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Climate Change and Drinking Water

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Abstract. The period June 2012 – March 2014 saw a prolonged deficit of precipitation below normal. This led to a major continental scale drought across southern Europe, and in eastern Kosova in particular. E.g. see figure 1 below for the month of December 2013, from Drought Monitoring Center for SEE. In fact December 2013 was the fifth driest month in the recorded history of Kosova.
February registered the driest month in the recorded hydro-meteorological history of Kosova, since 1927 with only 2.1 mm precipitation, which expressed in Standardized Precipitation Index (SPI). The chance of getting this value in February was 1 in 156. So, since June 2013, consecutively there were dry month, i.e. there was rainfall deficit (a meteorological drought) that consequently led to a hydrological drought. By March 2014 the water supply reservoirs of Batllava, Badovc were at 20% of normal levels, and nearly exhausted. There was approximately not more than 6-8 weeks of water supply remaining for upwards of 500,000 citizens.
Situation of drinking water supply was becoming much more difficult to citizens of Prishtina, Podujeva, Kastriot, Fushe Kosova and Gracanica. Thus, water supply restrictions hours were growing and there was a fear to citizens for the lack of water and at the same time were aware for a maximum of water saving. The Government Local and Central authorities, other Institutions, NGO's, were mobilized in order to find a solution, even for a temporary time, to deal with drought periods. There were few choices as the underground water level was affected by droughts and the only hope was the alternative supply from the Lake Ujmani (Gazivoda) where through the steel pipe fill Badovc Lake. Although, the pipe was not in a good condition because since year 1986 only once was included for operation to the system to fill Badovc Lake in 1996 as the water level fell at this Lake.

Keywords: Drought, Standardized Precipitation Index (SPI), Reservoirs levels, water losses

1. Introduction

The period June 2012 – March 2014 saw a prolonged deficit of precipitation below normal. This led to a major continental scale drought across southern Europe, and in eastern Kosova in particular. E.g. see figure 1 below for the month of December 2013, from Drought Monitoring Center for SEE. In fact December 2013 was the fifth driest month in the recorded history of Kosova.

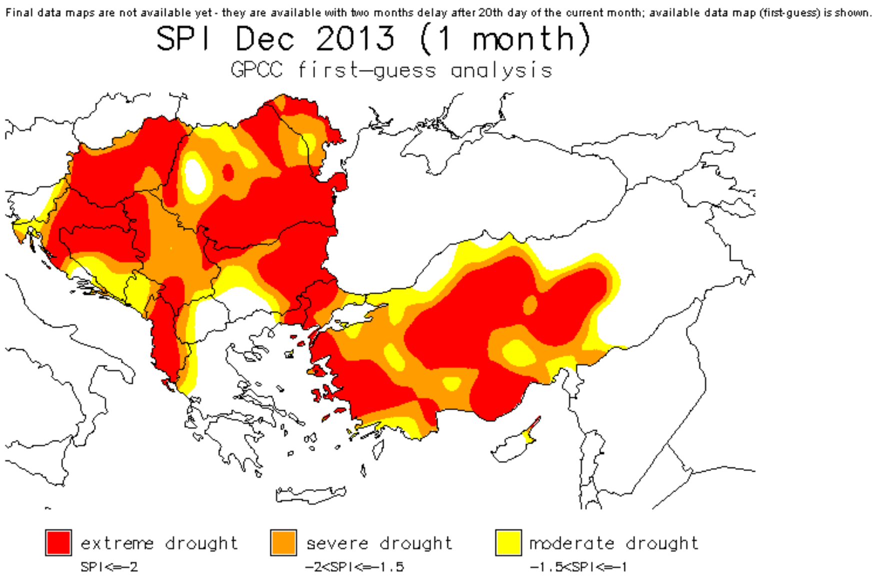


Figure 1 December 2013 continental drought

1.11 Analyze the situation.

February registered the driest month in the recorded hydro-meteorological history of Kosova, since 1927 with only 2.1 mm precipitation, which expressed in Standardized Precipitation Index (SPI) was -2.49 (fig. 2). The chance of getting this value in February was 1 in 156. So, since June 2013, consecutively there were dry month, i.e. there was rainfall deficit (a meteorological drought) that consequently led to a hydrological drought.
One of the most effective Early Warning Indicators is a simple measure of monthly precipitation expressed in terms of its deviation (from the average value for the last 1, 3, 6, 12 months). This is the **Standardized Precipitation Index - SPI**. The index ranges between +3.0 to -3.0. The SPI is used throughout Europe as an early indicator of precipitation deficits or surpluses, which, if they continue, may lead to significant water scarcity (or flood) conditions respectively.

