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Variation in water consumption in residential buildings: efficiency improvement methods

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Abstract. The aim of the paper is to analyze the variation in water consumption in old and new residential buildings in Cluj-Napoca through a critical and comparative approach. In this context, the study seeks to provide a general perspective on water demand and supply, consumption practices, the infrastructural characteristics of the buildings, and current efficiency methods. Efficiency involves reducing the amount of water used for domestic purposes through the implementation of appropriate methods and equipment, with the goal of meeting the functional requirements of the dwelling in a sustainable manner. The study aims to identify the specific differences of each building type, offering an integrated perspective on water resource management in the urban environment. Water consumption is an important indicator in assessing the sustainability of buildings and reflects their level of development. It contributes to the protection of natural resources and the sustainable development of water supply infrastructure.

Keywords: water consumption, efficiency, sustainability.

1. Introduction

Water is the natural resource that sustains life and socio-economic development. In the context of increasing pressure on natural resources, water consumption is an essential sustainability indicator, reflecting how societies use and manage this vital resource. To carry out a rigorous analysis of water consumption, it is important to understand the specific water needs and requirements established by current technical standards and regulations, which form the basis for correctly sizing water supply systems and estimating consumption. The specific water need is defined as the "average daily amount of water required by a consumer" and is expressed in [l/day.person]. For household needs, this includes water for drinking, food preparation, personal hygiene, laundry, dishwashing, cleaning, toilet use, and pets

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[1–2]. Annex 1.1 of Normative I9-2022 – Normative on the Design, Execution, and Operation of Sanitary Installations for Buildings – states that, in dwellings where domestic hot water is prepared locally, the daily water requirement ranges between 100 and 140 [liters/day.person], depending on the type of metering system used and the degree of wear of the fittings. In buildings with centralized hot water preparation, equipped with a toilet, washbasin, bathtub, and kitchen sink, the requirement ranges between 120 and 210 [liters/day.person], with these values being influenced by the type of metering and the age of the sanitary installations [3]. Water consumption estimation in an urban system involves both estimating water demand, the total volume needed by users during a period and determining the specific requirement, the normalized or calculated value used to size water supply systems based on the type of consumer and specific conditions [4].
Sustainability means the ability to exist and develop without compromising the natural resources needed by future generations [5]. Regarding water resources, it means ensuring an adequate quantity for human consumption regardless of climatic conditions or factors causing water shortages. In the residential sector, sustainability is crucial for efficient water management, especially as many studies show an increasing trend in consumption in recent years, along with the worsening global "water stress." A first step toward sustainability is increasing efficiency, which means reducing water usage in household activities by applying appropriate methods and technologies that meet housing needs responsibly. This study focuses on the variation in water consumption, the factors influencing it, and the evaluation of efficiency levels in residential buildings.

2. Experimental Framework

The study proposed in this paper focuses on a critical and comparative analysis of water consumption in residential buildings, as well as the factors influencing its variation. The analysis is based on real data collected from local sources, such as homeowners' associations, monthly water meter readings, direct interaction with users, and observation of their behavior regarding water use. The final objective of the study is to analyze the variation in water consumption and assess the degree of efficiency in residential buildings by identifying consumption patterns and optimization potential. Additionally, it aims to obtain an up-to-date dataset on the methods applied for water consumption efficiency and highlight the problems caused by the lack of such methods. The research is applied exclusively to the urban environment, focusing on the city of Cluj-Napoca and targeting collective housing buildings (apartment blocks), which are highly relevant for water consumption analysis given the user typology and existing infrastructure. The data obtained from this study provides a solid foundation for future research directions on accurately estimating the real water needs of residential buildings.

