IOSUD - Universitatea Politehnica Timişoara
Şcoala Doctorală de Studii Inginereşti

"DROUGHT AND HYDROAMELIORATIVE ARRANGEMENTS. CASE STUDY TIMIS COUNTY (RO) AND STRĂȘENI DISTRICT (MD) PERIOD 1980-2020"

Doctoral thesis – Summary

to obtain the scientific title of doctor at

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in the field of PhD CIVIL ENGINEERING AND INSTALLATIONS

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This hereby thesis is structured into 5 chapters, throughout 219 pages, encompassing a rich graphical material of 76 figures and 49 tables with data and results, and a bibliography containing 167 representative entries classical and updated which ensured a thorough documentation, bringing significant knowledge contributions, which will be highlighted as following.

CONTENT

CHAPTER I
DROUGHT. THE CONCEPT OF WATER DEFICIT BETWEEN TRADITIONALIST AND MODERN APPROACH

1.1 Purpose and importance of the approached topic

The main purpose of the doctoral thesis is to calculate and analyze the drought indices presented in the first chapter in order to obtain an overview of the impact of drought in the period 1980-2020 in the four areas of Timiș County and in the district of Straseni. The information obtained will contribute significantly to the forecast of possible droughts in the areas studied in this thesis.

The importance of the studied topic is evident considering the tendency of the average annual temperatures to increase from year to year due to global warming - in particular - but also to other factors such as pollution. Drought, even a temporary one of medium size, can have catastrophic effects in all branches of the economy, especially in agriculture, but also in other areas related to human life. [13]

1.3 Drought. Features and types of drought

Drought is one of the most dangerous natural phenomena with severe negative effects on humanity around the globe. The phenomenon of drought and its two recurring phenomena, aridization and desertification, is, according to the United Nations, the second major problem with global implications facing humanity after environmental pollution. Due to the negative effects it induces, drought is part of the category of dangerous phenomena.

The discreet way of establishing drought phenomena has traditionally been and still is the cause of a delayed response, most of the time, of both the population and the competent authorities in crisis management. Numerous definitions of drought have been developed worldwide in terms of knowledge, the reduction of reaction time and the negative effects caused by these phenomena. [33]

In spite of the growing importance given to the knowledge and mitigation of the negative effects of drought, it has been and is very difficult to find a general definition of the phenomenon of drought. That is why, over time, this phenomenon has benefited from a multitude of definitions in the literature, whether conceptual or operational.

One of the most common general definitions of drought, which should not always be viewed or limited to a strictly physical phenomenon, is that this phenomenon is considered to be a normal and recurring feature of any climate on the planet. These phenomena can occur anywhere in the world, of course having extremely dispersed characteristics, depending on the climate in which it manifests itself and often the socio-economic effects involved. In other words, the drought can be much better defined on a limited space, homogeneous both in terms of climate and the degree of socio-economic development.

For the temperate climate, in the strict climatic sense Palmer, W.C. 1965 defined the phenomenon of drought as a time interval, generally months or years, characterized by a significant decrease in precipitation, compared to normal expectations relative to a well-defined area.

Depending on the environment or the stages of the hydrological cycle in which it has its effects and the duration and extent of the phenomenon, the drought can be viewed from several angles: meteorological drought, agricultural or pedological drought, hydrological drought.

As a direct consequence of the manifestation of the types of drought presented above with the related negative effects superimposed on the social and economic activities of a region, a new type of drought can be defined, namely socio-economic drought.

Numerous definitions of the drought phenomenon can be divided into two broad classes, depending on the approach to the phenomenon and their usefulness: conceptual definitions of the drought phenomenon and operational definitions of the drought phenomena.

The conceptual definitions of the drought phenomenon are those definitions that address the general public in order to be as easy to understand as possible in order to communicate and raise awareness of the occurrence, magnitude and development of the phenomenon. Due to the target audience, these definitions are formulated in more general terms and as intuitive as possible for the general public so that they can be widely used in the media.

In addition to the importance of communicating and raising awareness of the phenomenon, these conceptual definitions also have the role of establishing risk management strategies for drought phenomena. The introduction of conceptual definitions in drought risk management policy has resulted in a better awareness of the normal component of climate variability involved in the occurrence and development of a drought phenomenon, so that people involved in primary economic sectors (agriculture, primary resources), most exposed to the adverse effects of the drought, have been able to provide more effective and accurate support for government and insurance companies, thus avoiding a number of social conflicts that may arise in such crisis situations.

The fundamental disadvantage of the conceptual definitions is the relatively low degree of certainty, which makes, in most cases, a sufficiently accurate assessment of drought phenomena impossible. This disadvantage has led to the search for definitions of the phenomenon that would allow a more accurate characterization of reality, thus developing operational definitions.

The operational definitions of the drought phenomenon are addressed to a wider audience in the case of specialists, given the higher complexity of these definitions. As mentioned above, these definitions were developed in the first phase from the conceptual definitions to which were added more and more relevant hydro-climatic parameters in specific situations so as to allow the determination of the characteristics of the drought phenomenon as accurately as possible. Addressing operational definitions requires a much larger body of information and in-depth knowledge of drought phenomenology. [49]

The relationship between the number of hydro-climatic parameters considered relevant and the accuracy of the definition of the phenomenon for a certain area more or less extended is a very sensitive topic among specialists, perhaps this is the reason for such a large number of operational definitions. of the drought phenomenon.

Meteorological drought is the first phenomenon that manifests itself in drought situations, it being caused by the appearance of periods with high temperatures superimposed with deficit of precipitation and intensification of winds.The overlap of these phenomena leads to a decrease in humidity and atmospheric cloudiness, in which case the phenomenon of evapo-perspiration is exacerbated, which further accentuates the feeling of dryness. The meteorological aspect of the drought is the direct and main cause of all other aspects of the phenomenon. [55]

In the vast majority of cases, the definition of a meteorological drought is based on the degree of atmospheric dryness compared to the normally expected values. Particular attention must be paid to the spatial development of the phenomenon in view of the great variability of atmospheric conditions, so that the criteria for defining a meteorological drought can be extended only to an area with sufficient homogeneity from a climatic or even micro-climatic point of view.

Thus, it can be said that the phenomenon of meteorological drought occurs after a certain number of days without precipitation or with a very low level of precipitation. This approach should be limited to year-round climates, such as equatorial, tropical, humid subtropical, and temperate temperate climates.

Another more general approach to identifying periods of drought can be achieved by comparing rainfall in a well-defined period and area with the monthly, seasonal, annual or multiannual rainfall characteristic of that area. For example, the Hellmann criterion can be pointed out using the method of calculating the frequency of negative deviations of the monthly or annual precipitation from the average values specific to the time interval, considered to be characteristic of normal periods from a climatic point of view.

It should be noted as a specificity of meteorological drought that it refers strictly to the natural phenomenon of abnormal reduction of precipitation in a well-defined period and over a limited area, unlike other types of drought, which refers mainly to direct effects. of meteorological drought on various environments such as soils, vegetation, groundwater reserves, human society in general and economic activities in particular.

Agricultural drought. Pedological drought is a recurrence of meteorological drought and is installed as a direct consequence of the lack of rainfall and the intensification of evapo-perspiration phenomena which has the direct effect of drastically decreasing the water resource in the soil, negatively affecting the development of vegetation in general and crops, especially agriculture. In the event of a significant prolongation of the agricultural drought, the amount of biomass produced by an ecosystem decreases, leading directly to an even greater increase in the evaporation component at ground level. [100]

Basically, agricultural drought can be defined as a period of time in which the water reserves in the soil are insufficient for the normal development of agricultural crops in a given area. The parameters that characterize this type of drought are diverse and multidisciplinary; agricultural drought is probably the most important aspect of drought phenomena being by far a more particular and complicated aspect than those who deal with it seem to achieve, a study on it will inevitably lead to a study of soil physics, plant physiology and agricultural economics.

Parameters that characterize the water reserve in the soil - the degree of soil moisture, the level of groundwater, the degree of soil supply in the groundwater reserve, etc .; pedological parameters - soil type, water retention capacity, physico-chemical characteristics of the soil, etc.; specific parameters of agricultural culture - type of crop, degree of development of the crop, etc.

The correct characterization of the agricultural drought must take into account as many of the relevant parameters as mentioned above, which is often a difficult task. From the above considerations it can be seen that the phenomenon of agricultural drought is very heterogeneous even in a climate homogeneous area, agricultural drought being specific to a type of crop, its stage of development and the type of soil on which it grows. [101]

Hydrological drought refers to the significant decrease in surface and groundwater resources due to the prior existence of excessively prolonged meteorological and pedological droughts. In other words, hydrological drought is a period in which river flows, lake levels, wetland area and groundwater resources are drastically reduced due to the meteorological drought and not their natural cyclicality.

The hydrological drought is similar to the previous two by causality - the decrease for a sufficiently long period of precipitation - but at the same time it differs from the previous types by some particular characteristics:

- the frequency of occurrence of hydrological droughts is much lower compared to the previously presented types, due to the “buffer” character of water reserves stored in various environments: snow cover, reserves of natural and artificial lakes, non-captive underground reserves;

-the “delay” effect of this type of drought due to a phase shift in relation to the meteorological and the pedological drought; in many cases the time of its onset is after the end of the meteorological drought, and the time to return to normal situations is longer than in the case of the droughts presented in the previous paragraphs.

Far from being considered only a direct consequence of the meteorological drought, the hydrological drought is directly and indirectly influenced by anthropogenic factors. The additional degree of vulnerability to hydrological droughts involved in changes in land use structure, which is becoming more pronounced with the industrialization and demographic explosion of human society, must not be neglected. These changes, in particular the excessive deforestation and the reduction of the wetland areas of some river basins, have drastically diminished the potential of the river basin to store water reserves, with negative effects on the hydrological runoff characteristic of that basin. By decreasing the storage capacity of water reserves during wet periods, the degree of torrentiality of watercourses in excessively deforested river basins has increased, the effect being a substantial increase in the frequencies, durations and amplitudes of hydrological drought phenomena.

Ecological drought can be defined as a prolonged and widespread shortage of available natural water resources - including natural and anthropogenic hydrological changes - which create multiple disturbances in ecosystems. Of all the types of drought identified and studied to date, ecological drought has been the least studied, although it is the most widespread and most severe type of drought. [55]

Salinization contributes to the edaphic drought due to the increase of the osmotic pressure of the soil solution over that of the cultivated plants. It has a direct toxic effect on crop plants and facilitates the intensification of evaporation by the formation of crusts and the growth of albido.

Socio-economic drought is that aspect of the drought phenomenon in which meteorological, agricultural and hydrological aspects of droughts are associated with the social and economic effects they produce, in other words socio-economic drought can be defined as an overlap between the ratio of water requirements: -resources available on the one hand and the elements of droughts: meteorological, agricultural and hydrological on the other.

The ratio of water requirements to available resources must be assessed at the level of the manifestation of the drought phenomenon and not under normal conditions. If this report is problematic and in periods of relative normalcy we can say that we no longer have a problem related to drought, rather we can talk about an unsustainable over-development of that area.

In view of the above observation, it can be said that socio-economic drought occurs when the water requirements for the economy and other social activities exceed the water availability of the region for a well-defined period of time and overlaps with the manifestation of at least one aspect of drought phenomenon other than socio-economic.

The vulnerability to the socio-economic aspect of droughts for a particular society is all the greater as the water requirements of society and the implicit economic activities approach the values of the availability of water resources in normal climatic periods. [52]

In conclusion, it can be stated that in order to reduce the degree of vulnerability of an economy to the socio-economic effects of drought phenomena, strategies can be implemented regarding controlled water reduction for the specific water requirements or identify opportunities to increase the water availability by increasing storage capacities (accumulations, artificial enrichment of aquifers) and identifying new water sources that can be transported to the area.Given the exacerbated economic development of human society over the last two centuries, with the exponential increase in water requirements, the only solution to maintaining an optimal and acceptable degree of vulnerability to drought is social and economic development in balance with the potential of the region, in other words, sustainable socio-economic development.

