ASSESSING URBAN MOBILITY CHALLENGES IN CLUJ-NAPOCA: A MULTIFACETED APPROACH

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***ABSTRACT**: Urban transportation and mobility in Cluj-Napoca are characterized by a heterogeneous and asymmetric infrastructure and dynamics due to the specific location and topology of a riverside locality. This analysis delves into urban mobility issues through the lenses of infrastructure and road dynamics, encompassing interurban passenger transportation, limited geographically and polarized by the existing network, and the analysis of regular air traffic from Cluj-Napoca's Avram Iancu Airport and its implications. The results and conclusions shed light on the reasons behind the upheavals witnessed in the last 15 years concerning urban mobility flows, influenced by transportation dynamics across all levels, commuter patterns, urban and peri-urban transit. Furthermore, original analyses are presented, diverging from existing mobility studies.*

***Key words:** urban mobility; asymmetric infrastructure; road transport; air traffic;*

1. Introduction

Urban mobility within the city of Cluj-Napoca, as approached in this analysis, scrutinizes the existing mobility infrastructure and various components that engender its dynamics. Demographic elements are considered as sources of mobility dynamics. Urban mobility stands as the essence of a city's vitality, serving as an economic catalyst and a vehicle for development. In the absence of sustainable measures that preserve the fluidity of both passenger and freight traffic, congestion may ensue, leading to disparities in urban functions with persistent and long-term effects. The concept of urban mobility, as described in specialized literature(Costa et al., 2017) encompasses eight indices of urban mobility known as IMUS (Mobility Index Sustainable Urban), comprising 87 indicators, with 22 of them centered on public transportation RMGV.

While public transportation is often scrutinized from various perspectives, other approaches consider elements of urban mobility quality, including transit type, social behavior, active demographic components, and environmental impact (Tyrinopoulos and Antoniou, 2013). Traffic, as a dynamic element of urban mobility, relies on transport infrastructure, which is reflected in existing investments and development strategies at various administrative levels (local, regional, and national). The involvement of social and technical elements, legal foundations, and interactions with administrative entities is highlighted in studies with a similar focus (Jones, 2014). The causes of urban mobility dysfunctions are analyzed from ecological, cultural, political, institutional, social, and economic perspectives (Corpade et al., 2012), explicitly described. Consequently, urban mobility is analyzed from diverse angles, making it a current topic not only in the academic realm but also in various institutions. Optimization of mobility, beyond its economic and time-related impact, directly contributes to societal developments and enhances the quality of life.

2. Theoretical Considerations

The concept of urban mobility, as defined by the World Bank, refers to the movement of the population within and between urban areas with the aim of accessing housing, employment, and services. It has been subsequently reformulated to emphasize population accessibility to urban functions. (Holland, 17.06.2021).

Urban mobility comprises multiple layers of components, with its foundation resting upon infrastructure and transport dynamics.

Infrastructure components encompass road, rail, airport, and maritime transport networks that facilitate the movement of the population to access urban functions such as education, healthcare, entertainment, administration, and more. Infrastructure comprises road networks, railway lines, canals, airports, and the elements that compose them, including public transport stations, train stations, bus terminals, ports, airports, bike lanes, and more.The dynamic component of urban mobility is represented by vehicles with either self-propelled or externally propelled mechanisms, including individual and public transportation, as well as medium and long-distance means of transportation such as trains, planes, and maritime passenger vessels. These described components involve both quantitative and qualitative elements, and the concept of sustainable urban mobility entails a smooth and efficient traffic dynamic. Various direct and indirect parameters determine the efficiency and quality of mobility, including land use, population density, and related indices, correlated with public transportation, such as traffic intensity, social behavior, which manifests differently across continents, (Kenworthy and Laube, 1996), accessibility to public transport stations, frequency, routes, and travel time.

Changes in existing approaches are noted, with a focus on qualitative parameters and their environmental implications, such as energy efficiency in transportation, the type of energy used, its green sourcing, direct pollutant emissions, carbon footprint of transportation means, noise pollution, health implications, and road safety (Gerlach et al., 2016).Consequently, there is an evolution in urban mobility approaches, where discussions about technical parameters intersect with political (Graham, 2018), administrative, and various other approaches, including social equity considerations.