SPI Value (σ)	Cumulative Probability	Description	Colour Code
+ 3.0	0.0014	Extreme flood conditions	
+ 2.5	0.0062		
+ 2.0	0.0228	Severe flood conditions	
+ 1.5	0.0668		
+ 1.0	0.1587	Moderate flood conditions	
+ 0.5	0.3085	Precipitation slightly above normal	
0.0	0.5000	Precipitation conditions fit long-term average	
- 0.5	0.6915	Precipitation slightly below normal	
- 1.0	0.8413	Moderate drought conditions	
- 1.5	0.9332		
- 2.0	0.9772	Severe drought conditions	
- 2.5	0.9938		
- 3.0	0.9986	Extreme drought conditions	

Fig.2 Standardized Precipitation Index (SPI

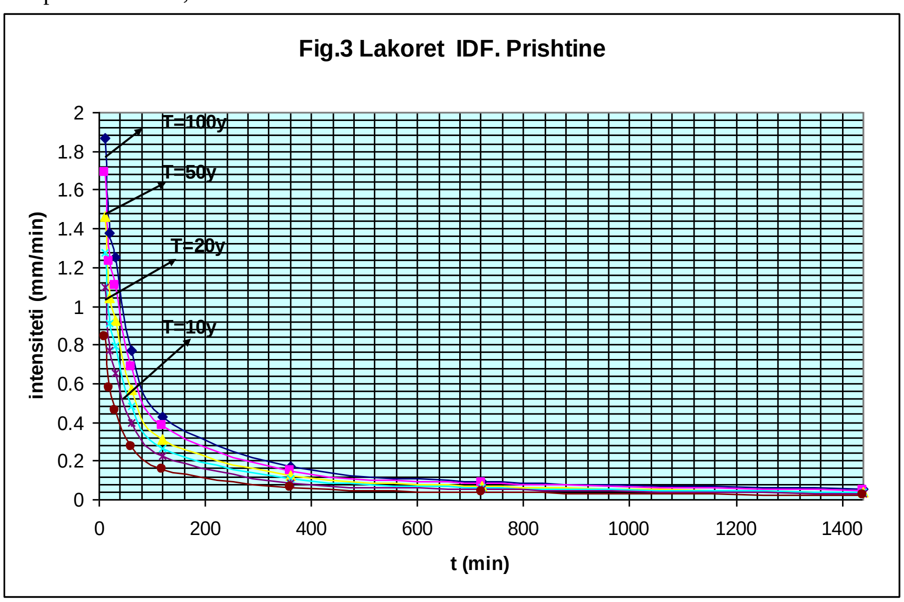
February registered the driest month in the recorded hydro-meteorological history of Kosova, since 1927 with only 2.1 mm precipitation, which expressed in Standardized Precipitation Index (SPI) was

-2.49 (fig. 2). The chance of getting this value in February was 1 in 156. So, since June 2013, consecutively there were dry month, i.e. there was rainfall deficit (a meteorological drought) that consequently led to a hydrological drought.