1.7 Climatic, hydrothermal, agricultural, hydrological drought indices

Of particular note is the detailed presentation of the most representative indices of drought: climatic, hydrothermal, agricultural, hydrological. The calculation relations for the climatic indices are presented: the Hellman criterion, the N. Topor index, the percentage of the normal value PN, the deciles, the Bhalme-Mooley Drought Index (BMDI), the standardized precipitation index (SPI) , Effective Drought Index (EDI). Also presented are the calculation relations of the hydrothermal indices: De Martonne index, characterization after Thornthwaite, Domuța Hydrothermal index, Selianinov hydrothermal index, Palfai drought index and agricultural indices respectively: Moisture Available Index (MAI). Crop Moisture Index (CMI), Soil Moisture Index (SMD), Agro-Hydro Potential - AHP and Hydrological Drought Characterization Indices: Surface Water Supply Index – (SWSI), the Reclamation Drought Index (RDI), the Nedealcov Index, the Lang Rain Index.

Drought characterization indexes calculated in the thesis are:

- Hellman criterion
- N. Topor index
- De Martonne index
- Domuţa hydroheliothermal index
- Selianinov hydrothermal index
- Palfai (PAI) drought index
- LANG rain index

1.9 Thesis objectives

The objectives of the doctoral thesis proposed in this paper on drought and hydro-amelioration arrangements in the two areas studied are the following:

- to carry out a complex, current and perspective bibliographic synthesis in the field of drought and of the climatic risks related to this phenomenon - drought, desertification-, as well as of the types of drought.
- presentation of databases for 41 years (period 1980-2020) on the evolution of temperatures, precipitation and solar radiation in the studied areas.
- presentation of the studied areas and highlighting the particularities of each region in Romania and the Republic of Moldova.
- presentation of the current state of the hydro-amelioration arrangements and of the irrigation system from the west of Romania and of the Straseni district of the Republic of Moldova.
- the analysis from the perspective of the nexus of land-water-climate-energy of the hydro-amelioration works that are required in this context.
- drawing up graphs of the evolution of average annual temperatures, precipitation and solar radiation in the period 1980-2020 for each area studied.
- selection, presentation of calculation relationships and interpretation of representative drought calculation indices (hydrothermal, climatic, agricultural drought indices).
- comparative study of the evolution of drought indices for case studies in Romania - Timișoara, Sânnicolau Mare, Lugoj and Banloc respectively in the Republic of Moldova - Straseni.
- comparative study of the evolution of drought indices between Romania and the Republic of Moldova
- assessment of the impact of the drought on agriculture and its agro-economic possibilities to mitigate it, correlated with the infrastructure of land improvement works in the studied areas
- recommendations for future research directions.

CHAPTER II
NATURAL FRAMEWORK OF THE STUDIED TERRITORIES

In chapter 2 entitled are justified and presented the studied areas (Banat Plain - Timiș County and Straseni District - Republic of Moldova), together with the following characteristics: physical-geographical position; the population; the relief; climate, temperature and precipitation; hydrography and hydrology; vegetation and fauna; geology and geomorphology; the current legislative / legal framework for combating drought and the national strategy for combating desertification and reducing the effects of drought in Romania and Moldova.

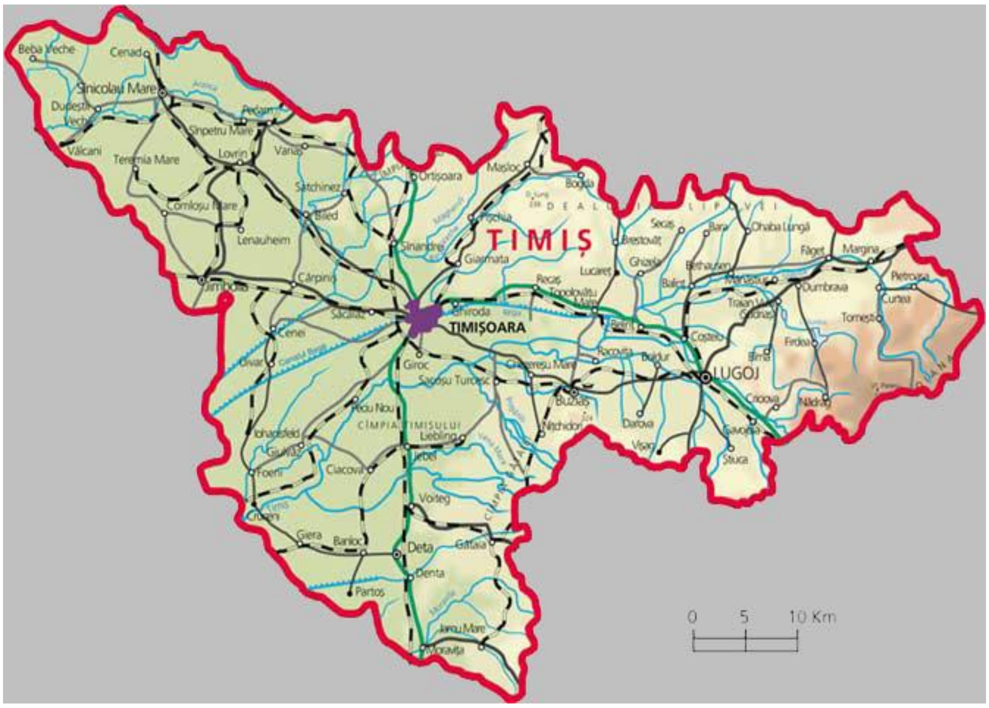


Fig 2.1 Timiș county map

Fig 2.2 Republic of Moldova map, Strășeni county

CHAPTER III
CURRENT GENERAL THEORETICAL PROBLEMS ON THE PHENOMENON OF DROUGHT. CURRENT STATE OF THE INFRASTRUCTURE OF THE HYDRO-IMPROVEMENT DEVELOPMENTS IN TIMIŞ COUNTY (RO) AND STRĂŞENI DISTRICT (MD)

In Chapter 3 we present the theoretical aspects related to:
- Sustainable land management
- Drought analysis and management in the perspective of practicing an agriculture adaptable to climate change. Modernization proposals and solutions in operation
- Hydro-improvement works analyzed from the perspective of the land-water-climate-energy nexus
- Agronomic possibilities for drought mitigation
- The impact of drought and desertification on agriculture: ways and mitigation actions
- Specific and particular problems regarding drought in Romania and the Republic of Moldova

The infrastructure of the hydro-amelioration arrangements from Timiş County and Straseni District is also presented synthetically.

CHAPTER IV
OWN RESEARCHES REGARDING THE CURRENT STATE OF THE DROUGHT INFLUENCES ON TIMIŞ COUNTY AND STRASENI DISTRICT.
CASE STUDIES