3. Methodology

The analysis is grounded in publicly accessible datasets from Local Administrative Units (UAT), the National Institute of Statistics' INSSE Tempus database, government datasets in Romania, along with supplementary information from specific websites, such as the weekly schedules of trains, airplanes, and county-specific public transportation details. Estimations regarding transport capacities are made under the assumption of full utilization at full capacity. In the case of the vehicle fleet analysis, the entire county's capacity is assessed due to the unavailability of precise data for each individual UAT unit. However, it is crucial to emphasize that the information presented in this article aims to provide a comprehensive overview of the dynamics at the specified analytical level.

Statistical processing of the information and data involves the use of both absolute values and indices, visually represented through tables and graphs. The computational and reporting aspects of this study were executed using spreadsheet software applications, specifically Microsoft Word, Excel, and ARCGIS.

4. Presentation of Results

Road Transport Infrastructure in Cluj-Napoca.

In a GIS-based analysis using maps encompassing the city's zones and neighborhoods as shown in Figure 1, the areas of neighborhoods and roadways are highlighted. Pedestrian accesses or servitudes, expressed in hectares, make up the difference. Calculations were conducted to determine the length of access routes in neighborhoods and zones, as well as the road surface area relative to the land it serves. Figure 1 represents the roadways according to their width, while the areas are depicted based on their road infrastructure using a calculated index shown in Table 1.

Similar calculations were carried out to represent the population density distributed across zones within the city's neighborhoods (left) and another index that represents the active population (18-65 years) in relation to the road infrastructure in each zone (Figure 2).

Table 1 presents the city's population (source: Ministry of Internal Affairs Population Register) by neighborhoods in column 1, and column 6 represents population density.

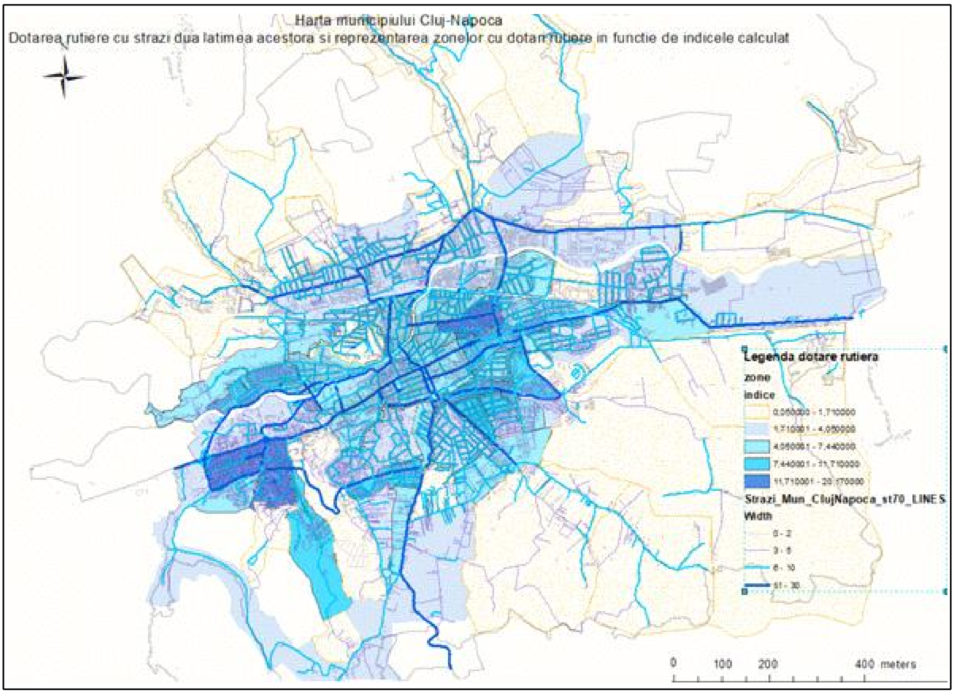


Fig. 1. Map of Cluj-Napoca municipality with road facilities

Table 1. Index of districts with different indexes calculate as mentioned before table

