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QUANTITATIVE ANALYSIS OF HUMAN PRESSURE AND CLIMATE ARIDITY IN THE PESCEANA RIVER BASIN, SOUTHWEST OLTENIA, ROMANIA

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Abstract

Quantitative analysis of aridity and drought at the local and regional levels has gained significance in recent years due to the impacts of global warming and variable precipitation, as well as their impact on the quality of life. In this study, a quantitative analysis of the temporal evolution of aridity conditions was performed in the Pesceana River Basin, Southwest Oltenia, Romania, using the De Martonne aridity index (AI_{DM}). Statistical data on the number of inhabitants in 2024 and the area occupied by forest in 2014 are taken from the Tempo online database, and data on temperature and precipitation for the period 2015-2024 are taken from the National Meteorological Administration (ANM) and other sources. According to the results of the AI_{DM} investigation, the Pesceana River Basin exhibits very humid and extremely humid climatic types, characterizing this location as having high humidity, abundant vegetation, and, often, high temperatures, which create a suffocating environment. At the same time, the I_{nat} results show that the basin's rural area is mostly characterized by landscapes with a moderate balance affected by anthropogenic intervention over time. Specifically, I_{nat} values between 20% and 40% were obtained for the six administrative-territorial units in this area.

Key words*: AI_{DM}, I_{nat}, precipitation, temperature, human pressure on the environment.*

INTRODUCTION

Human pressure on the environment, commonly referred to as a threat to biodiversity, is an action taken by individuals with the potential to harm nature (Martins et al., 2012).

Furthermore, according to Ionuș et al. (2011), anthropogenically induced transformations can have a significant influence on the environment and, especially, on the relief; the increasing vulnerability of land to dangerous geomorphological phenomena represents one of the most pressing problems that local communities currently face.

According to the literature, arid areas cover approximately 41% of the Earth's land surface (Yao et al., 2020; Coleine et al., 2024), and, according to estimates, by 2100, their area could further increase by 12% to 23% (Schlaepfer et al., 2017; Yao et al., 2020; Krivoguz, 2025).

Aridity is notable in the extra-Carpathian regions of Romania, mainly in the plains and plateaus of the country. Increases in aridity in these regions are triggered by two factors: (1) the constant increase in temperature and (2) potential evapotranspiration (Vlăduț & Licurici, 2020). In Romania, aridity has been highlighted and investigated by Croitoru et al., (2013) in the extra-Carpathian regions (Croitoru et al., 2013); by Paltineanu et al., (2007) and Vlăduț et al. (2017) in the south-eastern and southern regions of Romania (Paltineanu et al., 2007; Vlăduț et al., 2017); by Dragotă et al. (2011), Peptenatu et al. (2013), Prăvălie (2013), and Vlăduț (2010) in the Oltenia region (Vlăduț, 2010; Dragotă et al., 2011; Peptenatu et al., 2013; Prăvălie, 2013); by Lungu et al. (2011), Prăvălie & Bandoc (2015), and Tiscovschi et al. (2013) in the Dobrogea region (Lungu et al., 2011; Tiscovschi et al., 2013; Prăvălie & Bandoc, 2015); by Pelin (2016) in Moldova (Pelin, 2016); and by Lungu et al. (2012) for the Danube Delta.

AI_{DM} is most typically used in studies that fall under the fields of climatology/bioclimatology,

agricultural and land resource management, and water resource management. This index is also extremely useful in environmental assessments (Nistor & Mîndrescu, 2019; Cutini et al., 2021; Dimkić et al., 2022; Jafarpour et al., 2023; Gur et al., 2024).

The present research focuses on the temporal evolution of aridity in the Pesceana River Basin, Southwest Oltenia, Romania, using AI_{DM}. The main motivation for choosing to investigate this aridity index is its ability to simultaneously evaluate two research variables, namely temperature and precipitation. This ability is supported by recent research that confirms its value for investigating aridification not only at the national and global levels but also regionally and locally (Dikareva et al., 2021; Heidarizadi & Jamali, 2022).

Previous studies on the Pesceana River Basin have focused on the use of GIS techniques for evaluating land use (Măceșeanu et al., 2026) and investigating forest habitats and plant associations (Măceșeanu & Făgăraș, 2023), while others have quantified invasive plant species in European habitats (Măceșeanu & Făgăraș, 2024). Thus, this study represents the first comprehensive quantitative analysis of human pressures and climatic aridity in the Pesceana River Basin in southwestern Oltenia, Romania.