4.1. Climatic data: Case study Timis county

4.1.1. Temperatures: Timişoara, Sânnicolau Mare, Lugoj Banloc

4.1.1.1. Temperatures: Timisoara

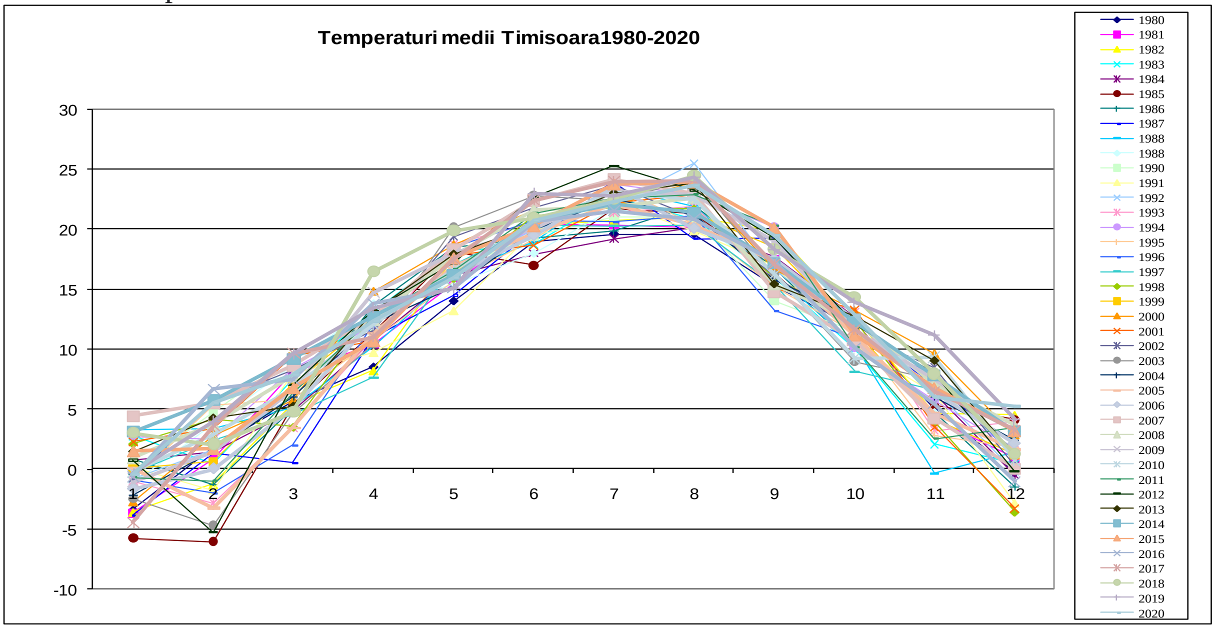


Figure 4.1 Evolution of temperatures in Timisoara 1980-2020

4.1.2.Rainfall: Timişoara, Sânnicolau Mare, Lugoj, Banloc

4.1.2.1. Rainfall: Timişoara

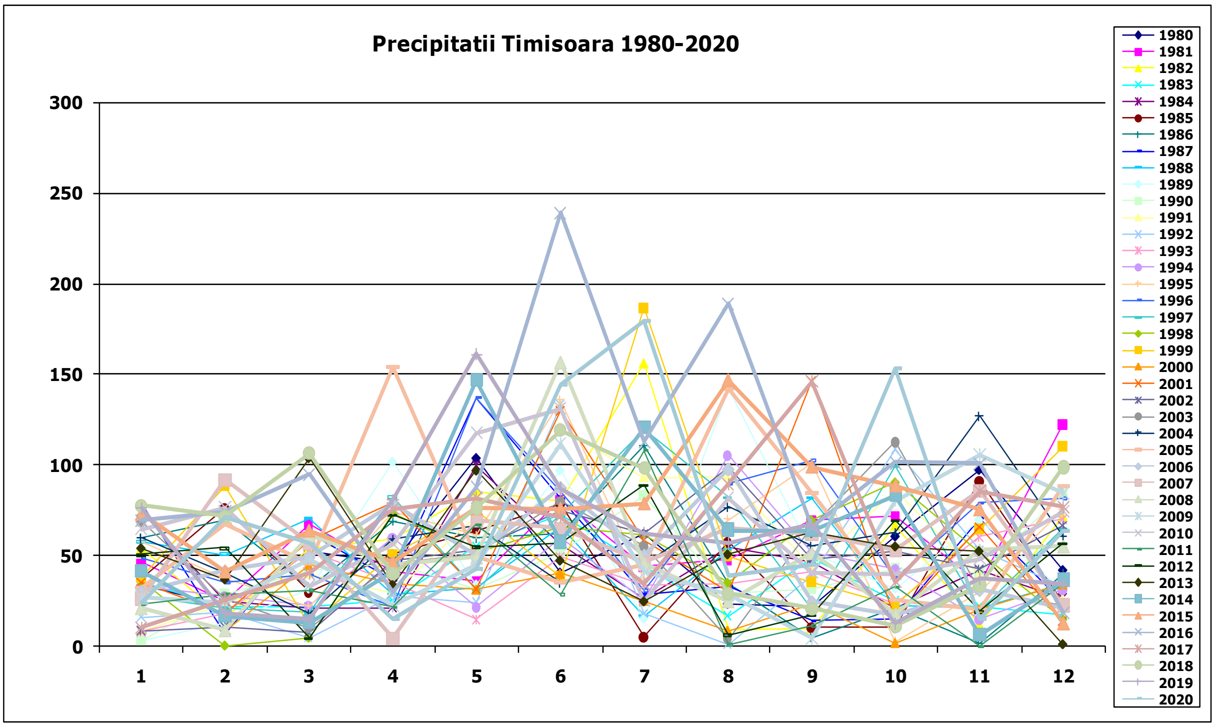


Figure 4.5 Evolution of rainfall in Timişoara in the 1980-2020 period

4.2. Climate data: Case study Strășeni district

4.2.1. Temperatures: Strășeni district

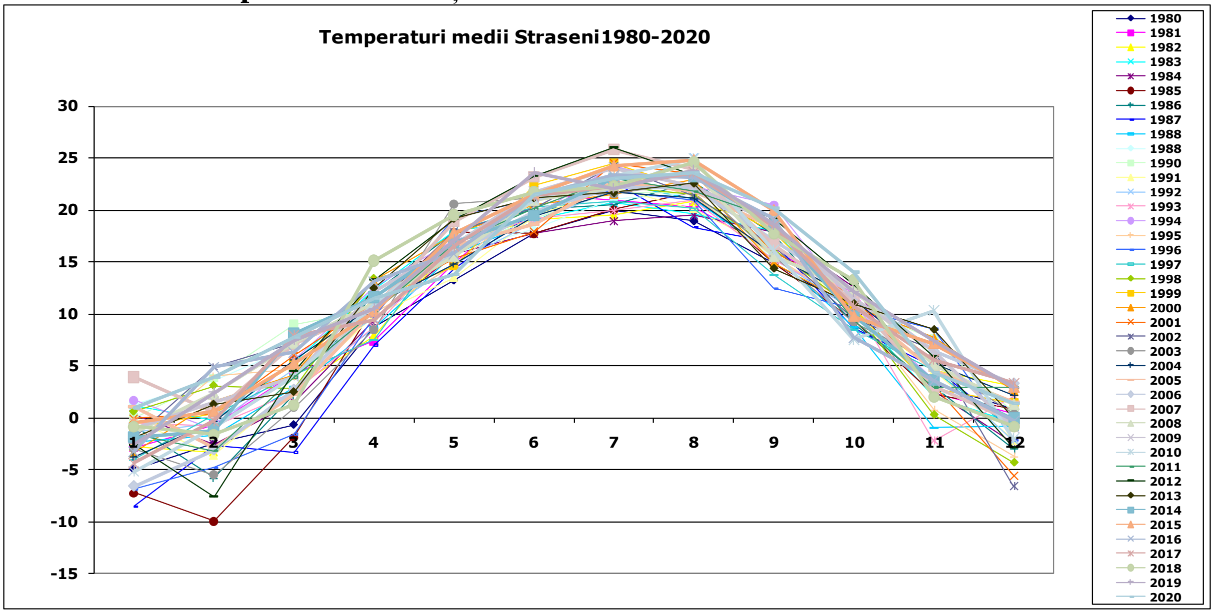


Figure no. 4.10 Evolution of temperatures in Strășeni district between 1980-2020

4.2.2. Rainfall: Strășeni district

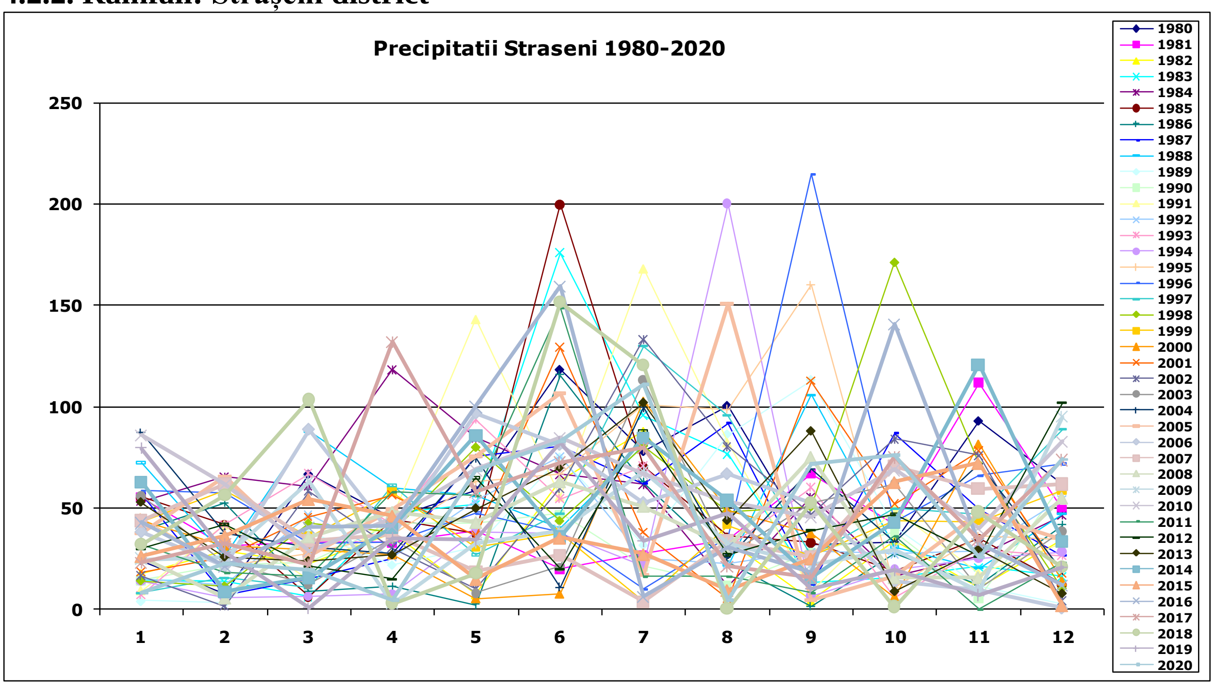


Figure no. 4.11 Evolution of rainfall Strășeni district in the 1980-2020 period

4.3. The results of the calculation of several indices of drought characterization in the localities Timişoara, Sânnicolau Mare, Lugoj and Banloc from Timiş county