Disitrict	Population	Scholar	Active	Streets length	District area	Streets area	D0	Ds	Da
		7-18	19-65	km	ha	ha	pers/km p	pers/km	pers/km p
	1	2	3	4	5	6	7=1/5	8=3/4	9=3/6
Andrei Muresanu	11.321	986	6.996	13,6	147,37	8,22	76,8	513,0	851,4
Becas	756	87	509	9,8	536,39	3,83	1,4	51,7	132,9
Borhanci	1.102	149	737	14.8	654.45	2.35	1.7	49.9	314.2
Bulgaria	5.099	419	3.614	10,8	189,71	7,48	26,9	335,3	483,4
Buna Ziua	6.097	632	4.342	16,3	352,22	9,04	17,3	266,1	480,3
Centru	6.281	324	3.869	3,4	69,08	3,22	90,9	1151,6	1200,4
Centru Est	15.927	1.352	10.772	12,0	191,74	9,45	83,1	894,9	1139,1
Centru Nord	5.616	482	3.712	3,5	54,53	3,83	103,0	1050,7	968,1
Centru Sud	3.562	361	2.285	9,3	122,93	4,38	29,0	245,8	522,2
Centru Vest	5.612	508	3.550	7.8	127.28	8.98	44.1	454.0	395.4
Dambul Rotund	12.462	1.333	8.282	39,4	1.227,06	16,33	10,2	210,1	507,1
Europa	3.915	429	2.754	15,9	240,95	5,63	16,2	173,6	489,1
Faget	630	103	399	26,0	592,17	12,18	1,1	15,4	32,7
Gheorgheni	28.818	2.150	18.661	27,9	349,12	17,65	82,5	668,9	1057,0
Grigorescu	23.459	1.856	14.692	18.5	258.20	19.19	90.9	795.6	765.6
Gruia	6.494	643	4.228	17,7	250,19	4,88	26,0	239,5	865,6
Iris	11.761	1.314	8.153	49,2	1.493,27	12,88	7,9	165,9	632,8
Manastur	89.158	7.351	61.076	43,5	765,40	51,07	116,5	1403,5	1196,0
Marasti	52.904	3.952	39.895	23,5	302,67	23,28	174,8	1696,3	1713,8
Muncii	3.378	308	2.610	49,5	1.218,16	12,86	2,8	52,8	202,9
Someseni	8.194	941	5.450	32,9	1.224,46	21,56	6,7	165,7	252,8
Sopor	835	99	542	20.9	1.668.98	2.68	0.5	25.9	202.5
Zorilor	18.054	1.355	13.373	8,1	109,89	5,86	164,3	1659,9	2283,7
total	321.437	27.535	220.501	474	12.146	267	26,46	465,0	826,4
average	13.976	1197,2	9587,0	20,6	528,1	11,6	51,1	534,2	725,6
median	6.281	632	4.228	16	303	9	27	266	522

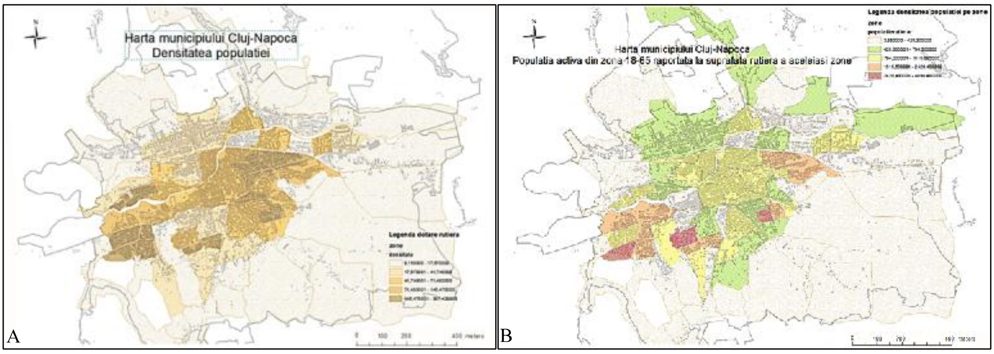


Fig. 2. Map of the municipality of Cluj-Napoca
A. Population density; B. Active population in the 18-65 zone.