The main objectives of this study were (1) to calculate the AIDM for two meteorological stations, RM Vâlcea and Drăgășani, and (2) to assess human pressure on the environment in the Pesceana River Basin's rural area.

MATERIALS AND METHODS

Study Area

The Pesceana River Basin is located in the southwestern region of Oltenia (Figure 1), and more precisely in the southeastern part of Vâlcea County, Romania. Also, on the map in Figure 1 are mapped the eight administrative-territorial units (Amărăști, Crețeni, Glăvile, Gușoeni, Lădești, Mitrofani, Pesceana, and Sutești), localities, national roads, the hypsometry of the relief steps, and the hydrographic network The climate of the investigated area is temperate-continental, being also influenced by the location of the Pesceana River Basin in the Subcarpathians (Marinică & Marinică, 2016).

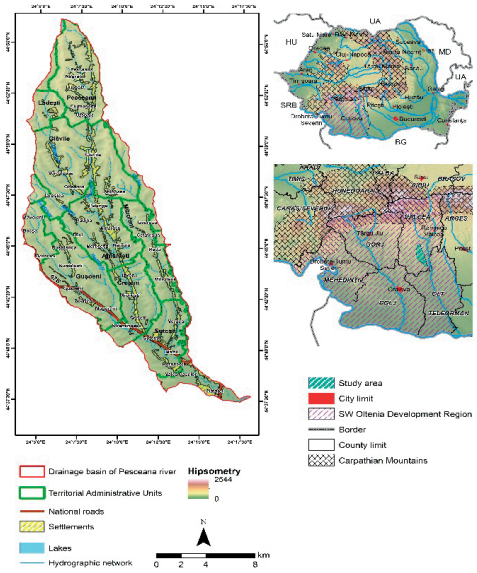

Figure 1. Location of the Pesceana River Basin in regional and national context
Source: Authors' own image created in ArcGIS 10.7.2. software

Data Sources and Methodology

In this study, the authors used a wide range of methods, including descriptive statistical methods (Crețan et al., 2023; Rotaru et al., 2023), statistical-mathematical (Popescu, 2014), and cartographic methods (Descultu et al., 2024; Drăguleasa et al., 2024), as well as one of the newest methods of the 21st century: "desk research" (Crețu et al., 2021; Niță, 2021; Mazilu et al., 2023; Vîlcea et al., 2023; Mazilu et al., 2024). The authors used several statistical data sets, including those from the National Institute of Statistics (NIS) and the National Meteorological Administration (ANM), and, based on these data sets, various tables were created (Popescu et al., 2019; Popescu et al., 2022; Popescu et al., 2023; Popescu et al., 2025).

For the study area, the authors chose to use the digital elevation model (DEM) at a resolution of 30 x 30 (Niță et al., 2025). The topographic map was georeferenced with longitude and latitude using ArcGIS software, version 10.7.2, with the boundary of the study area demarcated. The Geographic Information System (GIS) is an integrated hardware and software system capable of capturing, collecting, storing, and analyzing (Drăguleasa et al., 2023; Gordan et al., 2024; Călina et al., 2025a; Călina et al., 2025b; Călina et al., 2025c) as well as displaying

geographically referenced (spatio-temporal) information in order to support decision-making for the development of an area or territory, which, in this case, is the Pesceana River Basin. The De Martonne aridity index (AI_{DM}) was used to quantitatively assess the degree of humidity in the geographical space of the Pesceana River Basin. This index was calculated using the following formula (Martonne, 1920; Martonne, 1925; Martonne, 1926; Coscarelli et al., 2004):

$$AI_{DM.} = \frac{P}{(T+10)}$$

where:
AI_{DM} - De Martonne aridity index;
P - annual precipitation (in mm);
T - average annual air temperature (in °C);
10 - coefficient added to obtain positive values.
The AI_{DM} was calculated for two meteorological stations that frame the basin—the RM Vâlcea meteorological station in the north and the Drăgășani meteorological station in the south.
Human (anthropic) activities exert pressure on the environment that differs between types of spaces and areas. The values of human pressure "*highlight the directions through which man intervenes in the structure of the biotic envelope*" (Pătroescu, 1996).
The formula applied by the Food and Agriculture Organization of the United Nations (FAO) to calculate this indicator is (Vijulie, 2010):