4.3.1 Hellman criterion

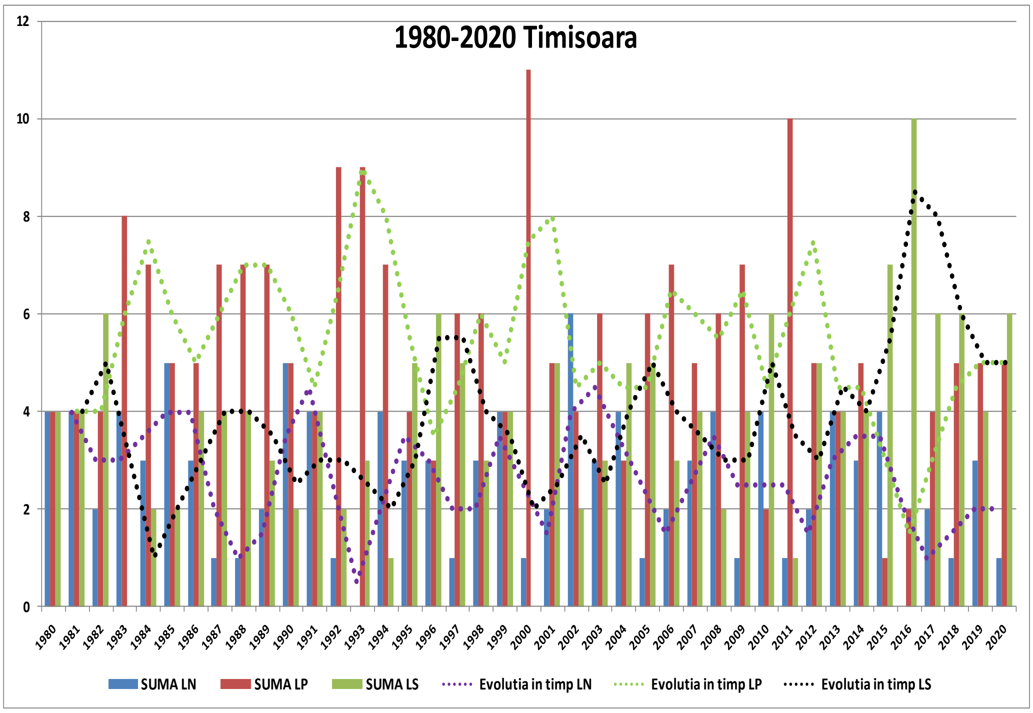


Figure no. 4.12 Results of calculation Hellman criterion for Timişoara

4.3.2 N. Topor index

4.3.2.1 N.Topor index Timişoara

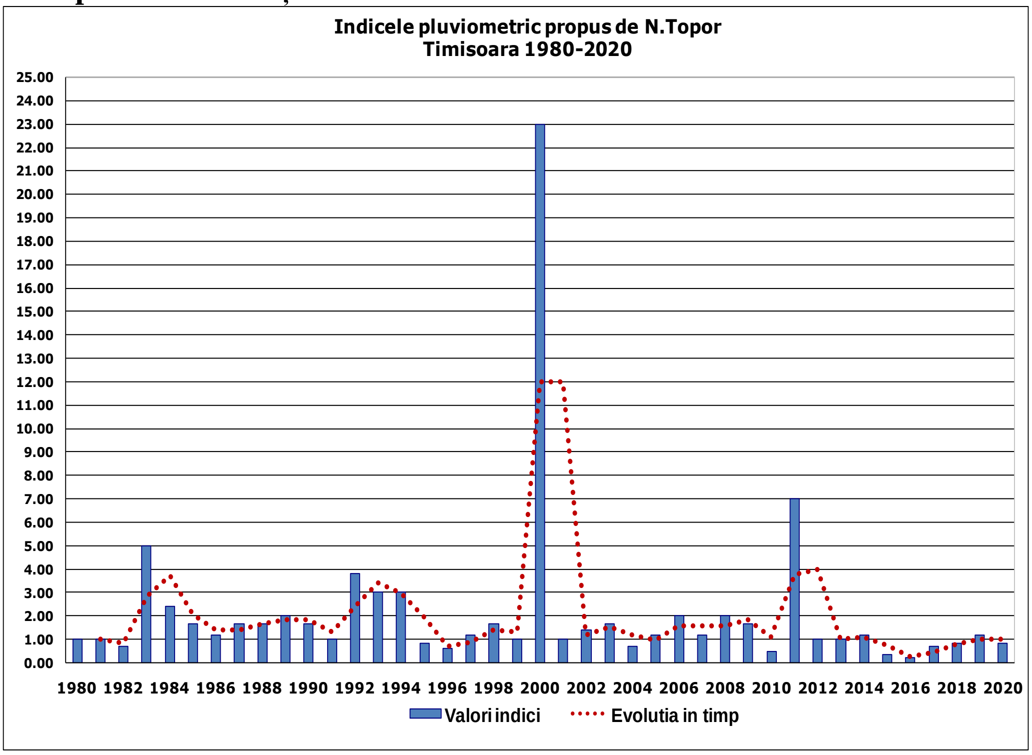


Figure 4.20 result of calculating N.Topor index for Timişoara

4.3.3 De Martonne index

4.3.3.1 De Martonne index Timişoara

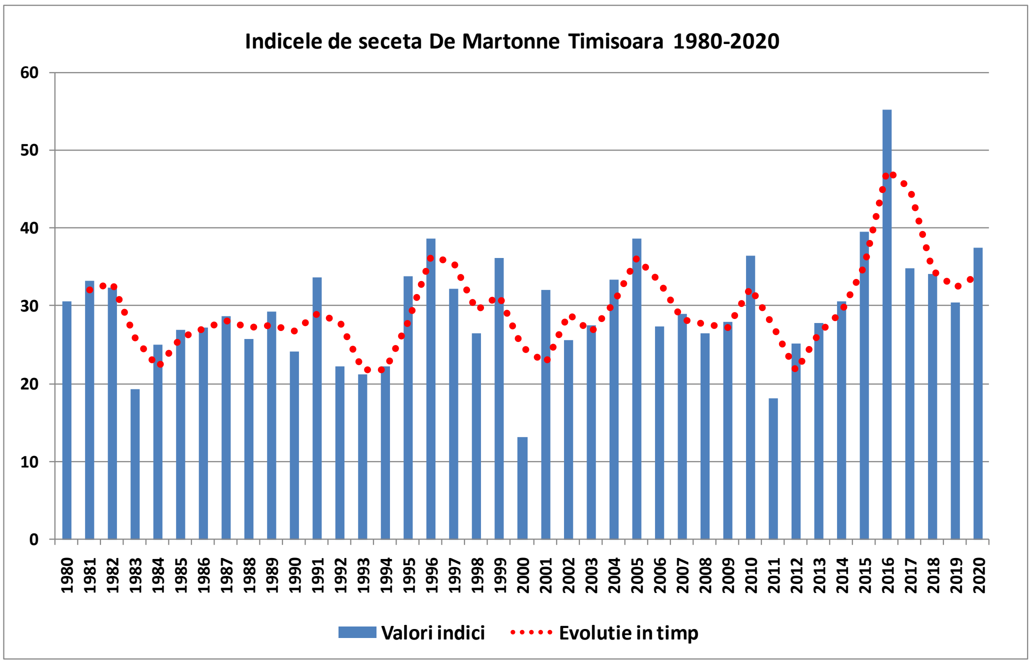


Figure 4.24 Result of calculation De Martonne index for Timișoara

4.3.4 Domuţa hydroheliotermical index

4.3.4.1 Domuţa hydroheliotermical index Timișoara

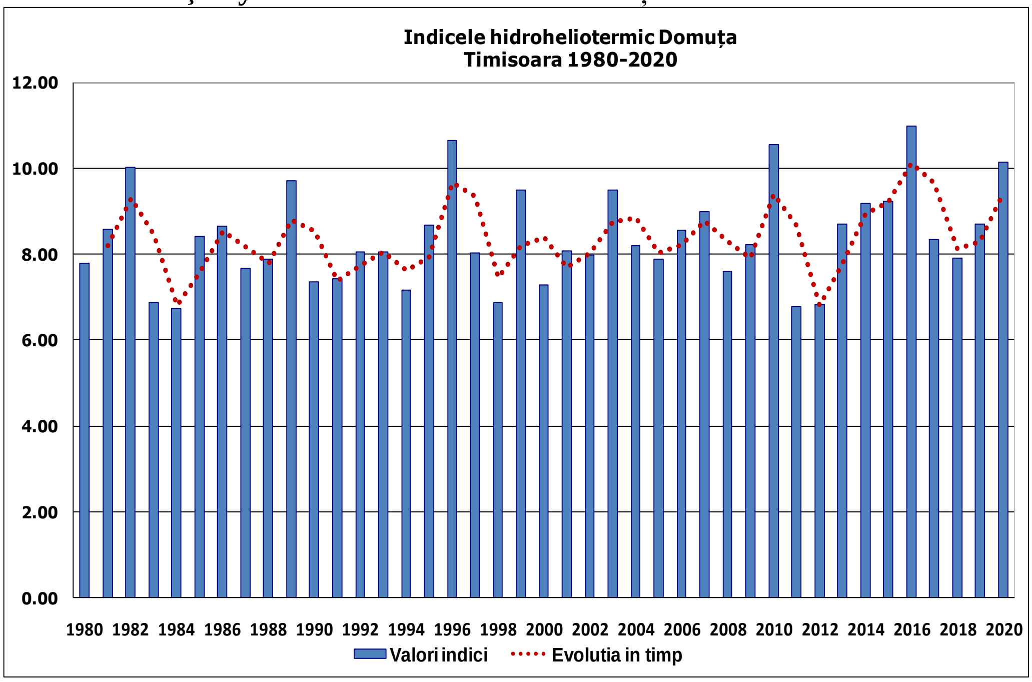


Figure 4.28 result of calculation Domuţa hydroheliotermical index for Timișoara

4.3.5 Selianinov hydrotermical index

4.3.5.1 Selianinov hydrotermical index Timișoara

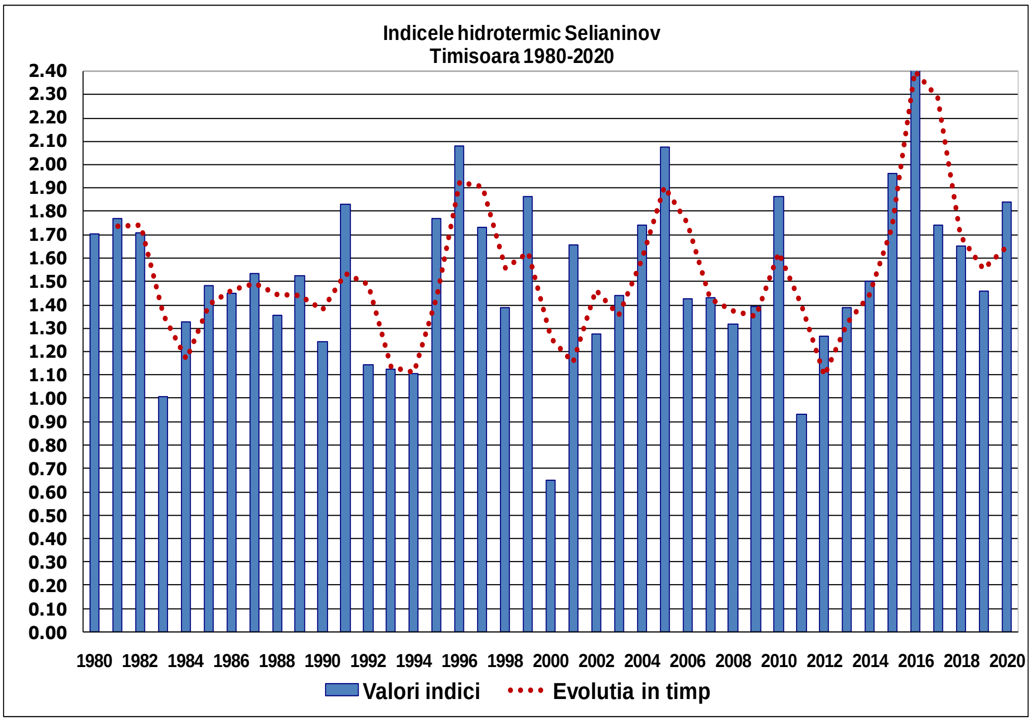


Figura 4.32 Result of calculation Selianinov hydrotermical index for Timişoara

4.3.6 Palfai drought index (PAI)

4.3.6.1 Palfai drought index (PAI)Timişoara

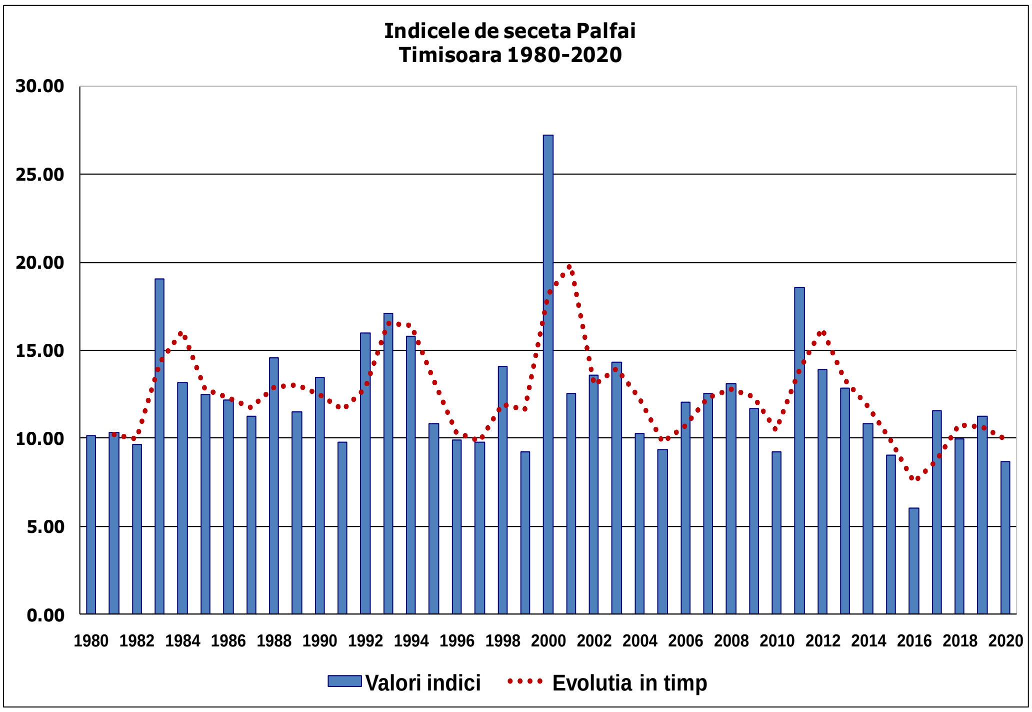


Figure 4.36 Result of calculation Palfai drought index for Timişoara

