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# TEMPORAL DYNAMICS OF HYDROLOGICAL DROUGHT IN THE TELEORMAN WATERSHED (ROMANIA)

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**Abstract.** Hydrological drought has significant societal and environmental consequences, as it alters the water resources and disrupts the equilibrium of aquatic ecosystems. To mitigate these negative impacts, a rigorous knowledge of drought features and dynamics is crucial. A wide range of methods and indices, both simple or composite is used, to enable spatial and temporal analysis of hydrological drought. This study aims to analyze the temporal dynamics of hydrological drought within the Teleorman catchment, a sub-basin of the larger Vedea River watershed, covering about 1,410 km$^2$ in the central part of the Romania Plain. The analyses are based on monthly and annual average discharges recorded during the period 1965–2013 at two gauging stations (g.s.) located on the Teleorman River: Tătărăștii de Sus, and Teleormanu. The temporal dynamics of drought was investigated using two complementary methods. Firstly, a chart matrix of monthly flow coefficient was designed, to identify the months in which drought is specific, as well as potential changes in temporal variability over the analyzed period. The monthly coefficient was computed as the ratio between the mean monthly discharge and the multiannual average discharges at each g.s. Secondly, the Standardized Streamflow Index (SSI) was applied to identify drought periods across multiple temporal scales (1, 3, 6, and 12 months). The discharge matrix at the Tătărăștii de Sus g.s. indicated that the lowest flows, characteristic of hydrological drought periods, typically occur between August and October. After 1990, the lowest flow began to extend in July and November, and occasionally in June and December, particularly during the early 2000s. At the Teleormanu g.s., although the magnitude of low flows was lower, such conditions were recorded in one or two months per year during the first 25 years of the analyzed period. Subsequently, they began to extend to 3-4 months annually. The SSI analysis at the Tătărăștii de Sus g.s. revealed several prolonged drought episodes, notably those occurring from 1989 to 1991, 1992 to 1995, 2000 to 2005, 2008 to 2009, and 2011 to 2013. For the Teleormanu g.s., the identified drought periods largely correspond to those observed at Tătărăștii de Sus, indicating a consistent regional pattern of hydrological deficit within the watershed during the periods mentioned above. The findings of this study underscore the necessity of implementing appropriate water management strategies aimed at mitigating the negative impacts associated with reduced water availability.

**Keywords:** hydrological drought, Standardized Streamflow Index (SSI), flow chart matrix, Teleorman watershed, Romania

## 1.INTRODUCTION

In recent decades, drought has become one of the most frequent and impactful natural hazards worldwide within the broader context of global warming and shifts in the variability of climatic parameters that influence its occurrence. This phenomenon leads to considerable adverse socio-economic and environmental impacts. Beyond it directs effects on water availability, drought exacerbates food insecurity, reduces agricultural productivity, threatens public health, and disrupts ecosystem services. Future projections by the World Health Organization estimate that, between 2030 and 2050, climate change could cause over 250,000 deaths annually (Sena et al., 2016), with considerable proportion attributed to drought.

Drought was defined as a prolonged and abnormally dry period during which a deficit in precipitation leads to a severe hydrological imbalance, posing significant challenges for water availability and use (McMahon and Diaz, 1982). Based on its genesis and impacts, the drought is generally categorized into four main types: meteorological, hydrological, agricultural and socioeconomic (Wilhite and Glantz, 1985). Hydrological drought represents only one component of this broader phenomenon, referring specifically to a deficit of water within the hydrological system. It is, typically manifested through unusually low streamflow, reduced water levels in lakes, reservoirs, and groundwater bodies (Van Loon, 2015). Unlike meteorological drought, which is directly linked to precipitation anomalies, hydrological drought often develops more slowly, gradually, as it reflects the cumulative effects of prolonged periods of reduced precipitation and increased evapotranspiration. Its persistence and severity can significantly disrupt water supply systems, aquatic ecosystems, and the socio-economic activities. Hydrological drought should not be equated with the low-flow period of a river, which are seasonal features that constitute an inherent component of a river's natural hydrological regime. As emphasised by Smakhtin (2001), although droughts may encompass low-flow periods, not all low-flow conditions can be classified as drought events. Generally, low flows are typically predictable and cyclical, whereas hydrological drought results from prolonged deficits in precipitation, often leading to extended and more severe impacts on water resources and ecosystem functioning. Recognizing this difference is essential for accurate drought monitoring and for developing appropriate management and mitigation strategies. Therefore, a major challenge in hydrological drought analysis lies in determining when streamflow values reach or fall below predefined deficit thresholds (Chakir et al., 2023). The classification framework proposed by Dracup et al. (1980), which establishes threshold values relative to annual mean streamflow, indicates that low-flow events typically occur over short temporal scales (days, weeks), whereas hydrological droughts persist over longer periods (months to years).

Various methods are available to characterize low-flow conditions and hydrological droughts, including flow duration curves, threshold flow rates, recession indices, and fixed-duration approaches. Among these, the mean annual minimum flow is frequently used in both short-term and long-term studies, serving as a common indicator for low-flow assessment (Hisdal et al., 2024). Hydrological drought can be also analyzed using a range of standardized indices derived from parameters specific to the study area. Several of these indices are conceptually comparable to climatic indices, as they are computed using similar methodologies (e.g., Standardized Precipitation Index - SPI, Standardized Precipitation Evapotranspiration Index - SPEI) (Meresa et al., 2016). Regarding hydrological drought, the most commonly used indices include the Standardized Streamflow Index (SSI) for riverine drought, the Standardized Water Level Index (SWI) and the Standardized Groundwater Level Index (SGI) for groundwater drought, and the Surface Water Supply Index (SWSI) for lake-related drought (Shafer and Dezman, 1982; Bhuiyan, 2004; Bloomfield and Marchant, 2013; Salimi et al., 2021). Additionally, some authors (Nalbantis and Tsakiris, 2009; Kermen and Onuşluel Gül, 2018) used Streamflow Drought Index (SDI), that has the same theoretical foundation as the SSI (Jahangir et al., 2024). These indices enable the assessment of drought severity and duration in a standardized form, facilitating comparisons across regions and time periods.