3. Results and interpretation of the study

3.1. Study area

Cluj-Napoca, located in northwestern-central Romania in the historical region of Transylvania, is the capital of Cluj County. With a population of approximately 286,598 residents [6], it is the second-largest city in Romania demographically. The city is crossed by the Someșul Mic River, one of the most important waterways in the region, and its tributary, the Nadăș. The climate is temperate-continental, characterized by hot summers and cold winters [7]. In Cluj-Napoca, winters can see temperatures drop below -20°C, while average summer temperatures range from 25°C to 30°C. However, heatwaves may cause peaks of 35–36°C [8,9]. These seasonal thermal variations directly influence water consumption: water demand increases significantly during the summer due to higher domestic use, irrigation of green spaces, and recreational activities. The main drinking water source for Cluj-Napoca is Lake Tarnița, with a capacity of approximately 70 million cubic meters. The water supply is managed by Compania de Apă Someș. The population's access to potable water is reflected by a satisfaction rate of 96.9% [10].

3.2. Water consumption variation and efficiency level

The objective of this study is to analyze the variation in water consumption and evaluate the efficiency level in old and new residential buildings in Cluj-Napoca. To assess whether a building is efficient in terms of water usage, ten minimum efficiency criteria were established, which each analyzed dwelling should ideally meet. Each criterion was assigned a score. At the end, each building in the sample was evaluated and scored based on how many of these criteria were fulfilled. Based on the total score, the efficiency level of each home's water consumption was classified. Table number 1 presents the 10 established criteria.

Table 1. Water Efficiency Assessment Criteria - Efficiency Measure Points

Existence of individual water metering at building level	10
Periodic replacement of fittings and taps (to prevent leaks)	10
Periodic rehabilitation of internal water distribution pipes	10
Use of toilet with dual flush system	10
Use of dishwasher instead of manual dishwashing	10
Use of washing machine with eco program	10
Periodic checking of the water meter index (to detect abnormal consumption)	10
Reducing water usage duration during daily activities (shower, dishwashing, etc.)	10
Use of water-saving devices (aerators, sensors, etc.)	10
Awareness through visible display of meter index	10

The first stage of the research focuses on older buildings constructed before 2006 and uses data on water consumption recorded between January 2023 and May 2025.

Study I. Presents an analysis of water consumption variation for four dwellings in an old residential complex. Homes 1 and 2 were continuously inhabited by two people each throughout the study (two and a half years). Homes 3 and 4 were inhabited by three people each. All homes have identical configurations, with one bathroom and one kitchen each. Domestic hot water is produced locally using individual gas boilers. Water metering is done via individual meters in each apartment, with readings submitted monthly by residents or quarterly by the homeowners' association. The analyzed water consumption reflects only domestic use. Table 2 presents the average water consumption recorded for these households, expressed in [m³/year], [m³/month], [m³/day], and [l/day.person]. Table 3 shows the score obtained according to the level of water consumption efficiency. The data were collected through direct interaction with the users, thus ensuring the accuracy and relevance of the information for the analysis carried out.

Table 2. Study I: Water Consumption Values per Household

Year	Unit	Home 1	Home 2	Home 3	Home 4
2023	[m³/year]	71	113	145	170
	[m³/month]	5.916	9.416	12.08	14.16
	[m³/day]	0.194	0.309	0.397	0.465
	[l/day.person]	**97.26**	**154.79**	**132.42**	**155.25**
2024	[m³/year]	103	108	168	182
	[m³/month]	8.583	9	14	15.16
	[m³/day]	0.281	0.295	0.459	0.497
	[l/day.person]	**140.71**	**147.5**	**153.01**	**165.75**
2025	[m³/year]	43	46	67	68
	[m³/month]	8.6	9.2	13.4	13.6
	[m³/day]	0.286	0.306	0.446	0.453
	[l/day.person]	**143.33**	**153.33**	**148.88**	**151.11**

Table 3. Study I: Water Efficiency Score per Dwelling

Criterion	Home 1	Home 2	Home 3	Home 4
Existence of individual water metering system	10 pts	10 pts	10 pts	10 pts
Periodic replacement of fittings and taps	10 pts	0 pts	0 pts	0 pts
Periodic rehabilitation of internal water distribution pipes	0 pts	0 pts	0 pts	0 pts
Use of toilet with dual flush system	0 pts	0 pts	0 pts	0 pts
Use of dishwasher instead of manual washing	0 pts	0 pts	0 pts	0 pts
Use of washing machine (eco program)	10 pts	10 pts	0 pts	0 pts
Periodic verification of water meter index	10 pts	10 pts	10 pts	10 pts
Reducing duration of water use in daily activities (shower, dishwashing, etc.)	10 pts	10 pts	0 pts	0 pts
Use of water-saving devices (aerators, sensors, etc.)	0 pts	0 pts	0 pts	0 pts
Awareness of consumption by displaying index in a visible location	10 pts	10 pts	10 pts	10 pts
Efficiency score	**50 pts**	**50 pts**	**30 pts**	**30 pts**