Other demographic elements are presented separately in column 2, which includes individuals aged 7-18, assumed to be part of the educational system, and column 3 includes the active population aged 19-65. Column 4 represents the length of road infrastructure in kilometers. Column 5 represents the neighborhood's surface area in hectares, while column 6 represents the road surface area obtained by multiplying the road's length by its width. Column 7 calculates population density (Figure 2, left: col1/col5), column 8 calculates an index representing the active population relative to road distance (col3/col4), column 9 calculates an index representing the active population relative to road surface area (Figure 2, right: col3/col6), and column 10 is a percentage value representing the ratio of road surface area to neighborhood area (col6/col5).

As a result of the calculated indices (6, 9, 10), rankings were established based on population density, infrastructure potential, and the ratio of road surface area to zone area. Each of these indices provides specific information about the neighborhoods. Following the rankings based on these indices, Table 2 was generated and analyzed to determine the characteristics of each neighborhood.

Table 2 ranking of neighborhoods according to density, potential and road infrastructure facilities

Clasifications	District	Total points	Density	Active population	Infrastructure
gr1	Marasti	4	1	2	1
	Zorilor	10	2	1	7
	Manastur	12	3	4	5
gr2	Centru Nord	16	5	7	4
	Centru	17	4	3	10
	Grigorescu	19	7	10	2
	Centru Est	20	6	5	9
	Gheorgheni	22	8	6	8
	Andrei Muresanu	24	9	9	6
	Centru Vest	30	10	17	3
gr3	Bulgaria	37	11	15	11
	Centru Sud	37	13	12	12
	Gruia	38	14	8	16
gr4	Buna Ziua	41	12	16	13
	Europa	44	16	14	14
gr5	Dambul Rotund	46	15	13	18
	Iris	48	17	11	20
	Someseni	54	18	19	17
	Muncii	58	19	20	19
	Borhanci	61	21	18	22
gr6	Faget	61	23	23	15
	Becas	63	20	22	21
	Sopor	66	22	21	23

Neighborhoods belonging to the same group exhibit similar characteristics:
Group 1 = residential neighborhoods characterized by high density and intense traffic, urbanized with developed road infrastructure that attracts intensive traffic, used for commuting as well.
Group 2 = mixed residential neighborhoods with moderate density and traffic.
Group 3 = with the exception of the Bulgaria neighborhood, which is more densely populated and exhibits characteristics of an industrial production activity zone, other neighborhoods are situated in hilly areas where road network development is more challenging.
Group 4 and 6 = residential neighborhoods built in "green field" areas, with group 4 located in more central zones, while group 6 is in peripheral areas.
Group 5 = bordering areas influenced by production and logistics activities.

Vehicle Fleet

Urban mobility is characterized by qualitative elements, and the quantity and quality of the road vehicle fleet are defining components, responsible for both emissions and noise. Table 3 presents a statistical summary derived from data provided by the Romanian Police - Vehicle Registration Office.

Statistical processing of the evolution of the vehicle fleet based on individual passenger transportation (mopeds, motorcycles, cars) in Table 3 is presented together with the proportional structure of the entire vehicle fleet in Figure 3.

Figure 3 indicates a continuous increase in the number of vehicles. The increasingly congested urban traffic has changed behavior, steadily increasing the number of mopeds and motorcycles, a trend exacerbated by the pandemic period, which led to a decrease in car fleet growth. However, considering the numerical ratio between cars (78.5%) and mopeds/motorcycles (2.3%), the graph does not indicate a major behavioral shift but rather a tendency.

The two graphs in figure 4 represent the multi-year evolution of the vehicle fleet's age (left) and three age groups (more relevant ones), indicating a pronounced aging trend and accumulation in a worrying and determining numerical ratio of vehicles older than 15 years.