According to Roşca et al. (2020), Romania can be considered moderately to highly exposed to drought risk, due to its geographical position, which favours the dominance of continental climatic influences across its territory. In Romania, average drought episodes generally last 2 to 3 months and mild drought spells may extend from 6 to 15 consecutive months at most. Extreme events generally develop over 2 to 3 consecutive months (Cheval et al., 2014). The areas with the highest risk of drought occurrence are primarily located in the southern and eastern regions, as well as in certain parts of the west and centre of the country, where semi-arid climatic conditions are more pronounced. The counties of Dolj, Olt, and Teleorman, which extend in southern Romania, are among the most severely affected. A large proportion of the areas susceptible to this phenomenon are used for agriculture, with more than 48% of such lands being impacted by drought (Lupu et al., 2010).

This study analyze the temporal streamflow variability within the Teleorman River watershed, located in the central-southern part of Romania, predominantly within the Romanian Plain - a region susceptible to water deficit - in order detect episodes of hydrological drought and assess their characteristics and dynamics. The analysis is based on the processing of monthly average discharges recorded over the period 1965-2013 at two gauging stations located along the Teleorman River. Two complementary approaches were employed: i) the construction of a chart matrix of the Pardé coefficients to identify periods with the lowest streamflow, indicative of drought events, and ii) the computation of the Standardized Streamflow Index (SSI) to quantify the magnitude and duration of drought episodes. The combination of these methods enables both a visual and statistical characterization of drought patterns, providing a comprehensive understanding of their temporal evolution.

Previous studies (e..g., Murărescu et al., 2014; Micu et al., 2014) have investigated key parameters contributing to the onset of drought conditions in the Romanian Plain. Croitoru and Toma (2010) reported decreasing trends in precipitation values, particularly during the summer months, with statistically significant results for the Alexandria station located near the Teleorman River`s watershed. This decline, coupled with high evapotranspiration rates, exerts the strongest influence on runoff in the Vedea basin (accounting for approximately 80%), while anthropogenic factors appear to play a minor role (Chelu et al., 2022). With regard to hydrological drought, no scientific information is available for the study region; therefore, this paper provides original and valuable findings, both from a scientific standpoint and from a practical perspective, for the proper management of the risks associated with this phenomenon.

## 2.STUDY AREA AND MEHODOLOGY

### *2.1. The Study Area*

The Teleorman watershed (1,410 km$^2$) extends, for the most part, across the central sector of the Romanian Plain, while its northern extremity lies at the contact with the Getic Piedmont (Figure 1.A), represented by the Cotmeana Plateau. The watershed has a markedly elongated shape oriented predominantly north-south, with altitudes decreasing progressively from approximately 450 m a.s.l. in the Cotmeana Plateau, where river originates, to about 25 m a.s.l. at the confluence of the Teleorman River with the Vedea River, an important tributary of the Danube in the central part of the Romanian Plain (Figure 1.B.). This location of the watershed, combined with its geographical features, exert a significant influence on the hydrological regime.

From a climatic perspective, the study area is situated within a zone with a temperate transitional climate, at the intersection of several climatic influences: oceanic from the west, sub-Mediterranean from the southwest, and continental aridity from the east and north-east (Ciulache, 2002). According to the Köppen–Geiger climate classification, the Teleorman basin corresponds to the warm-summer humid continental climate (Dfb) in the northern part, and a hot-summer humid continental climate (Dfa) in the rest of the basin. These climate types are characterized by high summer temperatures, sub-zero winter minimum, and a precipitation peak in late spring and early summer, resulting from the eastward expansion of western air masses (Vijulie, 2016). The average air temperature within the basin is 10.8°C, with a minimum of 9.6°C recorded in 1980 and a maximum of 12.5°C reached in 2007. The highest monthly temperatures are recorded in July (22.4°C) and the lowest in January (-1.72°C). As for precipitation, the watershed records an annual amount of 572.5

mm, with the lowest values in February (32.7 mm) and the highest in June (72.8 mm) (the values of temperatures and precipitation were extracted from Dumitrescu and Bîrsan, 2015, and cover the period 1965 – 2013).