The results obtained in the first study indicate that residents use high amounts of water to meet their daily needs. In three of the four cases analyzed, water consumption exceeds the value specified in the national Normative I9-2022 – Normative on the Design, Execution, and Operation of Sanitary Installations for Buildings and in STAS 1478-90 – Water Supply for Civil and Industrial Buildings. The excessive water consumption is mainly due to the absence of efficiency solutions, such as water-saving equipment or systems installed at the household level.

Study II. Focuses on four dwellings located in a complex built before the year 2000. Homes 1 and 4 were inhabited by one person each throughout the study (2.5 years). Home 2 was inhabited by two people. Home 3 was inhabited by three people. All homes have identical configurations: one bathroom and one kitchen each Domestic hot water is produced locally using individual gas boilers. Water metering is done with individual meters in each apartment, with monthly readings from the residents or quarterly by the association. Consumption analyzed refers strictly to household usage. Table 4 presents the average water consumption recorded for these households, expressed in [m³/year], [m³/month], [m³/day], and [l/day.person]. Table 5 shows the score obtained according to the level of water consumption efficiency.

Table 4. Study II: Water Consumption Variation per Dwelling

Year	Unit	Home 1	Home 2	Home 3	Home 4
2023	[m³/year]	52	101	154	58
	[m³/month]	4.333	8.416	12.83	4.833
	[m³/day]	0.142	0.276	0.421	0.158
	[l/day.person]	**142**	**138.35**	**140**	**158**
2024	[m³/year]	59	96	161	57
	[m³/month]	4.916	8	13.41	4.75
	[m³/day]	0.161	0.262	0.439	0.155
	[l/day.person]	**161**	**131.14**	**146.6**	**155**
2025	[m³/year]	28	55	73	22
	[m³/month]	5.6	11	14.6	4.4
	[m³/day]	0.186	0.366	0.486	0.146
	[l/day.person]	**186**	**183.33**	**162.22**	**146**

Similar to the previous study, the results indicate that the total water consumption exceeds the values specified in the national Normative I9-2022 and STAS 1478-90.

Study III. This study analyzes water consumption and its efficiency level for four homes located in a complex built in 2005. Homes 1 and 2 were each occupied by one person throughout the study period. Homes 3 and 4 were each occupied by two people. Each home includes one bathroom and one kitchen. Domestic hot water is supplied via the city's centralized heating network. Water metering is performed using individual meters installed in each home, with readings submitted monthly by residents or, alternatively, quarterly by representatives of the homeowners' association. The analyzed water consumption reflects strictly domestic usage. Table 6 presents the average water consumption recorded for these households,

expressed in [m³/year], [m³/month], [m³/day], and [l/day.person]. Table 7 shows the score obtained according to the level of water consumption efficiency.

Table 5. Study II: Water Efficiency Score per Dwelling

Criterion	Home 1	Home 2	Home 3	Home 4
Existence of individual water metering system	10 pts.	10 pts.	10 pts.	10 pts.
Periodic replacement of fittings and taps	0 pts.	0 pts.	0 pts.	0 pts.
Periodic rehabilitation of internal water distribution pipes	0 pts.	0 pts.	0 pts.	0 pts.
Use of toilet with dual flush system	0 pts.	0 pts.	0 pts.	0 pts.
Use of dishwasher instead of manual washing	0 pts.	10 pts.	0 pts.	0 pts.
Use of washing machine (eco program)	0 pts.	0 pts.	0 pts.	0 pts.
Periodic verification of water meter index	10 pts.	10 pts.	10 pts.	10 pts.
Reducing duration of water use in daily activities (shower, dishwashing, etc.)	0 pts.	0 pts.	0 pts.	0 pts.
Use of water-saving devices (aerators, sensors, etc.)	0 pts.	0 pts.	0 pts.	0 pts.
Awareness of consumption by displaying index in a visible location	10 pts.	10 pts.	10 pts.	10 pts.
Efficiency score	**30 pts.**	**40 pts.**	**30 pts.**	**30 pts.**

