changes in the amount of rainfall are more pronounced by seasons than annually.

	Year	Vegetation period	Spring	Summer	Autumn	Winter	
Sarajevo	1961-1990	932	468	276	242	241	223
	1981-2010	936	472	221	236	266	213
	Deviation	+4.0	+4.0	-5.0	-6.0	+25.0	-10.0
	2001-2010	1014	514	226	252	304	226

The largest increase – in the central mountains area – Bjelašnica and Sokolac

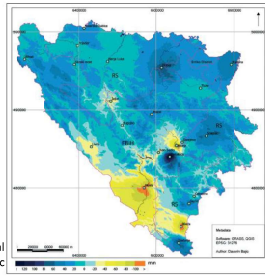
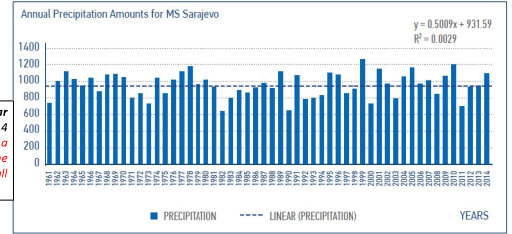


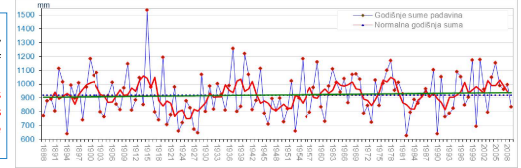
Figure 6. Changes in annual precipitation in Bosnia and Herzegovina [1981-2010 compared with 1961-1990]

## Precipitation regime

Linear trends for multi-year period from 1961 to 2014 indicate stagnation or a slight increase in the amount of rainfall



Although the level of annual precipitation has not significantly changed, a decrease in number of days with rainfall above 1.0 mm and an increase in the number of days with intense rain events has significantly distorted the pluviometric regime.



<https://youtu.be/kWo1LDagMDU>



Due to the increased intensity of rainfall and its greater variability, as well as due to the increased share of heavy rains in the total amount of rainfall, there is the increased risk of flooding especially in the north-eastern part of BiH, where the most disastrous floods in history have been recorded during May 2014.

Urban floods from storm waters are very often - What we can do?

- The method of collecting storm waters in Sarajevo is still conventional.



Floods after rain in Sarajevo



- The sewage system of Sarajevo is mostly designed as separate (on some part, exists combined system) - but still not efficient

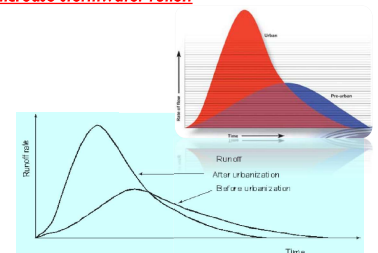
This video was made in Sarajevo, 04.06.2019., after a 5-minute rain



Natural hydrological system are affected – increase stormwater runoff

- Negative effects of urbanization and climate changes are recognized in Sarajevo.

- Increased peak discharge of runoff
- Increased volume of runoff
- Reduced time of concentration
- Reduced base flow from the catchment
- Increased wastewater flow/drainage flow



Urbanization – poor water quality

## CONCLUSIONS

1. According to the previous slides, it is evident that the **existing urban water sewage** system in Sarajevo **should be improved by application of new technologies**, (new sustainable and integrated approach has main aims to generate less runoff and to improve water quality).
2. **Urban Storm Water Management (USWM)**– include **re-use of rainwater, water catchment systems in the basin, infiltration, and only rainwater excesses are eventually released into the environment under conditions** that will not endanger the water.
3. New USWM approach (**sustainable and integrated**) has main aims to **generate less runoff** and to **improve water quality**.
4. This new USWM approach is an imperative for urban area and **could helping cities deal with flooding**.
5. New technologies are opportunities that could help foster, economic, social and environmental **development with preserving the quality of waters**.
6. **Which type of USWM decentralized technology is appropriate** for application in a particular location, like Sarajevo, or some other B&H City, depends on a set of different factors, including infiltration capacity, groundwater level, soil permeability and contamination, surface runoff characteristics, local climate, land availability and ground slope.

Thank you for attention !!!