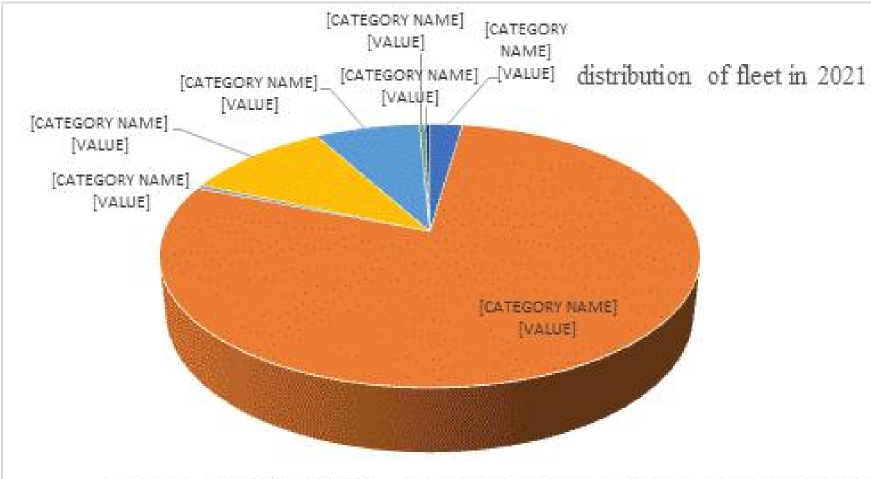
The proportions in Figure 5 are sufficiently concerning due to their environmental pollution effects, health impacts on residents, and on-road participants exposed to congested routes, affecting traffic safety and transportation efficiency, resulting in higher transportation costs.

Commuting - A Brief Overview

In the past 10 years, a phenomenon occurred due to the rising real estate market values, prompting a significant population to settle in areas where property prices were lower, with the intention of retaining their jobs in the city.

Table 3 Evolution of the Vehicle Fleet in Cluj County - Romanian Police - Vehicle Registration Office

Type	2013	2014	2015	2016	2017	2018	2019	2020	2021
Mopede, motociclete (L1e... L7e)	4452	4828	5231	5596	5997	6516	7161	7923	8769
Autoturisme M1, M1G	184046	193115	204024	217859	235707	253741	270235	282369	296870
Autobuze Microbuze M2, M3	1407	1460	1627	1703	1742	1897	2014	2073	1985
Transport Marfa N	22571	24220	26210	28810	31110	33568	35470	37878	39344
Camioane cu remorci N	15014	16559	18301	20253	21942	23890	25421	26446	28208
Remorci semiremoric	635	700	756	832	955	1050	1194	1568	1699
Tractoare	1383	1371	1344	1314	1291	1268	1241	1226	1212
Total	229508	242253	257493	276367	298744	321930	342736	359483	378087



	2014/2013	2015/2014	2016/2015	2017/2016	2018/2017	2019/2018	2020/2019	2021/2020
motorcycle, mopeds	8,45%	8,35%	6,98%	7,17%	8,65%	9,90%	10,64%	10,68%
cars	4,93%	5,65%	6,78%	8,19%	7,65%	6,50%	4,49%	5,14%
total	5,55%	6,29%	7,33%	8,10%	7,76%	6,46%	4,89%	5,18%

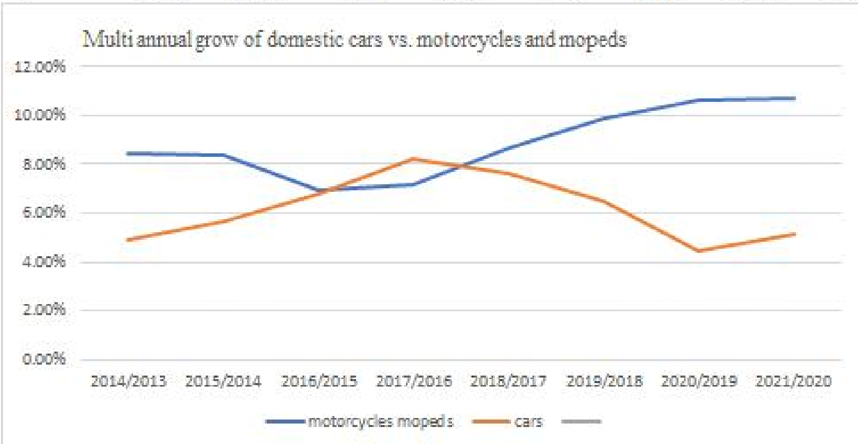


Fig. 3. Multi - year evolution of the car and moped flee (down)t,
and distribution of the entire vehicle fleet (up)