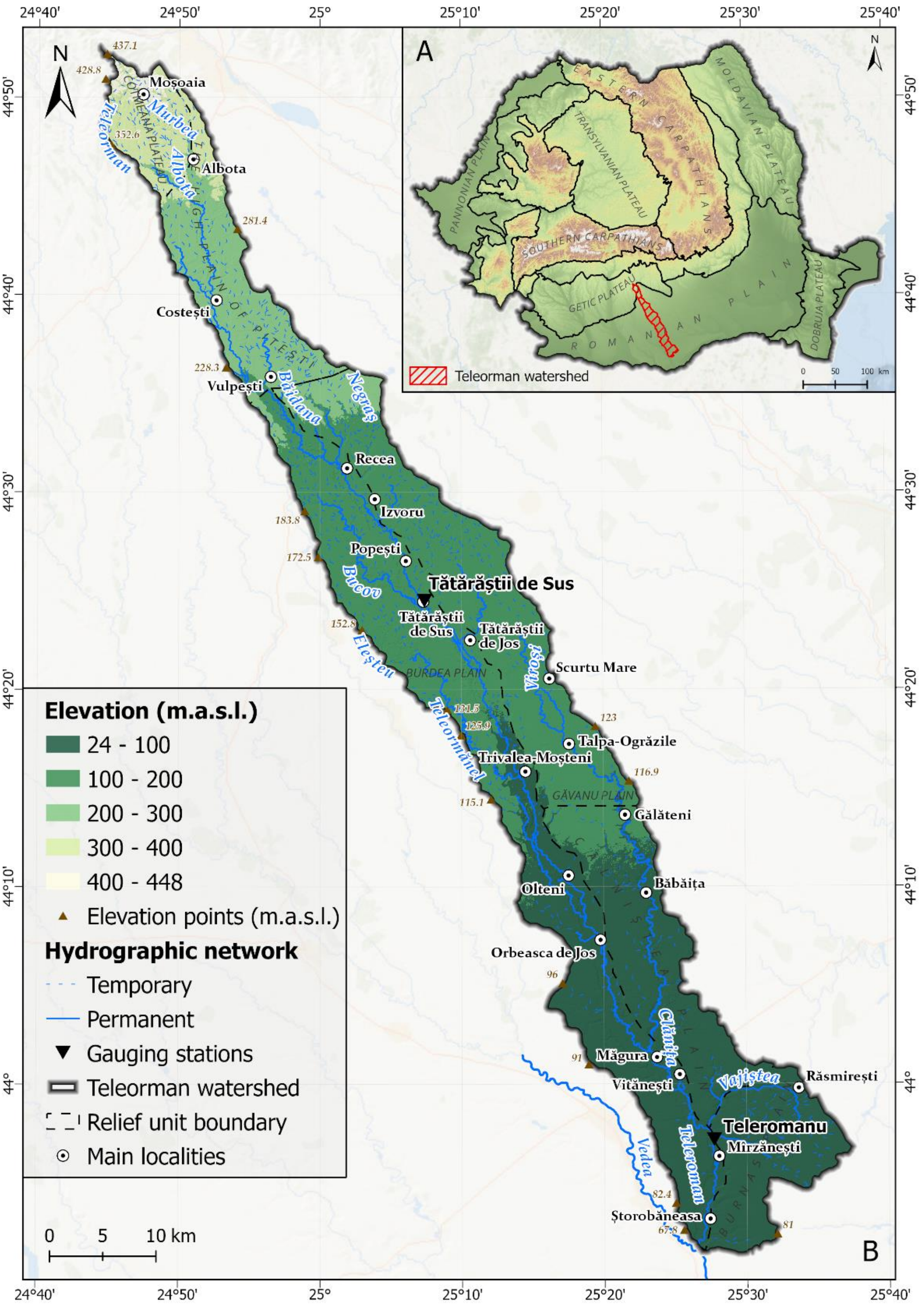


**Figure 1.** Teleorman watershed A) Geographical location in Romania B) Hypsometric map

Along its 170 km length, the Teleorman River receives several tributaries, the most important of which are: Albota, Negraş, Băidana, Clănița and Vajiștea (on the left bank), and Teleormănel and Bucov (on the right bank). Two gauging stations (g.s.) monitor the streamflow within the watershed: Tătărăștii de Sus g.s. located on the middle course of the Teleorman River, controlling an area of approximately 400 km² and Teleormanu g.s., situated in the lower course of the river, functioning as an outlet station and controlling a drainage area of 1,341 km² (the areas corresponding to the gauging stations are based on GIS-derived data). Both stations measure liquid and solid discharges, since the mid-20th century. At the Tătărăștii de Sus g.s., the multiannual average discharge for the period 1965–2013 was 1.3 $m^3/s$, varying between 0.53 $m^3/s$ in 1994, and 3.2 $m^3/s$ in 1980. At the Teleormanu g.s., the multiannual average discharge was 3.2 $m^3/s$, with a minimum of 1.5 $m^3/s$ in 1994, and a maximum of 8.1 $m^3/s$ in 1970.

Teleorman River exhibits a predominantly natural flow regime fed by precipitation, snowmelt, and groundwater contributions (particularly in the lower basin). High water occurs during the spring (with maximum in March), whereas low waters are characteristic for late summer and autumn (Grecu et al., 2012). The low-flow period is generally characterized by very reduced discharge values, even a complete lack of water in the piedmont sector, posing serious challenges for water resource management. However, due to the deepening of the Teleorman River valley, and the presence of terrace-based groundwater springs, the river maintains a permanent flow regime downstream of Costești. As a result, the local population benefits from significantly greater water resources compared to other rivers within the Vedea basin (Ujvari, 1972). Nevertheless, during certain periods, hydrological drought can lead to imbalances in the water demands of communities located along the river. Most of the basin includes only rural settlements, belonging to the Argeș and Teleorman counties, where the main economic activity is agriculture, specifically the cultivation of cereal and industrial crops. The water needs of the population and for irrigation come from both rivers and groundwater, and under conditions of hydrological drought, the communities within the basin are severely affected.

### 2.2. Data and methods

This study is based primarily on the processing of monthly discharge data from the Tătărăștii de Sus and Teleormanu gauging stations over the period 1965 – 2013. The data were provided and validated by the Argeș-Vedea Water Basin Administration. The analyses were carried out using two complementary approaches. The first approach involved constructing a chart matrix using the monthly flow coefficient, commonly referred to in international literature as the Pardé coefficient, for the two analyzed gauging stations. This coefficient reflects the seasonal variability and general dynamics of average monthly streamflow, and it is computed as the ratio between the mean monthly discharge and the mean multiannual discharge (Poschlod et al., 2020). To better illustrate the magnitude of discharges and identify drought periods, six threshold classes were established for the flow coefficient values: 0–0.2; 0.2–0.4, 0.4–0.6, 0.6–0.8, 0.8–1, and >1. Values close to 0 indicate extreme low-flow corresponding to hydrological drought conditions, whereas values greater than 1 correspond to wet periods. The chart matrix illustrating the temporal variability of monthly flow coefficients during the study period was generated and integrated within the ArcGIS Pro application.