2002	-99	-99	-99	2.12	-0.92	-3.06	-0.17	-0.62	-1.24	0.09	-0.36	0.49
2003	1.36	-0.04	-1.34	1.23	0.85	0.85	0.18	-0.44	-0.06	0.79	0.63	0.49
2004	-0.46	1.33	-0.64	-0.01	0.22	0.72	0.28	0.98	0.24	0.49	1.05	-0.66
2005	-0.42	-0.30	1.13	0.18	1.26	1.17	0.96	-0.70	0.21	-0.16	1.30	-0.27
2006	-0.19	-0.85	-0.65	0.65	-0.50	-0.14	-1.02	0.64	-1.19	-1.73	-0.32	-0.69
2007	1.21	1.85	-0.74	-0.57	-1.92	1.77	-1.63	0.15	1.64	0.81	-0.48	0.21
2008	-0.15	-0.12	1.54	0.91	0.60	1.38	-0.93	-0.03	1.16	-0.33	0.40	-0.90
2009	0.86	0.56	0.93	1.20	1.71	0.68	1.04	0.49	0.84	0.79	-0.19	-0.42
2010	0.77	1.06	1.66	-0.54	-0.47	-0.27	-0.55	0.19	-1.03	0.35	-1.75	-0.12
2011	-0.05	-2.64	0.74	1.93	0.27	-1.03	0.19	1.07	-2.54	0.43	-1.64	-1.07
2012	0.26	-0.75	0.41	-0.44	0.08	-0.25	-1.43	-0.11	-0.39	-0.22	-1.45	0.56
2013	0.36	-0.26	-1.54	-1.05	-2.49	0.68	3.90	0.32	-99	-99	-99	-99

Fig.3 Water Supply (min and max stats)

By March 2014 the water supply reservoirs of Batllava and Badovc were at 25% of normal levels, and nearly exhausted. There was approximately not more than 6-8 weeks of water supply remaining for upwards of 500,000 citizens.



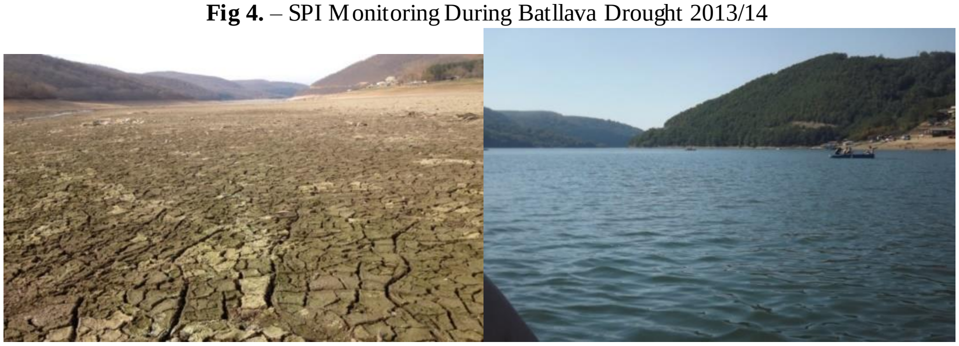
Graph.1 IDF Graphs

	2012			2013												2014				
Precipitation	**Tet**	**Nen**	**Dhj**	**Jan**	**Shk**	**Mar**	**Pri**	**Maj**	**Qer**	**Kor**	**Gus**	**Sht**	**Tet**	**Nen**	**Dhj**	**Jan**	**Shk**	**Mar**	**Pri**	**Maj**
Observed (mm)	60.4	29.6	60.8	21.4	31.3	25.7	18.9	56.2	37.5	32.6	5.6	56.6	64.8	42.6	15.9	11.9	2.1	50.1	220.0	
Normal (mm)	59.1	58.3	53.5	37.4	35.1	37.0	51.0	65.7	54.0	46.4	42.3	45.0	59.1	58.3	53.5	37.4	35.1	37.0	51.0	
% of Normal	102%	51%	114%	57%	89%	69%	37%	86%	69%	70%	13%	126%	110%	73%	30%	32%	6%	135%	431%	
SPI-1	0.26	-0.75	0.41	-0.44	0.08	-0.25	-1.44	-0.10	-0.39	-0.22	-1.45	0.56	0.36	-0.26	-1.54	-1.05	-2.49	0.68	3.81	
SPI-2	-0.40		-0.07		-0.27		-1.01		-0.53		-0.30		-0.04		-2.13		-0.42			
SPI-3	-0.21			-0.64			-1.24			-0.42			-0.73			-1.07				
SPI-4	-0.48				-0.98				-0.58				-1.20							
SPI-6	-0.67						-1.17						-1.36							
SPI-12	-1.42																			