Table 6. Study III: Water Consumption Variation

Year	Unit	Home 1	Home 2	Home 3	Home 4
2023	[m³/year]	37	105	142	193
	[m³/month]	3.083	8.75	11.83	16.08
	[m³/day]	0.101	0.287	0.389	0.528
	[l/day.person]	**101**	**287**	**194.52**	**264.38**
2024	[m³/year]	45	97	131	154
	[m³/month]	3.75	8.083	10.91	12.83
	[m³/day]	0.122	0.265	0.357	0.420
	[l/day.person]	**122**	**265**	**178.96**	**210**
2025	[m³/year]	19	46	53	71
	[m³/month]	3.8	9.2	10.6	14.2
	[m³/day]	0.126	3.06	0.353	0.473
	[l/day.person]	**126**	**306**	**176.6**	**236.66**

Table 7. Study III: Water Efficiency Score

Criterion	Home 1	Home 2	Home 3	Home 4
Existence of individual water metering system	10 pts.	10 pts.	10 pts.	10 pts.
Periodic replacement of fittings and taps	10 pts.	0 pts.	0 pts.	0 pts.
Periodic rehabilitation of internal water pipes	10 pts.	0 pts.	0 pts.	0 pts.
Toilet with dual flush system	0 pts.	0 pts.	0 pts.	0 pts.

Criterion	Home 1	Home 2	Home 3	Home 4
Dishwasher instead of manual dishwashing	0 pts.	0 pts.	0 pts.	0 pts.
Washing machine with eco program	10 pts.	0 pts.	0 pts.	0 pts.
Periodic verification of water meter index	10 pts.	0 pts.	10 pts.	0 pts.
Reduced water use duration in daily activities	10 pts.	0 pts.	0 pts.	0 pts.
Use of water-saving devices (aerators, sensors, etc.)	0 pts.	0 pts.	0 pts.	0 pts.
Visible display of consumption index	10 pts.	10 pts.	10 pts.	10 pts.
Efficiency Score	**70 pts.**	**20 pts.**	**30 pts.**	**20 pts.**

The first three studies were applied to old residential complexes. To obtain a complete dataset on water consumption variation and efficiency methods in residential buildings, the same methodology is applied to newly built housing complexes from the 2020–2022 period.

Study IV. This analysis was conducted for four dwellings in a complex completed in 2020. Home 1 was occupied by one person and includes one bathroom and one kitchen. Homes 2 and 3 were each occupied by two people with the same layout. Home 4 was occupied by three people and includes two bathrooms and one kitchen. Domestic hot water is locally prepared using individual gas boilers. Water metering is done individually through meters installed in each home, with readings submitted monthly by residents or quarterly by association representatives. The data analyzed reflects only household water use. Table 8 presents the average annual, monthly, and daily water consumption, expressed in [m³/year], [m³/month], [m³/day], and [l/day.person], for each analyzed household. Table 9 shows the score obtained according to the efficiency level in water resource usage.

Table 8. Study IV: Water Consumption Variation

Year	Units	Home 1	Home 2	Home 3	Home 4
2023	[m³/year]	42	90	61	174
	[m³/month]	3.5	7.5	5.083	14.5
	[m³/day]	0.115	0.246	0.167	0.476
	[l/day.person]]	**115**	**123.28**	**83.56**	**158.66**
2024	[m³/year]	48	91	76	167
	[m³/month]	4	7.583	6.333	13.91
	[m³/day]	0.131	0.248	0.204	0.456
	[l/day.person]	**131**	**124.31**	**102.45**	**152.09**
2025	[m³/year]	20	40	35	59
	[m³/month]	4	8	7	11.8
	[m³/day]	0.133	0.266	0.233	0.393
	[l/day.person]	**133**	**133.3**	**116.66**	**131.11**

Data from this first study of newly built residential buildings shows significantly lower water consumption compared to old buildings. The difference can be

attributed to the implementation of efficiency methods and the presence of modern infrastructure.