The second methodological approach is based on the Standardized Streamflow Index (SSI). It is analogous to the Standardized Precipitation Index (SPI), but is applied to the analysis of streamflow variability (McKee et al., 1993). SSI was introduced by Modarres (2007), who used different distributions to analyze monthly river flow for a catchment in Iran, and was subsequently further analyzed by Telesca et al. (2013) in Spain. The SSI is computed by standardizing streamflow values over a given time period. The general formula is (Modarres, 2007):

$$SSI = \frac{Q_i - \mu}{\sigma},$$

where:

$Qi$ = the observed streamflow value at time $i$

$\mu$ = the mean streamflow for the corresponding time period

$\sigma$ = the standard deviation of streamflow for that period

The SSI was calculated over four timescales - 1, 3, 6, and 12 months - using RStudio software, and the results were graphically represented in Excel. The values were classified into nine classes, ranging from extremely wet to extremely dry periods (Nam et al., 2015), as shown in Table 1.

**Table 1.** Classes of SSI (according to Nam et al., 2015)

| SSI values | Classes |
|---|---|
| >2.0 | Extreme wet |
| 1.5-2.0 | Severely wet |
| 1.0-1.5 | Moderately wet |
| 0.5-1.0 | Mildly wet |
| 0.5-(-0.5) | Near normal |
| (-0.5)-(-1.0) | Mildly dry |
| (-1.0)-(-1.5) | Moderately dry |
| (-1.5)-(-2.0) | Severely dry |
| <(-2.0) | Extremely dry |

## 3.RESULTS

### *3.1. Variability of the monthly flow coefficients*

The variability of the monthly flow coefficients at the two stations along the Teleorman River is illustrated through the chart matrices in Figures 2 and 3. At the Tătărăştii de Sus g.s. during the first 25 years of the series (1965-1990), the lowest flow values, corresponding to coefficient values between 0 and 0.4, generally occurred between July and October (Figure 2). This pattern indicates a frequency of 3 to 4 months per year during which hydrological drought conditions were likely to develop. After 1990, the occurrence of the lowest flows began to extend in June and November, and some years even in May and December, particularly during the early 2000s. This indicates an average frequency of 4 to 5, even 6 months per year dominated by severe hydrological drought. At the Teleormanu g.s. (Figure 3), although of lower magnitude during the first 25 years of the analyzed period, the lowest flows were typically recorded in only one or two months per year, predominantly between June and August, and in some years were even absent, being largely compensated by wetter periods (e.g., 1970, 1980). However, during the second half of the analyzed period, the months exhibiting lower flow coefficients expanded to 3–4 per year, particularly during the 1990–2000 period.