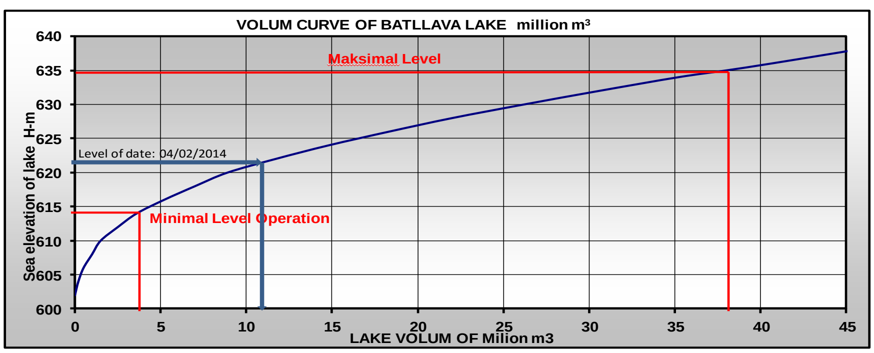
Storage	**Tet**	**Nen**	**Dhj**	**Jan**	**Shk**	**Mar**	**Pri**	**Maj**	**Qer**	**Kor**	**Gus**	**Sht**	**Tet**	**Nen**	**Dhj**	**Jan**	**Shk**	**Mar**	**Pri**	**Maj**
Observed (m)	630.36	630.07	629.69	627.9	628.08	630.57	631.53	630.98	630.15	629.02	627.87	626.74	625.55	624.49	623.49	622.53	621.83	621.35	630.04	*634.00*
Normal (m)	631.01	630.28	631.44	632.99	635.08	635.35	635.03	634.96	634.58	633.80	632.90	631.96	631.01	630.28	631.44	632.99	635.08	635.35	635.03	634.96
Observed (Mm^3)	26.200	26.200	25.150	21.075	22.000	27.300	29.500	27.300	26.200	24.100	21.075	19.225	17.425	14.800	13.250	12.475	11.000	10.300	26.200	35.200
Normal (Mm^3)	28.400	26.200	28.400	31.750	38.000	38.000	38.000	36.600	36.600	34.050	31.750	29.500	28.400	26.200	28.400	31.750	38.000	38.000	38.000	36.600
% of Normal	92%	100%	89%	66%	58%	72%	78%	75%	72%	71%	66%	65%	61%	56%	47%	39%	29%	27%	69%	96%

Production	**Tet**	**Nen**	**Dhj**	**Jan**	**Shk**	**Mar**	**Pri**	**Maj**	**Qer**	**Kor**	**Gus**	**Sht**	**Tet**	**Nen**	**Dhj**	**Jan**	**Shk**	**Mar**	**Pri**	**Maj**
Observed (Mm^3)	*2.100*	*2.100*	*2.100*	2.218	1.956	2.131	2.145	2.104	2.166	2.035	2.059	2.165	2.108	2.006	2.032	1.936	1.468	1.538	1.521	

Fig 4. – SPI Monitoring During Batllava Drought 2013/14



February-2014 The effects of drought-Batllava April-2014



By March 2014 the water supply reservoirs of Batllava and Badovc (fig. 3), were at 25% of normal levels, and nearly exhausted. There was approximately not more than 6-8 weeks of water supply remaining for upwards of 500,000 citizens.