4.3.7 LANG rain index

4.3.7.1 LANG rain index Timişoara

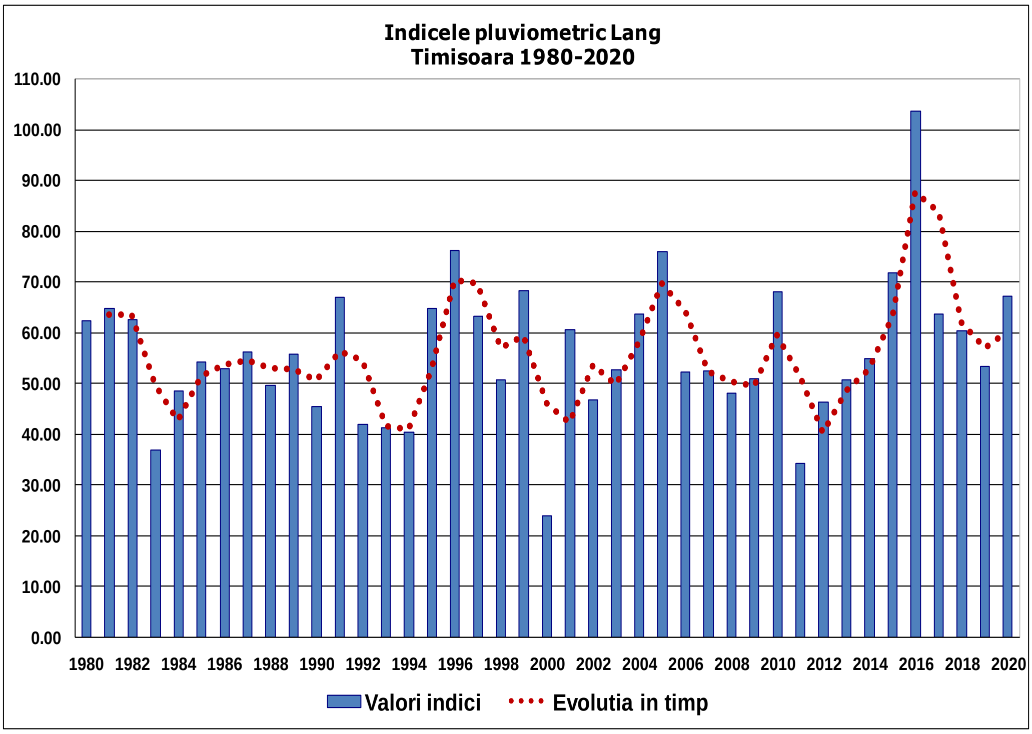


Figure 4.40 Result of calculation Lang rain index for Timișoara

4.4. The results of the calculation of several indices of drought characterization in Strășeni district

4.4.1 Hellman criterion

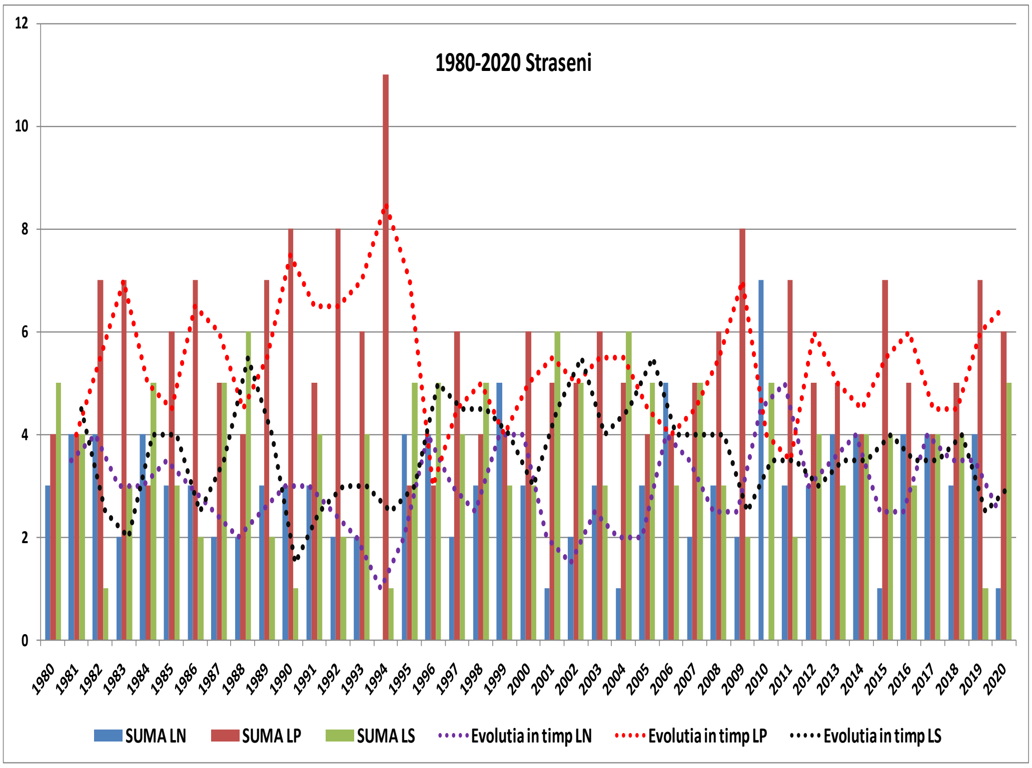


Figure 4.44 Result of calculation Hellman criterion for Strășeni district

4.4.2 N. Topor index

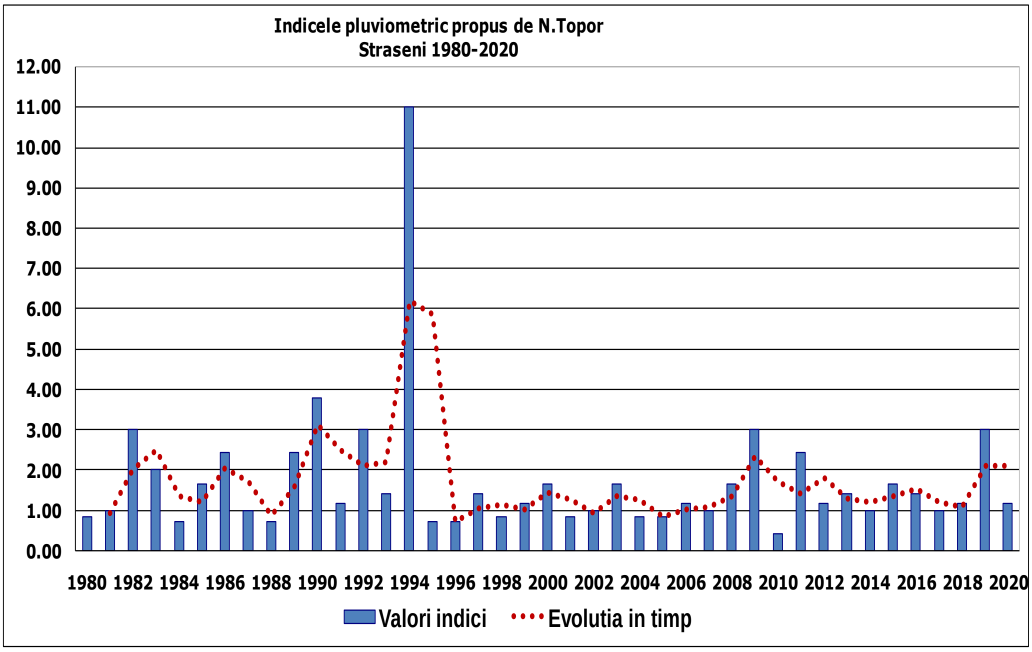


Figure 4.46 Result of calculation N.Topor index for Strășeni district

4.4.3 De Martonne index

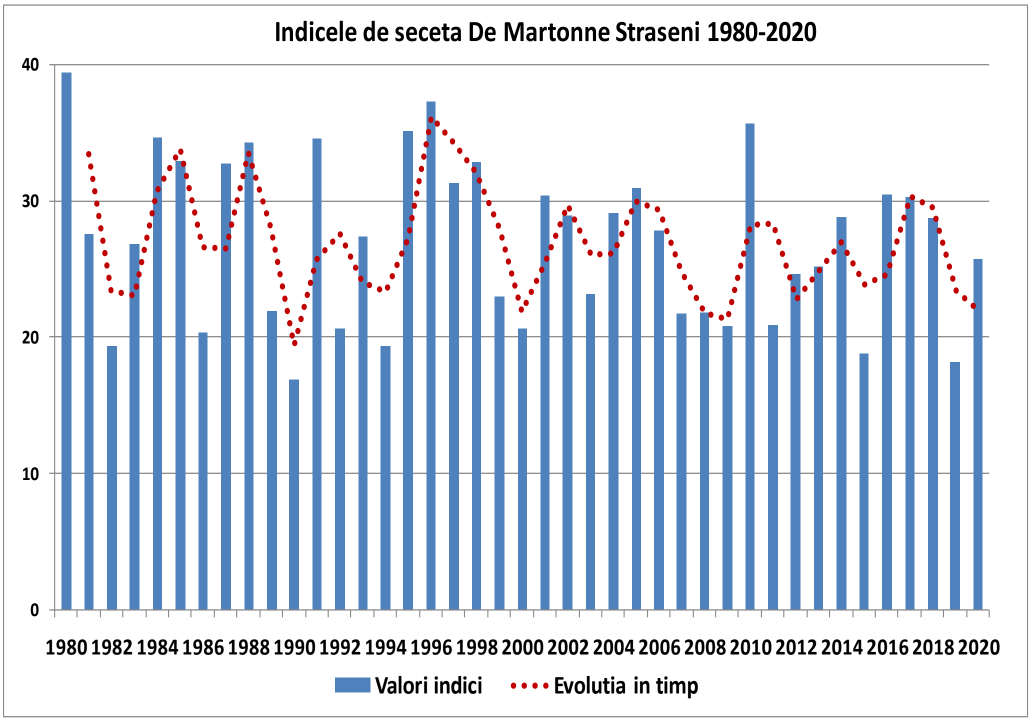


Figura 4.47 Result of calculation De Martonne index for Strășeni district

4.4.4 Domuţa hydroheliotermical index

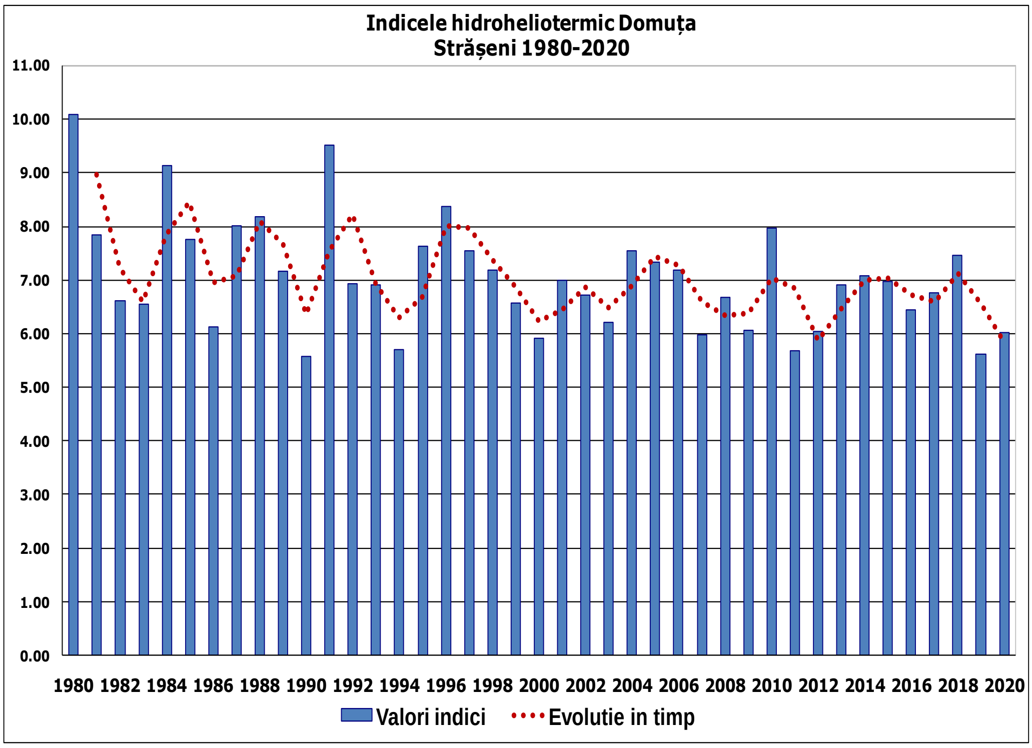


Figure 4.48 Result of calculation Domuţa hydroheliotermical index for Strășeni district

4.4.5 Selianinov hydrotermical index

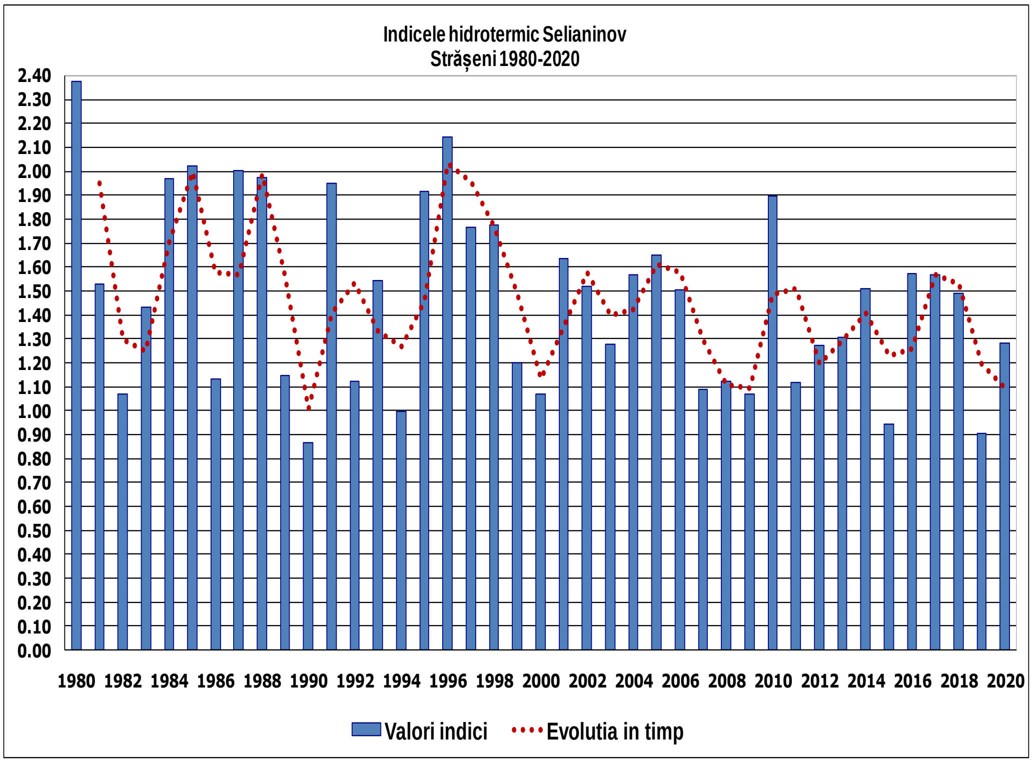


Figure 4.49 Result of calculation Selianinov hydrotermical index for Strășeni district