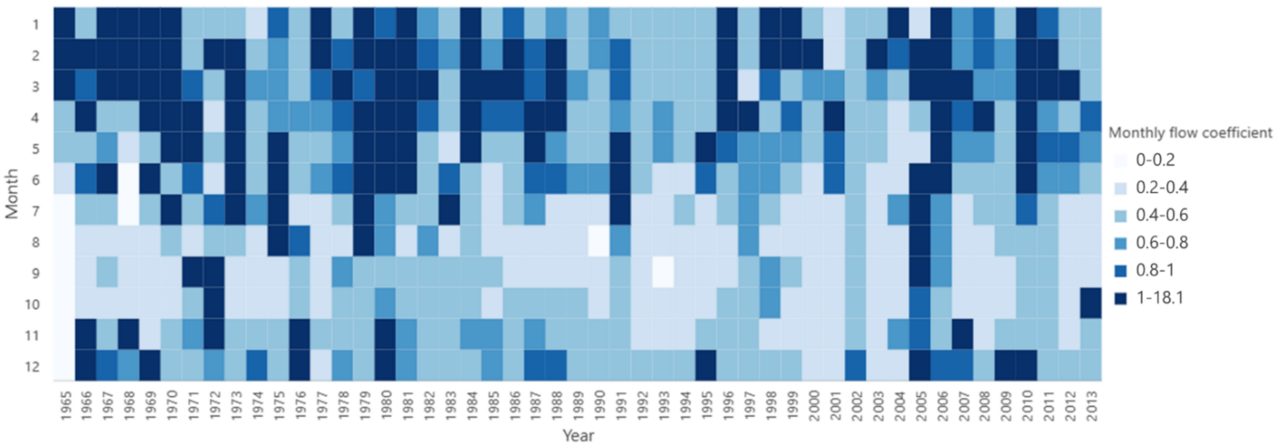


**Figure 2.** Matrix of monthly flow coefficients at the Tătărăşti g.s. (1965-2013)

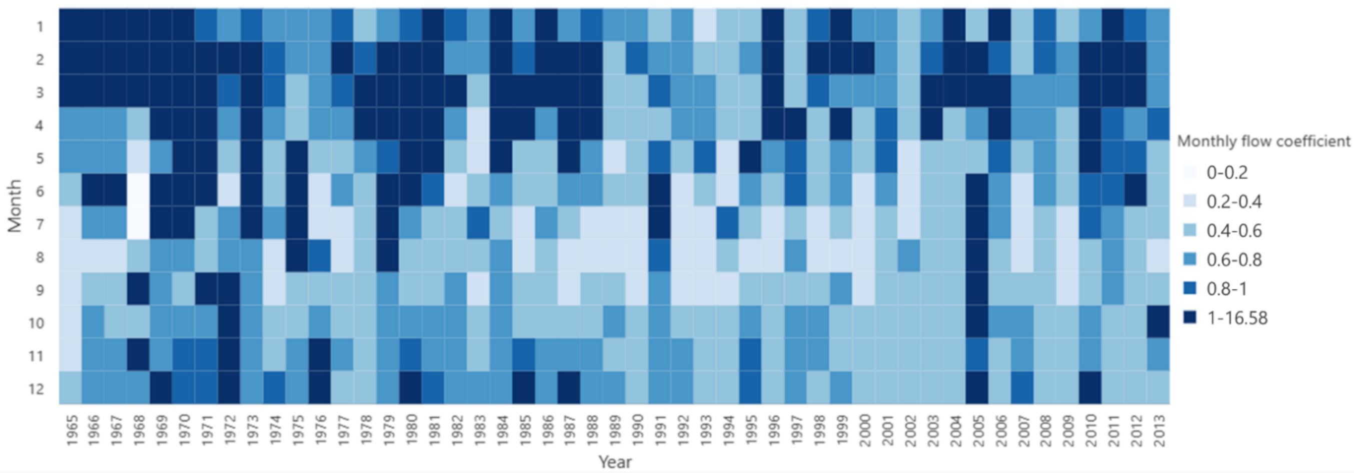


**Figure 3.** Matrix of monthly flow coefficients at the Teleormanu g.s. (1965-2013)

### *3.2. Standardized Streamflow Index (SSI)*

The variation of the SSI at different temporal scales (of 1, 3, 6, and 12 months) for the two gauging stations during the period 1965–2013 is illustrated in figures 4 and 5. At the Tătărăștii de Sus g.s., the SSI values corresponding to the shorter timescales (1-3 months) display higher magnitudes, particularly during extremely wet periods, compared to those calculated over longer durations. However, drought is a phenomenon that develops progressively over time. Accordingly, the 6-and 12-month SSI values better reflect the persistence of hydrological droughts, capturing longer drought periods than those indicated by short-term indices. Prolonged drought episodes were identified during the 1989–1991, 1992–1995, 2000–2005, 2008–2009, and 2011–2013. In terms of drought severity, the 1-month SSI analysis indicated a total of 126 slightly dry months, 16 moderately dry months, and 1 extremely dry month. For the 3-month SSI, 143 slightly dry months and 16 moderately dry months were identified. The 6-month SSI revealed 172 slightly dry months, 17 moderately dry months, and 1 severely dry month. By contrast, the 12-month SSI showed 177 slightly dry months and 40 moderately dry months, the majority of were concentrated in the 1992–1995 interval. Table 2 summarizes the SSI values recorded at the Tătărăștii de Sus g.s.

At the Teleormanu g.s. (Figure 5) the drought periods largely coincide with those identified at the Tătărăștii de Sus station. However, the primary difference lies in the higher magnitude of these events, which can be attributed to the station's location in the lower sector of the basin. Specifically, the 1-month SSI analysis indicated 138 slightly dry months, 24 moderately dry months, and 5 severely dry months. For the 3-month SSI, 157 slightly dry months, 22 moderately dry months, and 2 severely dry months were recorded. The 6-month SSI indicated 169 slightly dry months and 21 moderately dry months. Finally, the 12-month SSI revealed 161 slightly dry months and 46 moderately dry months. These results suggest that the lower basin experiences more pronounced drought conditions, with longer-lasting water deficits reflected at higher temporal scales. Table 3 summarizes the SSI values recorded at the Teleormanu g.s.

**Table 2.** Drought severity at the Tătărăștii de Sus g.s. (number of months)

| Drought severity | Slightly dry | Moderately dry | Severely dry | Extremely dry |
|---|---|---|---|---|
| 1-month | 126 | 16 | 0 | 1 |
| 3-month | 143 | 16 | 0 | 0 |
| 6-month | 172 | 17 | 1 | 0 |
| 12-month | 177 | 40 | 0 | 0 |