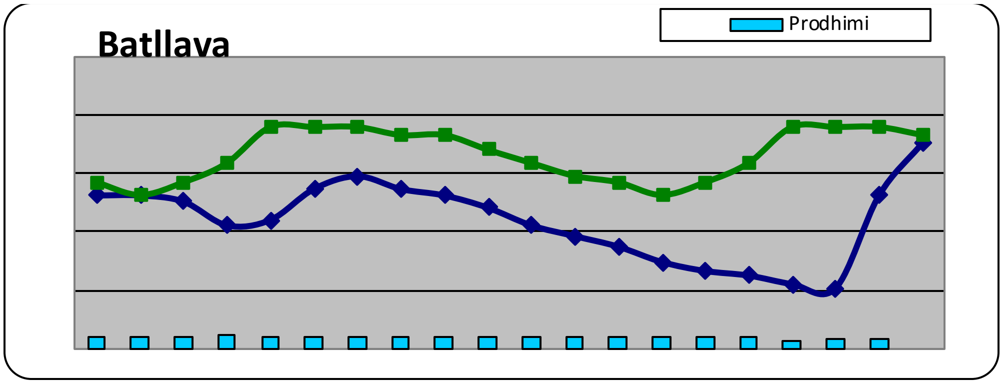
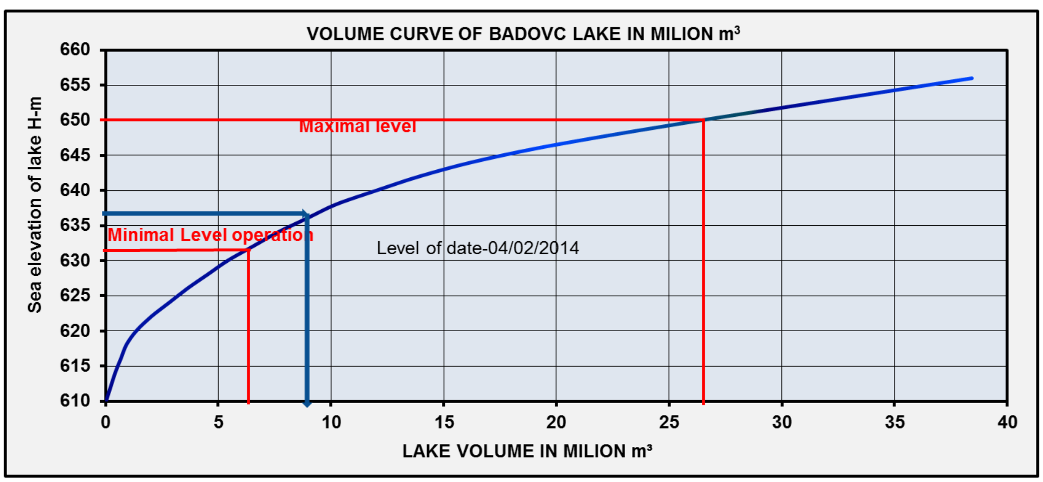


Fig 5. Batllava reservoir storage and production

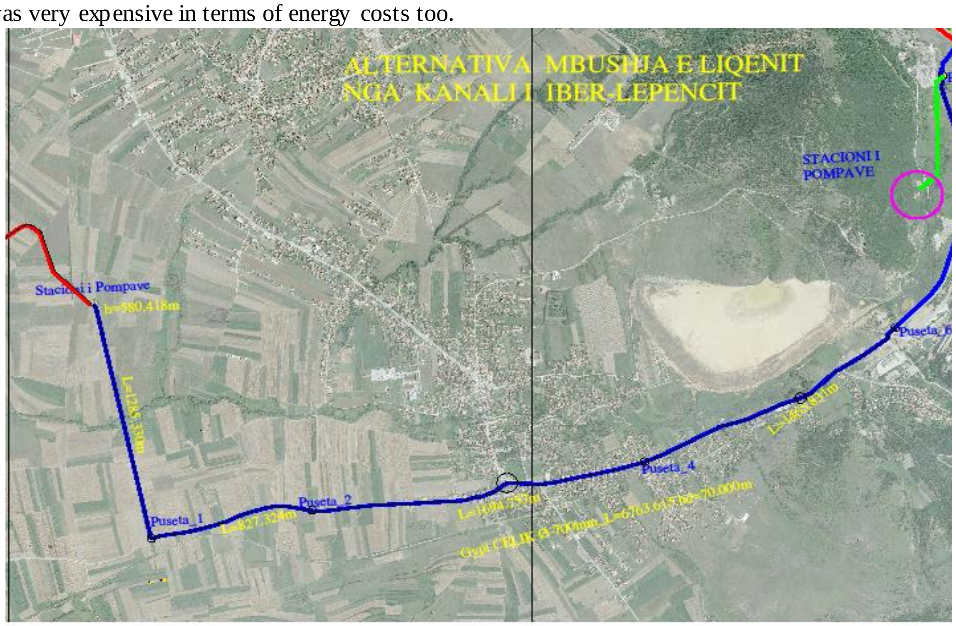
February-2014 The effects of drought- BADOVC LAKE April-2014



Graph 4.

