Chapter 9
An Assessment of Low Flow and Water Deficits on the Danube and Romanian Rivers During 1980 – 2020

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ABSTRACT

The daily streamflow data—at 93 gauges on Romanian rivers and other 17 on the Romanian part of the Danube River, covering the period 1980 – 2020—were used to assess the characteristics of low flows, deficits, and seasonality. It was necessary to consider several indicators, such as: meanflow (MQ), mean annual minimum n-day discharges (MAMn-day), low flow percentiles (Q80, Q95), base flow index (BFI), extreme values of annual minimum 7-day discharge (AM7) and the streamflow below a fixed Q80 threshold. For assessing the occurrence and variability of low flows, rate and index of seasonality was used. The statistical computation of indices was made using the LFSTAT application packages developed in the R program. Also, in order to have an overview, at the level of the Romania, of low flows magnitude, the variability of minimum discharges on different time durations (days), the relative contribution of base flow to total river flow and for highlighting the driest year in the period 1980 - 2020, there were produced several maps with the spatial distribution of low flow indices.

DOI: 10.4018/978-1-6684-8771-6.ch009

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At a regional scale, in this case the Danube and Romanian rivers, an assessment of both low flow and water deficit, over the last 41 years (1980 – 2020), is crucial in providing useful information, both at national and European level, for proactive management of drought risks. Specific aspects of low flows and deficits are the subject of many current research initiatives in the context of climate change.

There are studies that focus on low water periods characterized by standard methods that include minimum annual flows, drought duration and streamflow deficit below a certain threshold (e.g., Gustard and Demuth, 2008; Koffler et al., 2016; Hosking and Wallis, 2005; Hisdal et al., 2004; Gauster and Laaha, 2016; Tallaksen and Van Lanen, 2004; Laaha et al., 2013; Smakhtin, 2001; Salinas et al, 2013). Based on a range of low flow indices calculated from observed streamflow records of approximately 800 gauges across Europe, Laaha et al. (2016) was analyzed European drought of 2015 from a hydrological perspective.

During the period from 1990 to 2017, many parts of Europe suffered from noticeable droughts, such as in 1991–1995, 1996–1997, 2000, 2003, 2004–2007, 2010, 2011, 2015 (Stagge et al., 2013; Spinoni et al., 2015; Van Lanen et al., 2016, Sutanto and van Lanen, 2020).

As regards the Romanian rivers basins, a study by Sutanto and Van Lanen (2020), based on an analysis of hydrological characteristics in Europe from 1990 to 2017, showed that in the eastern part of Europe, from Poland to Bulgaria, there are clear regions with severe hydrological and groundwater drought hazards. These regions, as well as north-western Russia, experienced the longest drought duration and the highest deficit volume compared to other regions. Based on summary statistics of drought characteristics, the most severe droughts occurred from 1992 to 1997. The European 2003 drought was considered severe, but it appeared not the most extreme, in term of duration and water deficits (Sutanto and van Lanen, 2020).

A comprehensive characterization of hydrological drought events, such as those of 2015 and 2003, requires several different indices (Tallaksen and Van Lanen, 2004; Laaha et al., 2013; Smakhtin, 2001; Salinas et al., 2013, Laaha et al., 2016). First, the magnitude of the low flow discharge is important; it may be characterized by annual minimum flows or flow quantiles with high exceedance probability. Second, the timing of low flow is important. It may be characterized by a monthly low flow index, such as the monthly 7-day minimum flow, or by a seasonality index such as the day of occurrence for the annual minimum. Third, a characterization of drought events when the flow is below a given threshold is important. These drought events may be characterized by their duration, deficit volume, or similar indices (Yevjevich, 1967; Hisdal et al., 2004, Laaha et al., 2016).

The seasonality of hydrological characteristics is also one of the key factors controlling the development and stability of natural ecosystems. In the context of climate change, the use of seasonality indices, such as a cyclic index and seasonality rate, is recommended to assess the occurrence of minimum flows and to evaluate the seasonal variability of the low flow regime. The value of different seasonality indices for low flow regionalization was examined by Laaha and Blöschl (2006).

The Danube River in the Romanian section, like all major rivers in Europe, has been affected by significant low-flow events in the last two decades in 2003, 2011, 2012, 2015, 2018 and 2019. According to the 2022 edition of the Copernicus Climate Change Service's (C3S*) European State of the Climate (ESOTC) report (https://climate.copernicus.eu/esotc/2022/river-discharge), for 10 months of the year 2022, river discharge was below average and, also, river discharge was the second lowest on record across