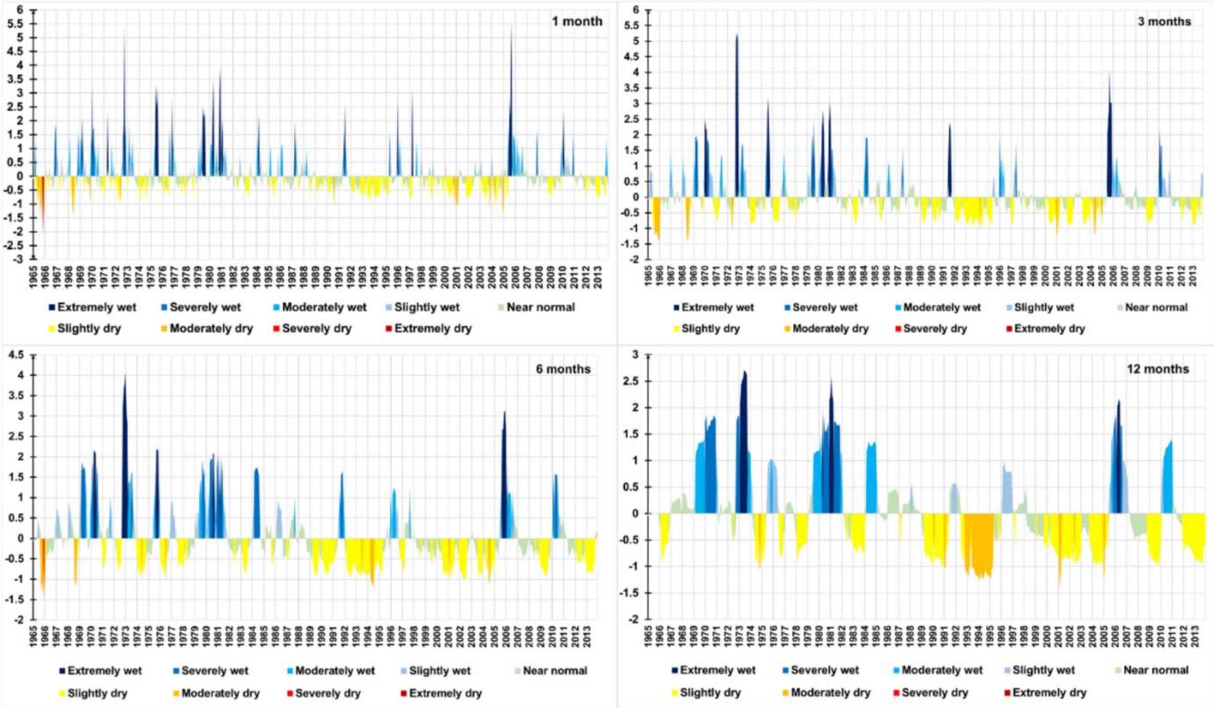


**Figure 4.** Variation of the SSI at the Tătărăşti g.s. at 1, 3, 6 and 12-month timescales (1965–2013)

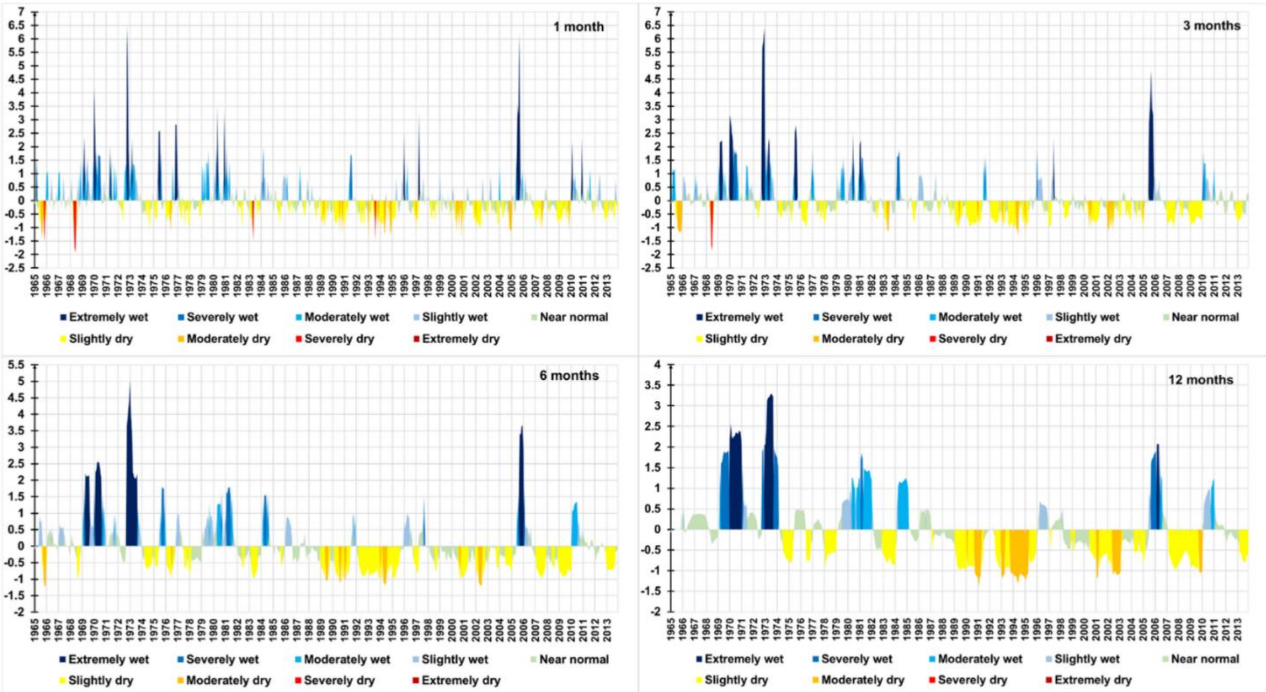


**Figure 5.** Variation of the SSI at the Teleormanu g.s. at 1, 3, 6 and 12-month timescales (1965–2013)

**Table 3.** Drought severity at Teleormanu g.s. (number of months)

| Drought severity | Slightly dry | Moderately dry | Severely dry | Extremely dry |
|---|---|---|---|---|
| 1-month | 138 | 24 | 5 | 0 |
| 3-month | 157 | 22 | 2 | 0 |
| 6-month | 169 | 21 | 0 | 0 |
| 12-month | 161 | 46 | 0 | 0 |

## 4.DISCUSSIONS

The results of this study reveal a clear intensification and temporal extension of hydrological drought phenomena in the Teleorman River basin over the period 1965–2013. The chart matrices of monthly flow coefficients indicate a distinct shift in the seasonal occurrence of low-flow conditions. At the Tătărăștii de Sus g.s., low flows initially occurred between July and October, but from the 1990s onward, they progressively extended into the adjacent months, including May, June, November, and December. A similar trend was observed at the Teleormanu g.s., where the frequency of low-flow months increased from 1-2 to 3-4 months per year in the latter half of the study period. These findings suggest a shift in the basin's hydrological regime, with longer and more frequent low-flow periods indicative of increasingly persistent drought conditions.