Table 9. Study IV: Water Efficiency Score

Criterion	Home 1	Home 2	Home 3	Home 4
Existence of individual water metering system	10 pts.	10 pts.	10 pts.	10 pts.
Periodic replacement of fittings and taps	10 pts.	10 pts.	10 pts.	10 pts.
Periodic rehabilitation of internal water pipes	10 pts.	10 pts.	10 pts.	10 pts.
Toilet with dual flush system	10 pts.	10 pts.	10 pts.	10 pts.
Dishwasher instead of manual dishwashing	0 pts.	10 pts.	10 pts.	0 pts.
Washing machine with eco program	0 pts.	0 pts.	10 pts.	0 pts.
Periodic verification of water meter index	10 pts.	10 pts.	10 pts.	0 pts.
Reduced water use duration in daily activities	0 pts.	0 pts.	10 pts.	0 pts.
Use of water-saving devices (aerators, sensors, etc.)	0 pts.	0 pts.	0 pts.	0 pts.
Visible display of consumption index	10 pts.	10 pts.	10 pts.	10 pts.
Efficiency Score	**60 pts.**	**70 pts.**	**80 pts.**	**50 pts.**

Study V: This study was conducted on four homes in a residential complex completed in 2022. Home 1 was occupied by one person and includes one bathroom and one kitchen. Homes 2, 3, and 4 were each occupied by two people, all with the same configuration. Domestic hot water is locally prepared by two boilers installed at the complex level. Water metering is done individually with meters installed in each unit. Readings are submitted monthly by the residents or quarterly by the homeowners' association. The analysis focuses strictly on domestic water use. Table 10 presents the average annual, monthly, and daily water consumption values, expressed in [m³/year], [m³/month], [m³/day], and [l/day.person], for each household. Table 11 highlights the scores obtained according to the level of water consumption efficiency.

Table 10. Study V: Water Consumption Variation

Year	Unit	Home 1	Home 2	Home 3	Home 4
2023	[m³/year]	49	78	68	130
	[m³/month]	4.083	6.5	5.666	10.83
	[m³/day]	0.134	0.213	0.186	0.356
	[l/day.person]	**134**	**106.84**	**93.15**	**178.08**
2024	[m³/year]	53	75	61	128
	[m³/month]	4.416	6.25	5.083	10.66
	[m³/day]	0.144	0.204	0.166	0.349
	[l/day.person]	**144**	**102.45**	**83.33**	**174.86**
2025	[m³/year]	15	34	24	52
	[m³/month]	3	6.8	4.8	10.4
	[m³/day]	0.1	0.226	0.16	0.346
	[l/day.person]	**100**	**113.33**	**80**	**173.33**

Table 11. Study V: Water Efficiency Score

Criterion	Home 1	Home 2	Home 3	Home 4
Existence of individual water metering system	10 pts.	10 pts.	10 pts.	10 pts.
Periodic replacement of fittings and taps	10 pts.	10 pts.	10 pts.	10 pts.
Periodic rehabilitation of internal water pipes	10 pts.	10 pts.	10 pts.	10 pts.
Toilet with dual flush system	10 pts.	10 pts.	10 pts.	10 pts.
Dishwasher instead of manual dishwashing	0 pts.	10 pts.	10 pts.	0 pts.
Washing machine with eco program	0 pts.	10 pts.	10 pts.	0 pts.
Periodic verification of water meter index	10 pts.	10 pts.	10 pts.	0 pts.
Reduced water use duration in daily activities	0 pts.	0 pts.	0 pts.	0 pts.
Use of water-saving devices (aerators, sensors, etc.)	0 pts.	0 pts.	0 pts.	0 pts.
Visible display of consumption index	10 pts.	10 pts.	10 pts.	10 pts.
Efficiency Score	**60 pts.**	**80 pts.**	**80 pts.**	**50 pts.**