Prishtina Regional Water Company prepared an emergency contingency plan to import water from Gazivoda - Ibër-Lepenc canal to the Badovc Reservoir which commenced in February 2014. This Plan, which involved considerable capital cost, IF fully operational would be able to import approximately 350 l/s (30.2 Ml/day or 907 Ml/month). The normal abstraction from Badovc is in the order of 710 Ml/month, therefore the Gazivoda import should have theoretically allowed the continuing operation of the reservoir to limited parts of the city.
However, Badovc was at critically low levels, and the import scheme did nothing more than allow a continued supply. It did nothing to increase or restore the reservoir towards normal levels. Due to settlements alongside the canal discharging wastewater directly into the canal, the imported water

risked being of very poor quality. Ministry of Environment and Spatial Planning together with the Prishtina municipality, Prishtina Regional Water Company and Ibër-Lepenc Company took measures to stop this practice. However, feedback from other municipalities alongside the canal, especially from Serbian upstream settlements indicated there was still some wastewater discharge. The water was nevertheless imported and was sent directly to the water treatment plant. This emergency measure was very expensive in terms of energy costs too.



Ortofoto-Transmission pipe Iber-Lepenc canal to Badovc Lake


WATER FLOW TO LAKE


PIPE REPERATION

On the other hand, there was no ready ‘Plan B’ for Batllava Reservoir, which is larger and supplies a greater part of the city (60%), although there were a couple of measures proposed to bring water directly from other streams into the reservoir. Each required a proper study and risked being implemented too late. Termination of water supplies from Batllava would have caused significant disruption and hardship to citizens.Analysis of precipitation statistics for Prishtina (1926 – 2014) confirms that a severe or extreme meteorological drought of 4-6 months duration can be expected 21% of the time, or once every five years on average. 4-6 months of severe/extreme precipitation deficit will cause depletion in surface water resources, possibly leading to the potential failure of water supplies if the resources are not better managed.

It should be noted that the two SPI-6 precipitation periods April-September 2013 and October 2013-March 2014 had values of -1.17 and -1.36 respectively (fig. 5). Since a Severe Drought technically starts only when SPI = -1.5, then the drought sequence in Kosovo was no more than a Moderate Drought. In spite of this all the reservoirs were brought to the point of failure through inadequate monitoring and inadequate understanding of precipitation versus reservoir supply-demand dynamics by the RWCs.

This raises concerns if Kosova was to be faced with an extended period of Severe Drought!

	SPI-1	SPI-1	SPI-1	SPI-1	SPI-1	SPI-1	SPI-1	SPI-1	SPI-1	SPI-1	SPI-1	SPI-1
H Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2002	-99	-99	-99	2.12	-0.92	-3.06	-0.17	-0.62	-1.24	0.09	-0.36	0.49
2003	1.36	-0.04	-1.34	1.23	0.85	0.85	0.18	-0.44	-0.06	0.79	0.63	0.49
2004	-0.46	1.33	-0.64	-0.01	0.22	0.72	0.28	0.98	0.24	0.49	1.05	-0.66
2005	-0.42	-0.30	1.13	0.18	1.26	1.17	0.96	-0.70	0.21	-0.16	1.30	-0.27
2006	-0.19	-0.85	-0.65	0.65	-0.50	-0.14	-1.02	0.64	-1.19	-1.73	-0.32	-0.69
2007	1.21	1.85	-0.74	-0.57	-1.92	1.77	-1.63	0.15	1.64	0.81	-0.48	0.21
2008	-0.15	-0.12	1.54	0.91	0.60	1.38	-0.93	-0.03	1.16	-0.33	0.40	-0.90
2009	0.86	0.56	0.93	1.20	1.71	0.68	1.04	0.49	0.84	0.79	-0.19	-0.42
2010	0.77	1.06	1.66	-0.54	-0.47	-0.27	-0.55	0.19	-1.03	0.35	-1.75	-0.12
2011	-0.05	-2.64	0.74	1.93	0.27	-1.03	0.19	1.07	-2.54	0.43	-1.64	-1.07
2012	0.26	-0.75	0.41	-0.44	0.08	-0.25	-1.43	-0.11	-0.39	-0.22	-1.45	0.56
2013	0.36	-0.26	-1.54	-1.05	-2.49	0.68	3.90	0.32	-99	-99	-99	-99
2014	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99