$$P = \frac{S\ (ha)}{N\ (loc)}$$

where:
P - human pressure;
S - analyzed area (hectares);
N - number of inhabitants in the analyzed area.
In order to assess the natural state of the landscape, a synthetic index was calculated—namely, *the naturalness index*—for the rural landscape of the Pesceana River Basin (Dumitrașcu, 2006), its value represents the share of the area covered by forest in the analyzed territorial unit. This index was calculated using the following formula (Niculae, 2012):

$$I_{nat} = \frac{Spad}{Stot}\ x\ 100$$

where:
I_{nat} - naturalness index;
S_{pad} - area occupied by forest (hectares);
S_{tot} - total area.

RESULTS AND DISCUSSIONS

AI_{DM} - De Martonne aridity index

The AI_{DM} is used to assess the degree of dryness of a given environment by classifying it into one of seven classes - which range from "*dry*" to "*extremely humid*" - based on climatic parameters, i.e., the two research variables taken into account in this study: air temperature and precipitation (Charalampopoulos et al., 2023; Claro et al., 2023; Charalampopoulos et al., 2025).
In order to identify trends, in this study, the index's formula was applied to each year or shorter periods to obtain data sets for calculating trends. According to the values obtained by calculating the AI_{DM}, the climatic type of a region can be classified as shown in Table 1.

Table 1. Climate type according to AI_{DM}

Climate type	AI_{DM} value
Arid	< 10.0
Semi-arid	$10.0 \leq I_{DM} < 20$
Mediterranean	$20.0 \leq I_{DM} < 24.0$
Semi-humid	$24.0 \leq I_{DM} < 28.0$
Humid	$28.0 \leq I_{DM} < 35.0$
Very humid	$35.0 \leq I_{DM} \leq 55.0$
Extremely humid	$I_{DM} > 55.0$

Source: Adapted by the authors from Baltas (2007) and Croitoru et al., 2013 (Baltas, 2007; Croitoru et al., 2013)

Based on the climatic parameters (air temperature and precipitation), the AI_{DM} was calculated for two meteorological stations (RM Vâlcea and Drăgășani) for the period 2015-2024 (Table 2 and Table 6). The highest AI_{DM} index was recorded at the RM Vâlcea station in 2018 (81.51), and, at the opposite pole, a value of 40.04, at the Drăgășani station in 2024.

Table 2. AI_{DM} values for the period 2015-2024

Weather station	Annual precipitation (mm)		Average annual temperature (°C)		AI_{DM}	
	2015	2024	2015	2024	2015	2024
RM Vâlcea	704.9	532.5	13.3	14.3	63	47.23
Drăgășani	701.4	441.6	13.1	14.7	63.54	40.04

Source: Authors' own calculations based on data from the National Administration of Meteorology database 2025, ANM (ANM, 2024)

Table 3. AI_{DM} values for the period 2016-2023

Weather station	Annual precipitation (mm)		Average annual temperature (°C)		AI_{DM}	
	2016	2023	2016	2023	2016	2023
RM Vâlcea	750.5	745.2	12.6	13.6	69.56	64.79
Drăgășani	683.7	690.1	12.6	14.1	64.26	58.94

Source: Authors' own calculations based on data from the National Administration of Meteorology database 2025, ANM (ANM, 2024)

Table 4. AI_{DM} values for the period 2017-2022

Weather station	Annual precipitation (mm)		Average annual temperature (°C)		AI_{DM}	
	2017	2022	2017	2022	2017	2022
RM Vâlcea	820.7	684.3	12.6	13	75.13	62.63
Drăgășani	663	664.6	12.8	13.5	61.79	59.22

Source: Authors' own calculations based on data from the National Administration of Meteorology database 2025, ANM (ANM, 2024)

Table 5. AI_{DM} values for the period 2018-2021

Weather station	Annual precipitation (mm)		Average annual temperature (°C)		AI_{DM}	
	2018	2021	2018	2021	2018	2021
RM Vâlcea	929.7	695.6	13	12.3	81.51	66.55
Drăgășani	891.8	693.8	12.8	12.7	79.67	64.62