Study VI. This study analyzed water consumption and efficiency for four homes located in a residential complex completed in 2022. Homes 1 and 3 were each occupied by one person and include one bathroom and one kitchen. Homes 2 and 4 were each occupied by two people, with the same layout as the others. Domestic hot water is locally prepared by two boilers installed at the complex level. Water metering is done individually through meters installed in each unit, with readings submitted monthly by residents or quarterly by the homeowners' association. The analysis focuses strictly on household water use. Table 12 presents the average annual, monthly, and daily water consumption values, expressed in [m³/year], [m³/month], [m³/day], and [l/day.person] for each home. Table 13 shows the scores corresponding to the water efficiency level.

Table 12. Study VI: Water Consumption Variation

Year	Unit	Home 1	Home 2	Home 3	Home 4
2023	[m³/year]	46	75	39	73
	[m³/month]	3.833	6.25	3.25	6.083
	[m³/day]	0.126	0.205	0.106	0.2
	[l/day.person]	**126**	**102.73**	**106**	**100**
2024	[m³/year]	44	73	41	78
	[m³/month]	12	6.08	3.416	6.5
	[m³/day]	0.12	0.199	0.112	0.213
	[l/day.person]	**120**	**99.72**	**122**	**106.55**
2025	[m³/year]	22	35	18	45
	[m³/month]	4.50	7	3.6	9
	[m³/day]	0.146	0.233	0.12	0.3
	[l/day.person]	**146**	**116.66**	**120**	**150**

Table 13. Study VI: Water Efficiency Score

Criterion	Home 1	Home 2	Home 3	Home 4
Existence of individual water metering system	10 pts.	10 pts.	10 pts.	10 pts.
Periodic replacement of fittings and taps	10 pts.	10 pts.	10 pts.	10 pts.
Periodic rehabilitation of internal water pipes	10 pts.	10 pts.	10 pts.	10 pts.
Toilet with dual flush system	10 pts.	10 pts.	10 pts.	10 pts.
Dishwasher instead of manual dishwashing	0 pts.	10 pts.	10 pts.	10 pts.
Washing machine with eco program	0 pts.	10 pts.	0 pts.	10 pts.
Periodic verification of water meter index	10 pts.	10 pts.	10 pts.	10 pts.
Reduced water use duration in daily activities	0 pts.	0 pts.	0 pts.	0 pts.
Use of water-saving devices (aerators, sensors, etc.)	0 pts.	0 pts.	0 pts.	0 pts.
Visible display of consumption index	10 pts.	10 pts.	10 pts.	10 pts.
Efficiency Score	**60 pts.**	**80 pts.**	**70 pts.**	**80 pts.**

4. Conclusions

The analysis of the six case studies highlights that old residential complexes record significantly higher water consumption compared to the normative values specified in I9-2022 – Normative on the Design, Execution, and Operation of Sanitary Installations for Buildings – and STAS 1478-90 – Water Supply for Civil and Industrial Buildings. This overconsumption is primarily caused by poor infrastructure conditions: worn-out pipes, outdated fittings, and lack of modernization efforts. All of these factors lead to large water losses, as demonstrated in Study III where Home 2 recorded very high water usage. New residential complexes feature technically optimized infrastructure and appropriate fittings (such as dishwashers and dual-flush toilets), which allow water consumption to be maintained within the limits set by current legislation. Although Cluj-Napoca is experiencing rapid urban development, old buildings continue to operate using outdated systems, contributing to inefficiency in water resource management. Data collected in 2025 shows a daily average consumption of 176.62 [l/day.person] in old homes, compared to 126.11 [l/day.person] in new ones. Based on the current rate of 12.69 [RON/m^3], the daily cost for 176.62 liters is 2.24 [RON/day], while for 126.11 liters the cost is 1.6 [RON/day]. This cost difference becomes more significant during the warm season when water demand increases. Another important factor influencing consumption is user behavior. In homes where efficiency methods such as regular water meter monitoring or the use of water-saving devices are applied, water consumption is noticeably lower than in

homes lacking awareness of responsible usage. For example, Home 4 in Study V showed high water consumption due to user habits. Efficiency scores also highlight a clear contrast between the two categories of homes. Older complexes scored between 20 and 50 points (with one exception scoring 70), while newer ones scored between 50 and 80. These results confirm an inverse relationship between efficiency level and water consumption: the better the efficiency practices, the lower the water usage, without compromising daily needs or service quality.