	SPI-2	SPI-2	SPI-2	SPI-2	SPI-2	SPI-2	SPI-3	SPI-3	SPI-3	SPI-3	SPI-4	SPI-4	SPI-4	SPI-6	SPI-6	SPI-12
H Year	Oct-Nov	Dec-Jan	Feb-Mar	Apr-May	Jun-Jul	Aug-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Jan	Feb-May	Jun-Sep	Oct-Mar	Apr-Sep	Oct-Sep
2002	-99	-99	-2.28	-0.73	-0.76	0.01	-99	0.57	-1.48	-0.03	-99	-1.78	-0.48	-99	-0.94	-99
2003	1.01	0.16	1.01	-0.35	0.43	0.58	0.41	1.45	-0.45	0.73	0.89	0.37	0.55	1.14	0.32	0.89
2004	0.63	-0.64	0.52	0.87	0.37	0.39	0.23	0.28	0.86	0.44	0.12	0.86	0.39	0.24	0.75	0.61
2005	-0.70	0.90	1.52	0.08	-0.09	0.74	0.03	1.29	0.12	0.46	0.00	1.03	0.39	0.75	0.35	0.65
2006	-0.88	-0.08	-0.58	-0.08	-2.04	-0.74	-1.17	-0.15	-0.79	-1.36	-0.86	-0.50	-1.68	-1.14	-1.61	-2.06
2007	2.08	-1.13	0.79	-0.80	1.52	-0.25	1.65	0.29	0.62	0.17	1.43	-0.07	0.78	1.47	0.39	1.18
2008	-0.37	1.68	1.26	-0.68	0.54	-0.28	0.54	1.44	0.24	-0.45	0.83	0.38	0.10	1.23	-0.32	0.53
2009	0.90	1.43	1.53	0.94	0.97	-0.50	1.15	1.85	1.30	0.01	1.56	1.58	0.28	1.97	0.68	1.73
2010	1.17	1.05	-0.66	-0.29	-0.43	-0.95	1.76	-1.04	-0.94	-0.55	1.55	-0.71	-0.91	1.00	-1.11	-0.14
2011	-1.40	1.90	-0.54	0.89	-0.83	-1.68	-0.69	1.02	-0.09	-0.88	0.47	0.32	-1.57	0.05	-0.83	-0.67
2012	-0.40	-0.07	-0.27	-0.99	-0.53	-0.30	-0.21	-0.64	-1.24	-0.42	-0.48	-0.98	-0.58	-0.67	-1.17	-1.42
2013	-0.04	-2.13	-0.42	3.12	-99	-99	-0.73	-1.07	-99	-99	-1.20	2.29	-99	-1.36	-99	-99
2014	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99

Fig 5. Monthly, bimonthly, quarterly, semi-annual and annual SPIs for Prishtina

The situation was only rescued by an extraordinary occurrence of extreme surplus precipitation in April that averted a catastrophe. In fact, April 2014 registered the wettest month in the recorded hydro-meteorological history of Kosova, since 1927 with 227 mm precipitation, which expressed in Standardized Precipitation Index was 3.90! This means, that the chance of getting this value in April was 1 in 2000! Normal precipitation for the month of April would be 51 mm.

This is a massive fluctuation from only 8 weeks earlier, in February 2014. Complacency that this was always going to happen has already rapidly set in.In order to avoid contentment and possible future failures, important lessons must be learned from the recent crisis. Precisely the same issues were encountered in 2007, and no action was taken to learn from that experience, with the consequence that almost the same lack of preparedness occurred six years later. Droughts (and floods) cannot of course be prevented. However, by continuous monitoring of precipitation and water levels in strategic rivers, more effective data processing, and the use of simple early warning systems, these can significantly improve regional level preparedness and resilience to floods and droughts.

Detailed analysis of the Prishtina precipitation record 1927-2014 confirms the statistical severity of the current meteorological drought. For example, the long-term annual average precipitation value for Prishtina is 582mm/year. Annual values of less than 480mm represent moderate to severe drought situations. The hydrological year October 2012 – September 2013 (436mm) was the fifth driest year since 1927 and December 2013 was also the fifth driest December since 1927 (16mm compared to the average 59mm). August 2013 received 6mm compared to the more normal 38mm.

The need for water conservation measures could therefore have been identified already in August 2013, if not earlier, if an Early Warning System (EWS) had been operating. With earlier conservation of water in the Batllava and Badovc

Reference

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2. Kosovo Hydrometeorological Institute
3. GIZ