4.4.6 Palfai drought index(PAI)

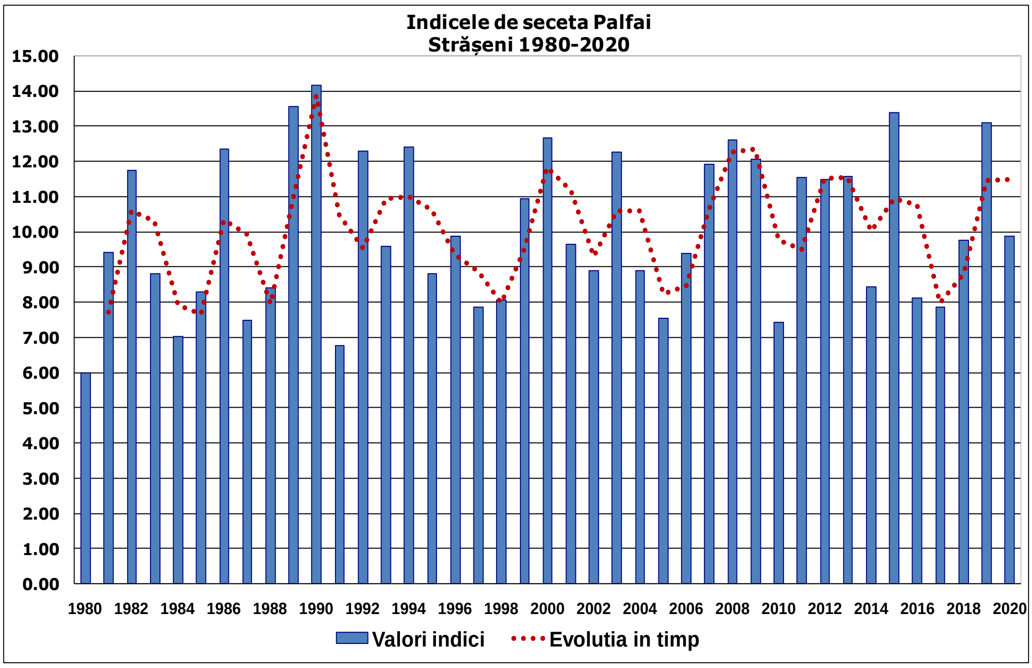


Figure 4.50 Result of calculation Palfai drought index for Strășeni district

4.4.7 LANG rain index

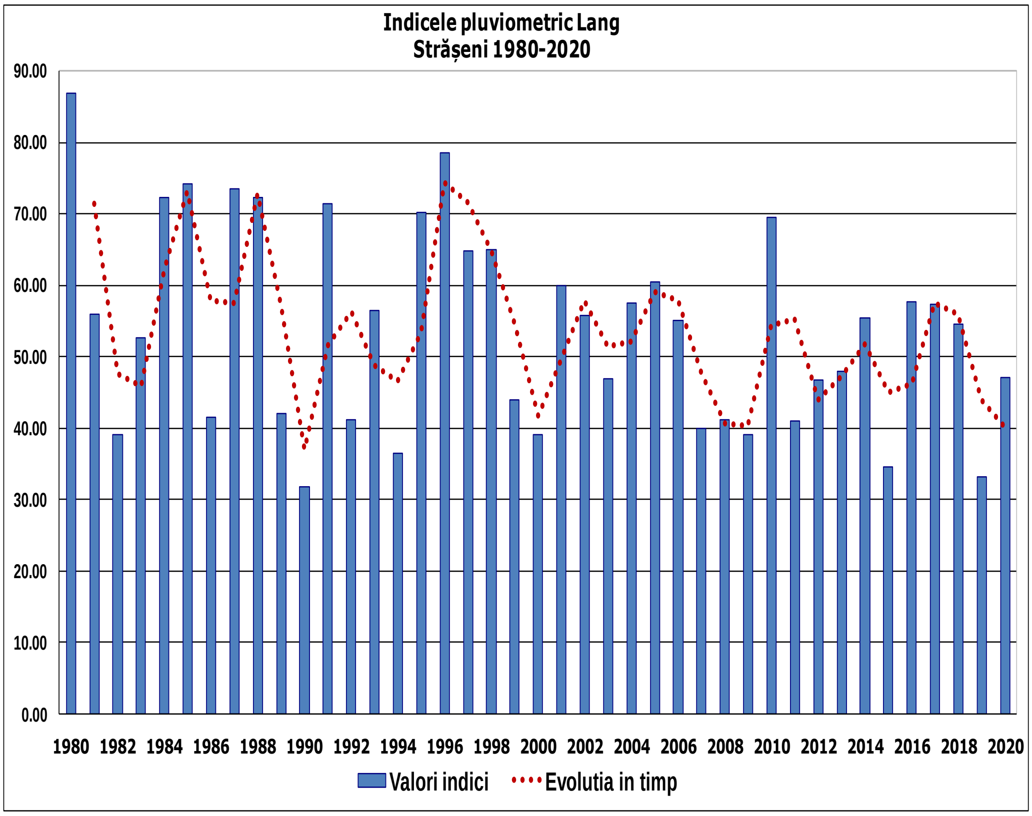


Figure 4.51 Result of calculation Lang rain index for Strășeni district

4.5. Comparisons between the results obtained on the basis of the indices calculated over the period 1980-2020 for Timişoara, Sânnicolau Mare, Lugoj, Banloc and Straseni District

4.5.1 Comparisons between the results obtained on the basis of the Hellman Criterion during the period 1980-2020 for the localities of Timişoara, Sânnicolau Mare, Lugoj, Banloc and Strășeni district

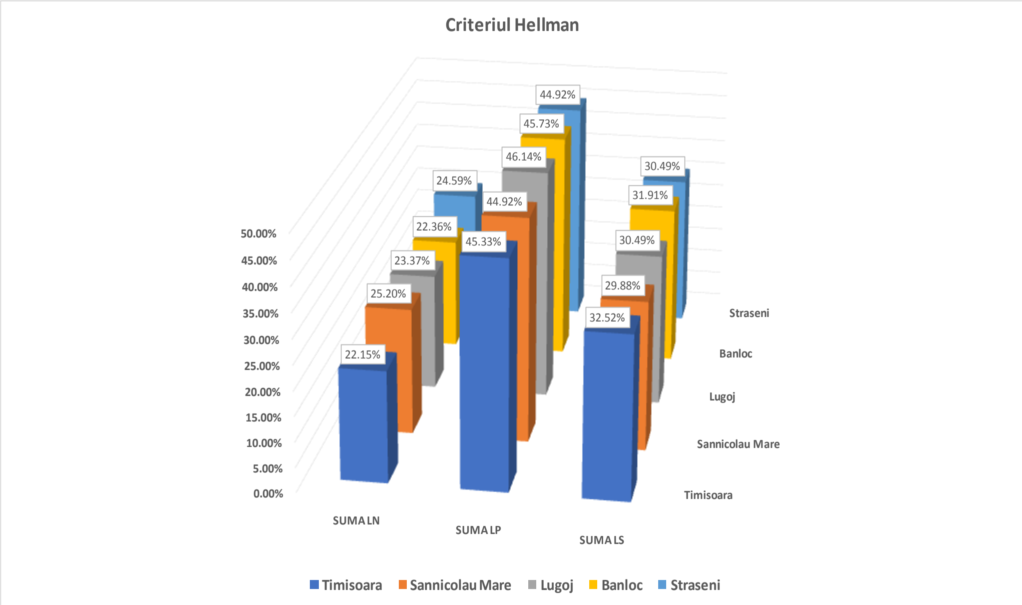


Figure 4.52 Comparison between the areas studied based on results from Hellman criterion

4.5.2 Comparison between results obtained based on calculating N.Topor index throught the 1980-2020 period for Timișoara, Sânnicolau Mare, Lugoj , Banloc and Strășeni district

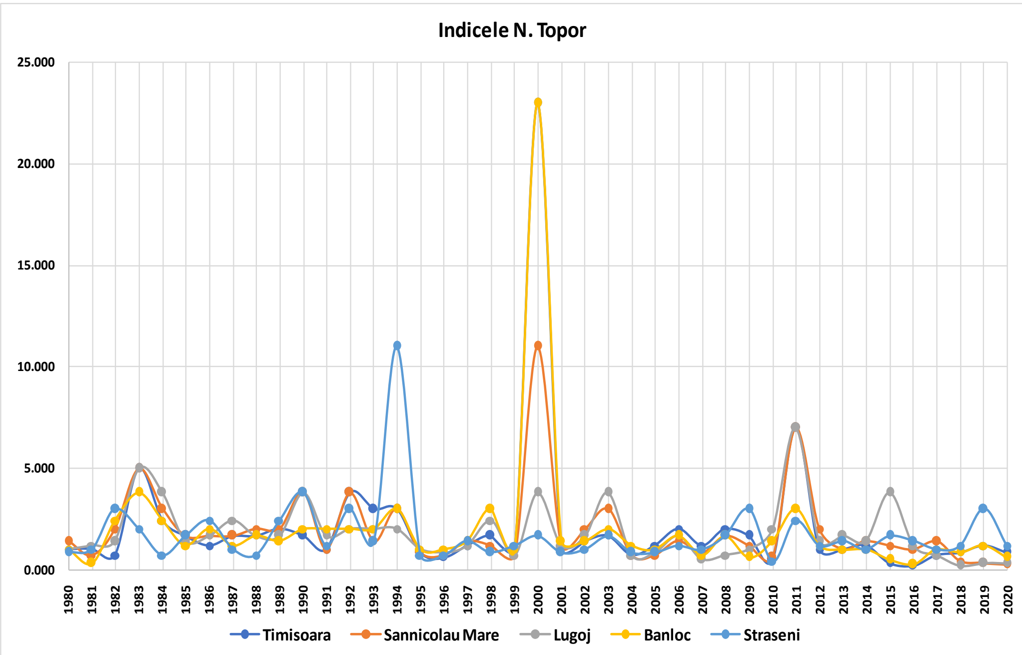


Figure 4.53 Comparison between the areas studied based on results from N.Topor index

4.5.3 Comparison between results obtained based on calculating De Martonne index throught the 1980-2020 period for Timișoara, Sânnicolau Mare, Lugoj , Banloc and Strășeni district

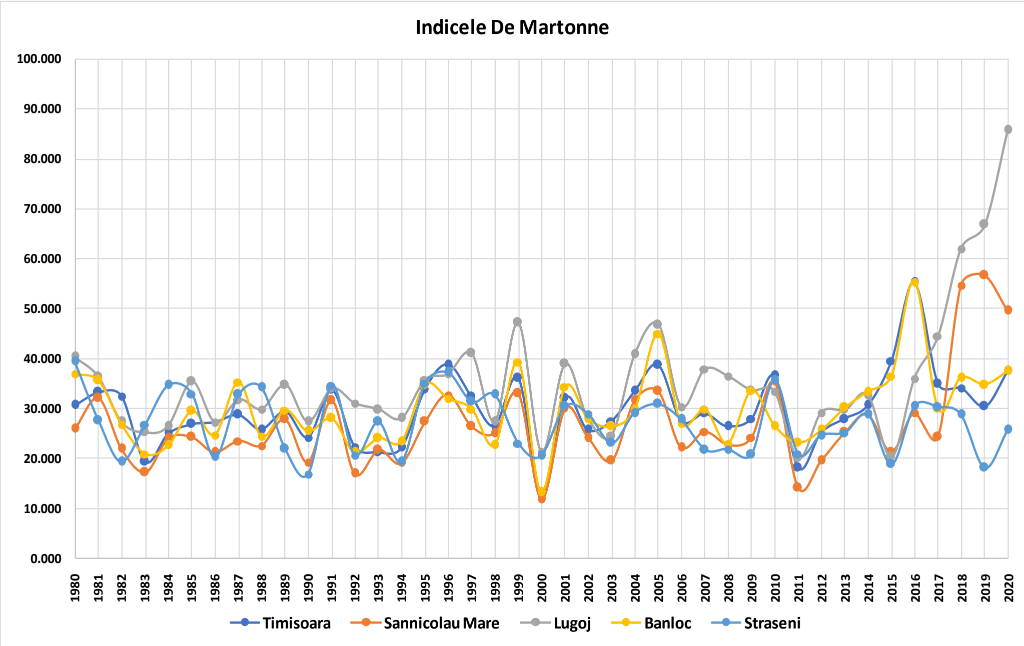


Figure 4.54 Comparison between the areas studied based on results from De Martonne index

4.5.4 Comparison between results obtained based on calculating Domuța index throught the 1980-2020 period for Timișoara, Sânnicolau Mare, Lugoj , Banloc and Strășeni district