The SSI analysis confirms and complements these findings by quantifying the severity and duration of hydrological drought events. At both gauging stations, longer accumulation periods (6–12 months) proved more effective in capturing extended drought episodes than shorter timescales (1–3 months), consistent with previous literature that emphasize the cumulative nature of hydrological droughts (Van Loon, 2015; Hisdal et al., 2024). Major multi-annual drought events were identified in 1989–1991, 1992–1995, 2000–2005, 2008–2009, and 2011–2013, aligning with known regional drought periods across southern Romania, which have also been detected through climatic indices by Ioniță et al. (2025).

The findings of this study, reflect the broader evidence of increasing drought susceptibility in southern Romania, as previously reported by Lupu et al. (2010) and by Roșca et al. (2020), and are consistent with global patterns of drought intensification projected under climate change scenarios (Sena et al., 2016). The extension of hydro-climatic drought-prone months into early summer and late autumn, as also noted by other studies (Croitoru and Toma, 2010; Chelu et al., 2022), has critical implications for agricultural productivity and water availability. This is particularly significant in counties such as Argeș and Teleorman, where agriculture heavily relies on stable hydrological conditions. Drought in the study watershed is further exacerbated by the limited groundwater supply from the Getic Piedmont and the lowland areas of the Romanian Plain (Bârsan, 2017).

Despite the robust methodological framework, some limitations should be acknowledged. The use of SSI which is based exclusively on streamflow data, does not account for groundwater contributions, evapotranspiration dynamics, or land use changes. Moreover, potential data inconsistencies in the hydrological records, as well as anthropogenic alterations (e.g., water abstraction) may affect the accuracy of the observed streamflow variability. To address such shortcomings, future research should integrate multiple drought indicators (e.g., SPI, SPEI, SWI) and incorporate climate model projections to enhance the understanding of drought risk under future climate conditions. Such an integrated approach would not only allow for a more comprehensive assessment of hydrological drought but also improve the capacity to anticipate its impacts on water resources, agriculture, and ecosystems.

## 5.CONCLUSIONS

This study provides a comprehensive assessment of the temporal dynamics of hydrological drought in the Teleorman River basin over a period of nearly five decades (1965–2013), using both chart matrices of monthly flow coefficients and the Standardized Streamflow Index (SSI) across multiple temporal scales. The main findings reveal a noticeable shift in drought seasonality and severity, particularly after 1990, with drought episodes more prolonged, expanding beyond their traditional periods and more frequent. The lower basin experienced more pronounced drought conditions, with longer-lasting water deficits reflected at higher temporal scales.

These findings indicate a significant alteration of the basin's hydrological regime, driven likely by changing climatic conditions and possibly amplified by local anthropogenic factors. They align with broader regional evidence of increasing drought severity under climate change. The results of this study highlight the necessity of adopting integrated water management strategies in the

Teleorman watershed, particularly in the context of increasing climatic variability. Monitoring efforts should be complemented by the use of complementary drought indices and other driving factors of drought occurrence (e.g., groundwater, land use, anthropogenic influences). Future work should aim to integrate climate projections and socio-economic vulnerability assessments to enhance the accuracy of drought monitoring and support resilience planning in the region.


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## REFERENCES


Bîrsan, M.V. (2017). *Variabilitatea regimului natural al râurilor din România*, Editura Ars Docedi, București

Bhuiyan, C. (2004). *Various drought indices for monitoring drought condition in Aravalli terrain of India*. In O. Altan (Ed.), ISPRS Archives – Volume XXXV Part B7, XXth ISPRS Congress, Technical Commission VII (pp. 1283–1288). International Society for Photogrammetry and Remote Sensing.

Bloomfield, J. P., Marchant, B. P. (2013). Analysis of groundwater drought building on the standardised precipitation index approach, *Hydrology and Earth System Sciences*, 17, 4769–4787. https://doi.org/10.5194/hess-17-4769-2013

Chakir, M., Ghadbane, O., El Ghachi, M. (2023). Low-flow: Hydrological definition, statistical identification and regulatory thresholds for precise management and rationalization of water resources, *International Journal of Latest Research in Humanities and Social Science*, 6(4), 591-600

Chelu, A., Zaharia, L., Dubreuil, V. (2022). Estimation of climatic and anthropogenic contributions to streamflow change in southern Romania. *Hydrological Sciences Journal*, 67(10), 1598–1608, https://doi.org/10.1080/02626667.2022.2098025

Cheval, S., Busuioc, A., Dumitrescu, A., Bîrsan, M.V. (2014). Spatiotemporal variability of meteorological drought in Romania using the standardized precipitation index (SPI). *Climate Research*, 60, 235-248 https://doi.org/10.3354/cr01245

Ciulache, S. (2002). *Meteorologie și Climatologie*, Editura Universitară, București

Croitoru, A.E., Toma, F.M. (2010). Trends in precipitation and snow cover in central part of Romanian Plain. *Geographia Technica*, 1:460–469

Dracup, J. A., Lee, K. S., Paulson, E. G. (1980). On the definition of droughts. *Water Resources Research*, 16(2), 297–302. https://doi.org/10.1029/WR016i002p00297

Dumitrescu, A., Bîrsan, M.V., (2015), ROCADA: a gridded daily climatic dataset over Romania (1961–2013) for nine meteorological variables, *Natural Hazards,* 78, 1045–1063. https://doi.org/10.1007/s11069-015-1757-z

Hisdal, H., Tallaksen, L. M., Gauster, T., Bloomfield, J. P., Parry, S., Prudhomme, C., Wanders, N. (2024). Hydrological drought characteristics. In: Tallaksen, L.M., Van Lanen, H.A.J. (Eds.) Hydrological Drought: Processes and Estimation Methods for Streamflow and Groundwater, Second Edition, 157–231. https://doi.org/10.1016/B978-0-12-819082-1.00006-0