In conclusion, older residential complexes are characterized by higher water consumption compared to newer ones, a difference explained by outdated infrastructure and less efficient user behavior. These findings highlight the need for systematic rehabilitation efforts and the promotion of water-saving methods in existing buildings.

References

[1] Badea G., *Water supply*, Risoprint Publishing House, Cluj-Napoca, p. 35.
[2] Monitorul Oficial al României, *Normative regarding the design, execution, and operation of water supply and sewerage systems of localities – Code NP 133-2022*, Volume I – Water Supply Systems, 2023, p. 31, Retrieved from https://drimand.ro/download/62%20NORMATIV%20NP%20133-2022.pdf;
[3] Monitorul Oficial al României, *Normative regarding the design, execution, and operation of sanitary installations for buildings – Code* I9-2022, Annex 1.1, 2022, p. 123, Retrieved from https://drimand.ro/download/45%20NORMATIV%20I9%20-%202022.pdf;
[4] Aşchilean I., *Rehabilitation and modernization of urban water supply systems*, Risoprint Publishing House, Cluj-Napoca, 2014, p. 1–331.
[5] TWI Global Romania. (n.d.). *What is sustainability?* Retrieved from https://www.twi-global.com/locations/romania/ce-facem/intrebari-frecvente-faq/ce-este-sustenabilitatea;
[6] Wikipedia contributors. (n.d.). Cluj-Napoca [in Romanian]. Wikipedia – The Free Encyclopedia. Retrieved from https://ro.wikipedia.org/wiki/Cluj-Napoca.
[7] Enciclopedia României. (n.d.). Cluj-Napoca, Retrieved from https://enciclopediaromaniei.ro/wiki/Cluj-Napoca.
[8] Vremea.ro. (n.d.). *Cluj-Napoca climate*, Retrieved from https://www.vremea.ro/gt/clima-cluj-napoca/
[9] Meteoblue. (n.d.). Cluj-Napoca – Modeled climate, Retrieved from https://www.meteoblue.com/ro/vreme/historyclimate/climatemodelled/cluj-napoca_românia_681290;
[10] Focus Energetic. (n.d.). Sibiu, Cluj-Napoca and Târgoviște are the cities with the best access to water . Retrieved from https://www.focus-energetic.ro/sibiu-cluj-cluj-napoca-si-targoviste-sunt-orasele-cu-cel-mai-bun-acces-la-apa-92077.html.
[11] Homeowners Association – Cluj-Napoca.
[12] Badea Gheorghe, Iacob Cristina, Aşchilean Ioan, Teodor V. Chira, *Losses in Water Supply Systems*, Conference "Modern Science and Energy", 27th Edition, Cluj-Napoca, 2008, ISSN 2066-4125, p. 323–331.
[13] Huimiao Yuan, Huijuan Hao, Yuanyuan Zhao, Yu Zhang, Yu Chen, *Intelligent monitoring and control system and control method of intelligent water meter*, 2022 IEEE 6th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC), 9 November 2022. Online: https://ieeexplore.ieee.org/document/9929669/authors#authors.
[14] Romanian Standards Institute, STAS 1478-90, *Water Supply for Civil and Industrial Buildings*, 01.07.1990. Available online: https://arhitectura5tm.files.wordpress.com/2014/11/calcul-wc-stas-actual-stas-1478-90.pdf.

[15] Smart Water Magazin, *Water ranking in Europe* 2020, information on https://smartwatermagazine.com/news/locken/water-ranking-europe-2020
[16] Stiința Tehnică Magazine, *Water Under (Unconscious) Siege by Humans*, November 23, 2017.