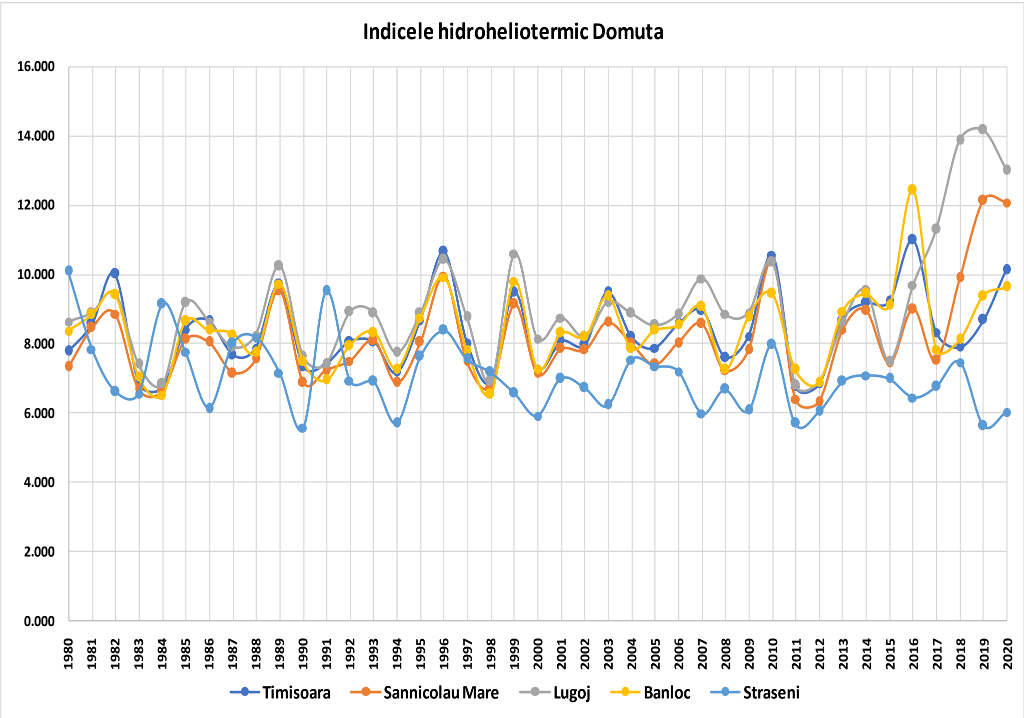


Figure 4.55 Comparison between the areas studied based on results from Domuța index

4.5.5 Comparison between results obtained based on calculating Selianinov index throught the 1980-2020 period for Timișoara, Sânnicolau Mare, Lugoj , Banloc and Străşeni district

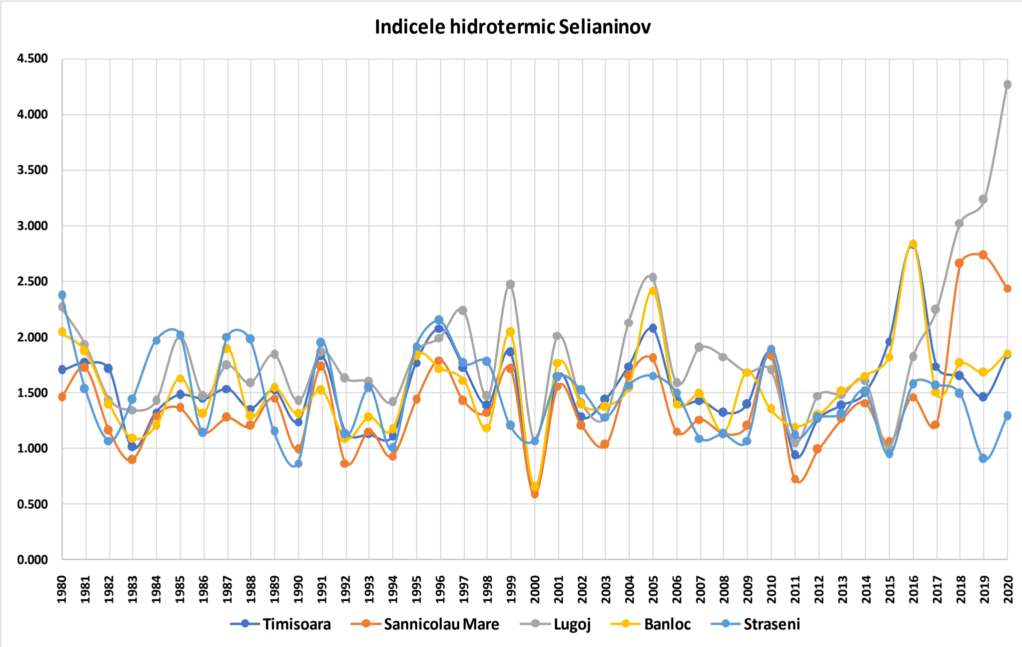


Figure 4.56 Comparison between the areas studied based on results from Selianinov index

4.5.6 Comparison between results obtained based on calculating Palfai index throught the 1980-2020 period for Timișoara, Sânnicolau Mare, Lugoj , Banloc and Străşeni district

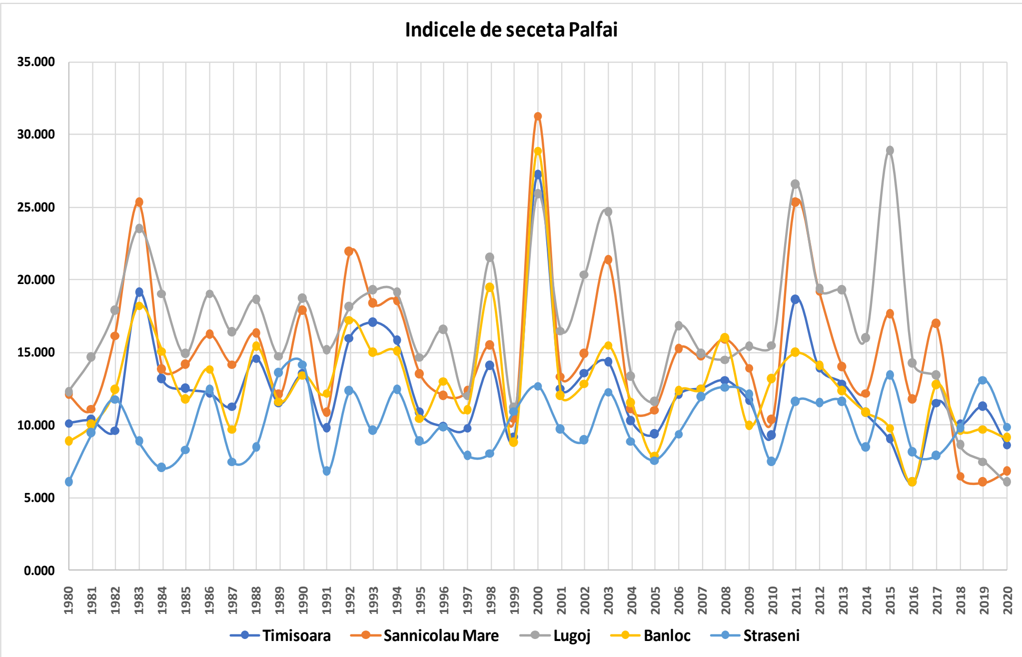


Figure 4.57 Comparison between the areas studied based on results from Palfai index

4.5.7 Comparison between results obtained based on calculating Lang index throught the 1980-2020 period for Timişoara, Sânnicolau Mare, Lugoj , Banloc and Străşeni district

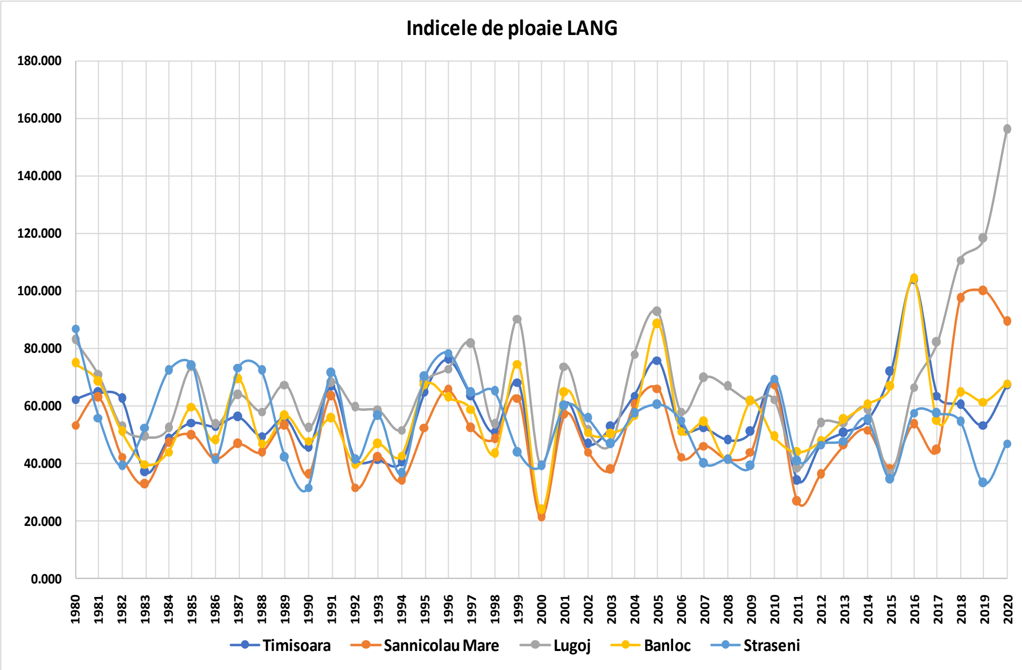


Figure 4.58 Comparison between the areas studied based on results from Lang index

4.6.Results of statistical data processing from 1980-2020 for each locality by calculated drought indices and global comparative statistics for calculated indices