Ionita, M., Antonescu, B., Roibu, C.C., Nagavciuc, V. (2025). Drought's Grip on Romania: A Tale of Two Indices. *International Journal of Climatology*. https://doi.org/10.1002/joc.8876

Jahangir, M. H., Zarfeshani, A., Danehkar, S. (2024). Numerical comparison of streamflow drought index (SDI) and standardized streamflow index (SSI) for evaluation of Isfahan drought status. *Geology, Ecology, and Landscapes*, 1–14. https://doi.org/10.1080/24749508.2024.2359775

Kermen, C., Onuşluel Gül, G. (2018). Comparing two streamflow-based Drought Indices. pp. 190-195. In Gastescu, P., Bretcan, P. (edit, 2018), *Water resources and wetlands*, 4th International Conference Water resources and wetlands, 5-9 September 2018, Tulcea (Romania), p.312

Grecu, F., Zaharia, L., Ghiță, C., Comănescu, L., Cîrciumaru, E., Albu, M. (2012), *Sisteme Hidrogeomorfologice din Câmpia Română. Hazard-Vulnerabilitate-Risc*, Editura Universității din București, București

Lupu, A.B., Ionescu, F.C., Borza, I. (2010). The phenomenon of drought and it's effects within Romania, *Research Journal of Agricultural Science*, 42 (4). 96-101

McKee, T.B., Doesken, N.J., Kleist, J. (1993). The relationship of drought frequency and duration to time scales. *Proceedings of the 8th Conference of Applied Climatology*, 17-22 January 1993, Anaheim, California, 179-184

McMahon, T.A., Diaz Arenas, A. (1982). *Methods of Computation of Low Streamflow*, Studies and Reports in Hydrology, UNESCO, Paris

Meresa, H.K., Osuch, M., Romanowicz, R. (2016). Hydro-Meteorological Drought Projections into the 21-st Century for Selected Polish Catchments, *Water*, 8(5):206. https://doi.org/10.3390/w8050206

Micu, D., Havriş, L.E., Dragotă, C.S., Mărculeț, C., (2014). Changes in summer types in relation to drought occurrence in the Romanian Plain region, *Air and Water: Components of The Environment International Conference*, Cluj-Napoca, Editura Universitară Clujeană, 118-125

Modarres, R. (2007). Streamflow drought time series forecasting Stochastic Environmental Research and Risk Assessment, 21, 223–233. https://doi.org/10.1007/s00477-006-0058-1

Murărescu, O., Murătoreanu, G., Frînculeasa, M. (2014). Agrometeorological drought in the Romanian plain within the sector delimited by the valleys of the Olt and Buzău Rivers. *Journal of Environmental Health Science and Engineering,* 12(1):152. doi: 10.1186/s40201-014-0152-0

Nalbantis, I., Tsakiris, G. (2009). Assessment of Hydrological Drought Revisited. *Water Resources Management*. 23, 881–897. https://doi.org/10.1007/s11269-008-9305-1

Nam, W.H., Hayes, M. J., Svoboda, M. D., Tadesse, T., Wilhite, D. A. (2015). Drought hazard assessment in the context of climate change for South Korea, *Agricultural Water Management*, Elsevier, 160, 106-117. https://doi.org/10.1016/j.agwat.2015.06.029

Poschlod, B., Willkofer, F., Ludwig, R. (2020). Impact of Climate Change on the Hydrological Regimes in Bavaria. *Water*, 12(6), 1599. https://doi.org/10.3390/w12061599

Roșca, S., Bilașco, Ș., Fodorean, I., Vescan, I., Petrea, D., Pacurar, I., Rusu R. (2020). Pedological risks in Romania. Preliminary analysis, *Risks and Catastrophes Journal*, 27(2), 33-45. https://doi.org/10.24193/RCJ2020_10

Salimi, H., Asadi, E., Darbandi, S. (2021). Meteorological and hydrological drought monitoring using several drought indices, *Applied Water Science,* 11, 11. https://doi.org/10.1007/s13201-020-01345-6

Sena, A., de Freitas, C.M., Barcellos, C., Ramalho, W., Corvalan, C. (2016). Measuring the invisible: Analysis of the Sustainable Development Goals in relation to populations exposed to drought, *Ciencia & Saude Coletiva*, 21(3):671-84. https://doi.org/10.1590/1413-81232015213.21642015

Shafer, B.A., Dezman, L.E. (1982). Development of a Surface Water Supply Index (SWSI) to Assess the Severity of Drought Conditions in Snowpack Runoff Areas. *Proceedings of the Western Snow Conference*, Colorado State University, Fort Collins, CO, 164–175.

Smakhtin, V.U. (2001). Low Flow Hydrology: A Review. *Journal of Hydrology*, 240, 147-186. https://doi.org/10.1016/S0022-1694(00)00340-1

Telesca, L., M. Lovallo, I. Lopez-Moreno, Vicente-Serrano, S. (2012). Investigation of scaling properties in monthly streamflow and Standardized Streamflow Index time series in the Ebro Basin (Spain). *Physica A: Statistical Mechanics and its Applications*, 391(4), 1662–1678. https://doi.org/10.1016/j.physa.2011.10.023

Ujvari, I. (1972). *Geografia Apelor României*, Editura Științifică, București

Van Loon A.F., 2015, Hydrological drought explained, *WIREs Water2015*, 2, 359–392. https://doi.org/10.1002/wat2.1085

Vijulie, I., (2016), *Geografia Fizică a Europei*, Editura Universității din București, București

Wilhite, D.A., Glantz, M.H. (1985). Understanding the Drought Phenomenon: The Role of Definitions, *Water International*, 10(3), 111–120