Source: Authors' own calculations based on data from the National Administration of Meteorology database 2025, ANM (ANM, 2024)

Table 6. AI_{DM} values for the period 2019-2020

Weather stations	Annual precipitation (mm)		Average annual temperature (°C)		AI_{DM}	
	2019	2020	2019	2020	2019	2020
RM Vâlcea	706	612.7	13.5	13.3	62.29	56.06
Drăgășani	616.8	603.8	13.8	13.6	54.69	54.39

Source: Authors' own calculations based on data from the National Administration of Meteorology database 2025, ANM (ANM, 2024)

Human pressure on the environment

The human pressure on the environment - a synthetic indicator of the landscape's quality and degree of artificialization (Dumitrașcu, 2006; Vijulie, 2010) - was evaluated in the study area.

Table 7. Human pressure in the Pesceana River Basin, Romania

Administrative-territorial unit	Surface (hectares)	Number of inhabitants (number of people)	Human pressure
Amărăști	2.843	1608	1.76
Crețeni	2.680	2116	1.26
Glăvile	5.005	1824	2.74
Gușoeni	3.665	1233	2.97
Lădești	5.013	1808	2.77
Mitrofani	1.724	920	1.87
Pesceana	2.876	1427	2.01
Sutești	2.491	2113	1.17

Source: Authors' own calculations based on data from the National Institute of Statistics. TEMPO Online database 2025, NIS [42] and Ciobotea et al., 2012 (Ciobotea & Avram, 2012; Ciobotea & Avram, 2012)

Analyzing the statistical data for the eight administrative-territorial units in the Pesceana River Basin, it is observed that the highest human pressure (2.97) was recorded for Gușoeni and the lowest (1.17) was recorded at the opposite pole, in Sutești (Table 7).

The dynamics of the rural landscape in the Pesceana River Basin are expressed as the change in naturalness (Table 8) as well as diversification as a result of intensified anthropogenic activity.

Table 8. I_{nat} values for 2014

Administrative-territorial unit	Surface (hectares)	S_{pad}	I_{nat} 2014
Amărăști	2.843	531	18.67%
Crețeni	2.680	842	31.41%
Glăvile	5.005	1941	38.78%
Gușoeni	3.665	1385	37.78%
Lădești	5.013	1547	30.85%
Mitrofani	1.724	758	43.96%
Pesceana	2.876	735	25.55%
Sutești	2.491	582	23.36%

Source: Authors' own calculations based on data from the National Institute of Statistics (TEMPO Online database 2025, NIS) (NIS, 2025) and Ciobotea & Avram, 2012 (Ciobotea & Avram, 2012; Ciobotea & Avram, 2012)

Thus, only one administrative-territorial unit is characterized by landscapes with a strongly affected balance (index values lower than 20%): Amărăști (18.67%).

From the analysis of the values obtained, most administrative-territorial units (six) are characterized by landscapes with balances that are moderately affected by anthropogenic intervention over time (index values between 20% and 40%).

Relatively few of the communes (Mitrofani 43.96%) are administrative-territorial units with a weakly affected ecological balance of landscapes (index values between 40% and 50%).

CONCLUSIONS

According to the calculated AI_{DM} values, the Pesceana River Basin is characterized as exhibiting the very and extremely humid climatic types. Thus, we can conclude that the Pesceana River Basin is characterized by high humidity, abundant vegetation, and, often, high

temperatures, which creates a suffocating environment.

When analyzing the degree of naturalness of the basin's rural area, it was found to be mostly characterized by landscapes with a balance moderately affected by anthropogenic intervention over time, with I_{nat} values between 20% and 40% obtained for the six administrative-territorial units considered here.

In order to capture the full complexity of climatic aridity and human pressure on the environment, future studies would benefit from integrating these objective findings with qualitative and sociodemographic information in the form of a questionnaire. A second limitation of this research is the statistical data employed; future research should also include field statistical data, such as sampling coordinates for plant association types.

ABBREVIATIONS

The following abbreviations are used in this manuscript:

AI_{DM}	De Martonne aridity index
NAM	National Administration of Meteorology
GIS	Geographic Information System
DEM	Digital Elevation Model
NIS	National Institute of Statistics
FAO	Food and Agriculture Organization of the United Nations

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