4.6.1 Timişoara locality

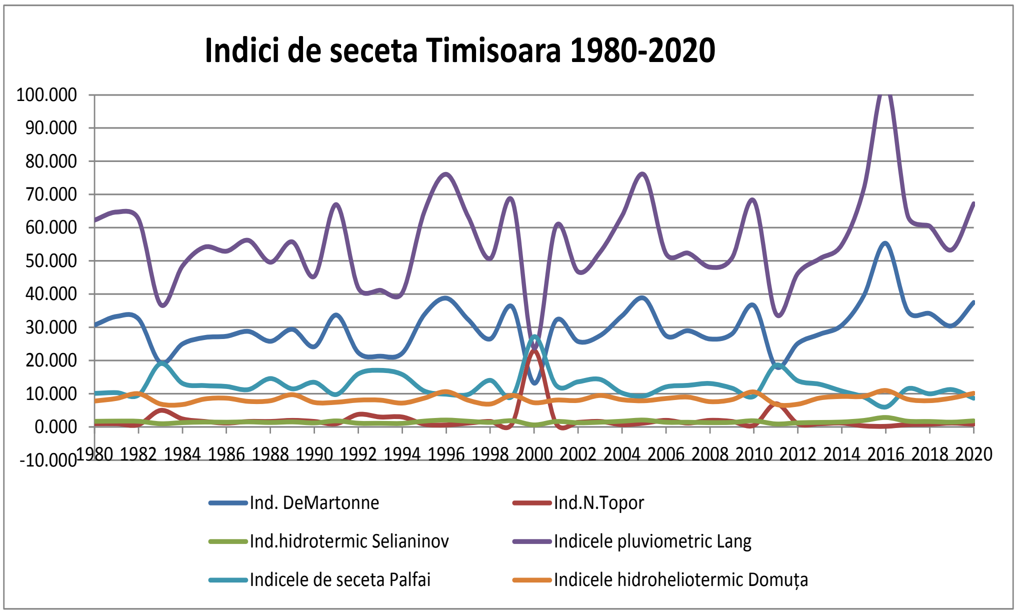
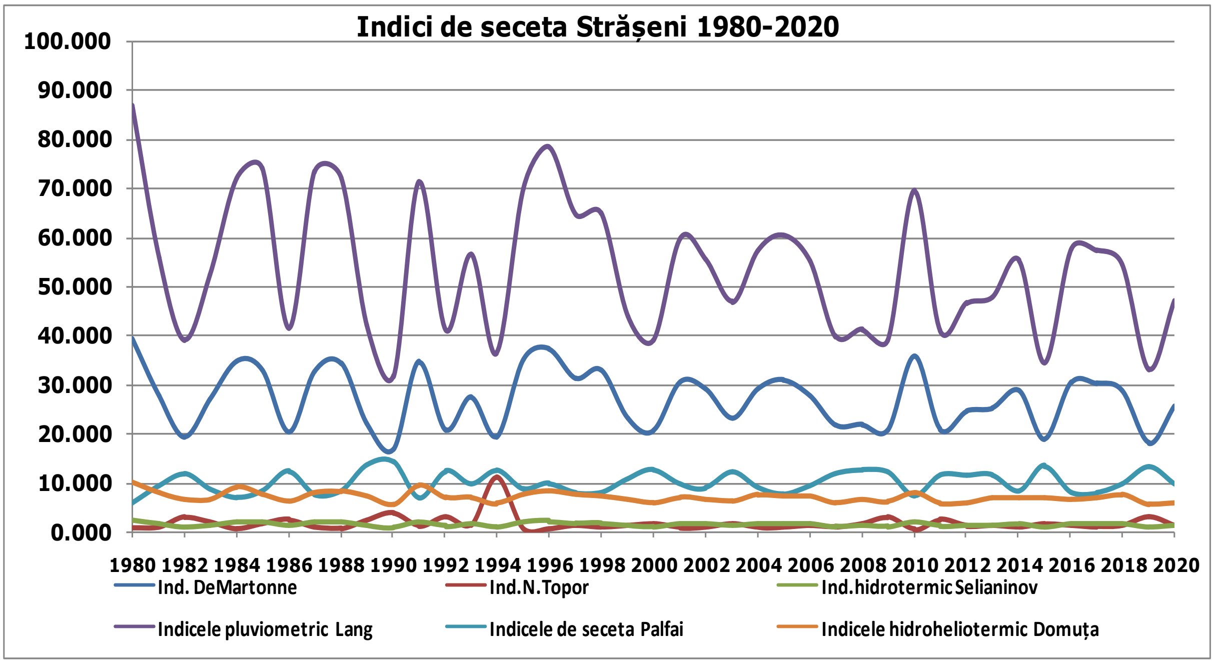


Figure 4.59 Presentation of drought indexes from the 1980-2020 period for Timişoara

4.6.5 Strășeni locality



4.6.6 Gaussen climogram – Timiş county and Străşeni district

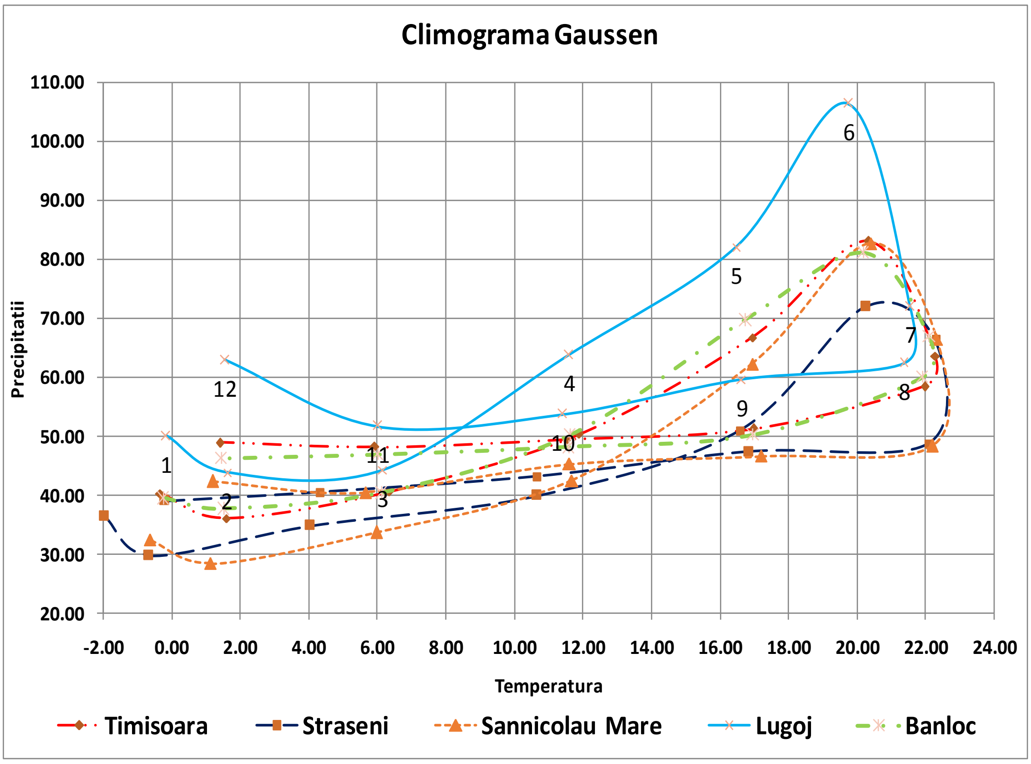


Figure 4.64 Comparison between studied areas based on Gaussen climogram

CHAPTER V
GENERAL CONCLUSIONS AND PERSONAL CONTRIBUTIONS
5.1 General conclusions

This paper reports on the current state of research on the phenomenon of drought, the current situation and the prospects of drought worldwide and in Europe, with special reference to the 2 case studies analyzed in western Romania and the center of the Republic of Moldova.

Droughts are extreme climatic phenomena that due to their effects are natural disasters that occur periodically, consisting of drastic reduction of rainfall and depletion of water resources over long periods of time. The deficit of precipitation leads to the reduction of the available water reserves for all uses, as well as for the damage to the environment. Drought in the context of understanding phenomena is considered the most complex hazard, but at the same time it is also the least understood natural hazard, having greater effects than other hazards.

Drought occurs and occurs most frequently and has the maximum impact in arid and semi-arid regions of the globe. It also appeared in the USA (1934, 1950, 1988, 2000), China (2000) but also in Romania (1894-1905 with a maximum drought in 1897, 1942-1953 with a maximum in 1946, 1947, 1982-1996).

The damage caused by the drought gives it inclusion in the category of natural disasters, along with other disasters such as floods, earthquakes, hurricanes, volcanic eruptions. The element that distinguishes it from other disasters is the fact that the phenomenon appears insidious, becoming important and predominant after a period of time.

In order to be aware of the fact that the drought phenomenon has settled in the area, a number of 7 climate characterization indices and the Gaussen Climogram have been calculated, from which we can conclude that:

-the drought has settled in the area and increases in intensity with the passing of the years;

- drought is a phenomenon that, at least in the studied areas, manifests itself cyclically alternating drier years with less dry or even rainy years;

Drought management is currently seen as water resources management, as its direct manifestations are in this sector. The effects of drought appear on all levels, including social, affecting living conditions and the state of environmental factors. The negative effects depend on its size (on which the level of water supply depends), as well as on the water requirement. Lack of drought planning and action can exacerbate the impact of drought, increase economic losses, and have major consequences for the health of the population and the environment.

As a synthesis of the study of the specialized technical literature and of the research presented in the doctoral thesis, I appreciate that “drought” can be defined conceptually and operationally, and is classified as follows:

1. Meteorological drought is defined in relation to the degree of precipitation reduction compared to a multiannual or “normal” average value and the duration of the period with reduced precipitation. Some definitions of meteorological drought identify periods of drought based on the number of days with precipitation below a certain threshold.
2. Agricultural drought in which characterization are considered and analyzed the climatic elements that have an influence on the size of agricultural production, respectively: precipitation, current and potential evapo-transpiration, as well as soil water balance. Plants show a variable sensitivity to the insufficiency of water in the soil, in relation to the development phase, in some phases, called "critical", the drought may have more pronounced effects of reducing agricultural production.

3. Hydrological drought is another category of drought that takes into account the effects of periods of low rainfall (including solid rainfall) on the volume of water accumulated in lakes and underground aquifers. The frequency and severity of this drought is defined by river basins. The hydrological drought manifests itself with a certain delay compared to the agricultural and meteorological drought.
4. Socio-economic drought associates the demand and supply of economic goods with meteorological, hydrological and agricultural drought. Satisfying the demand for water for fodder, agricultural crops, fish farming, as well as for the production of hydroelectric power, depends on the climate.
Low rainfall means that in times of drought it is impossible to meet human needs and the ones to maintain the balance of environmental factors. Socio-economic drought occurs when the demand for water as an economic good exceeds supply, as a result of droughts and reduced water quantity.
The existence of various types of environments (soils, waters, atmosphere) and sectors affected by droughts (agriculture, industry, fish farming, hydropower, leisure - tourism, sanitation, health, etc.), the particular geographical conditions and variability over time of droughts lead to a difficult definition of unitary indices to characterize the drought phenomen.
In the thesis I presented all the indexes found in the specialized technical literature from which I selected 7 indexes for which I was able to collect the input data. Some of them need technical equipment and software that are currently less available in the country.
From a meteorological point of view and punctual considerations, droughts are characterized by intensity and duration. These elements are important because the effects on local agricultural production depend on them, the worst droughts being those of great intensity and duration.
If the analysis is on a regional scale, the area of extent of the drought will be taken into account, with the observation that the analysis of the territorial extent of the drought will be preceded by specific analyzes at meteorological stations in the region. In this context, four areas / localities from the west of the country (Timișoara, Sânnicolau Mare, Lugoj and Banloc) and one area from the center of the Republic of Moldova (Straseni District) were chosen in the thesis.
The historical analysis of droughts also requires the study of their frequency of production. The connection between the elements that characterize droughts largely depends on the local physical-geographical conditions, which have a pronounced non-uniformity, determined by climatic influences, non-uniformity of relief, soils, geological conditions, etc.

5.2 Personal contributions

Personal contributions in this paper are directed on several levels, including the following:
- collecting and processing a large volume of climate data from weather stations for 41 years (1980-2020) using a calculation program in the Visual Basic programming language under the OFFICE 365 platform through EXCEL, on the evolution of temperatures, precipitation and solar radiation in the studied areas.
- presentation of the studied areas and highlighting the particularities of each region in Romania and the Republic of Moldova, in terms of sustainable land management, drought analysis and management in the perspective of practicing agriculture adaptable to climate change, and some specific and particular drought issues in Romania and Moldova.
- presentation of the current state of the hydro-amelioration arrangements and of the irrigation system in western Romania and of the Straseni District of the Republic of Moldova.
- the analysis from the perspective of the nexus of land-water-climate-energy of the hydro-amelioration works that are required in this context.

- drawing up original graphs of the evolution of the average annual temperatures, precipitation and solar radiation in the period 1980-2020 for each studied area, highlighting the average annual temperatures, minimum and maximum recorded over a period of 41 years under study.
- selection of 7 representative drought characterization indices, presentation of calculation relationships and interpretation of these drought calculation indices (hydrothermal, climatic, agricultural drought indices).
- comparative study of the evolution of drought indices for case studies in Romania - Timișoara, Sânnicolau Mare, Lugoj and Banloc, respectively Straseni District of the Republic of Moldova, highlighting the similarities and differences between the results for the studied localities.
- comparative study of the evolution of drought indices in Romania and the Republic of Moldova
- outlining new research directions on additional drought control measures. (protection curtains, agrotechnical works, agropedological measures, etc.) and the use of solar energy in irrigation arrangements.

5.3 Proposals for new directions for future research

- Studies on the role of protection curtains, agrotechnical works and the agropedological measure on lands in case of droughts;
- Drought assessment based on indices other than those used in this thesis and comparisons with them, such as: Agricultural indices: Moisture Available Index (MAI), Crop Moisture Index (CMI)), Soil Moisture Index (SMD) and Agro-Hydro Potential (AHP) and Satellite Data Indices: Normalized Difference Vegetation Index (NDVI), Intensified Vegetation Index (Enhanced Vegetation Index - EVI), Vegetation Condition Index (VCI), Temperature Condition Index (TCI), Climate Moisture Index (CMI), Soil Humidity Index (Soil Moisture Index - SMI);
- Studies on the use of solar energy in irrigation arrangements.

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