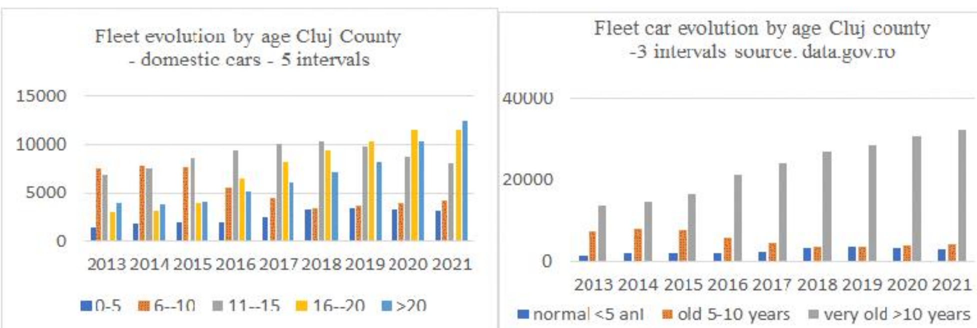


Fig. 4. Left: multi-year evolution of the car fleet's age in five series, and
right: three series of age (more relevant ones)

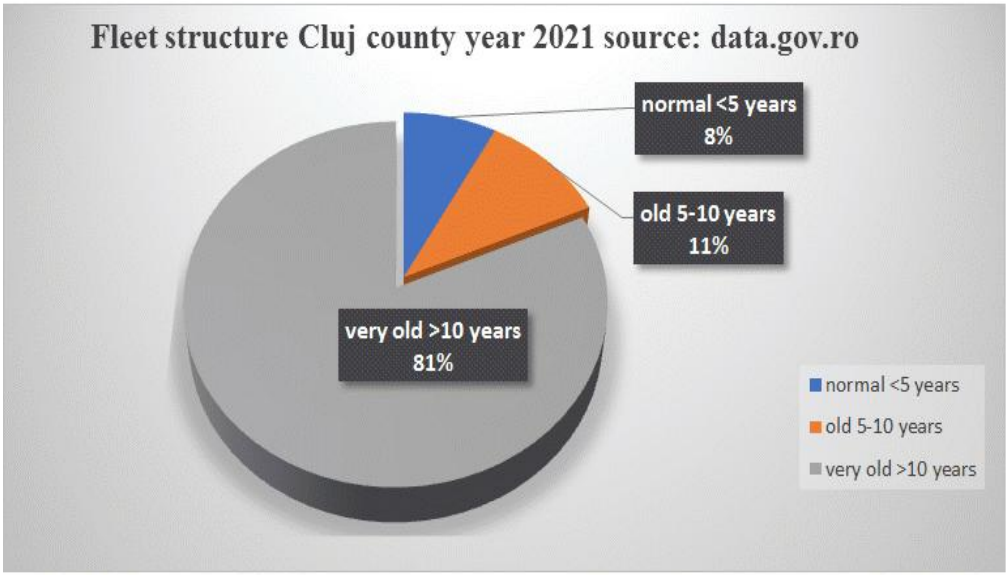


Fig. 5. Fleet distribution by age

Figure 6 reflects developments in the peri-urban areas of Cluj-Napoca (source: National Institute of Statistics), including Aghireşu, Apahida, Baciu, Bonţida, Căpuşu, Chinteni, Ciurila, Feleacu, Floreşti, Gârbău, Gilău, Jucu, Luna, Săvădisla, as well as other rural communes, municipalities in the county, and Cluj-Napoca itself. Increasing population trends are highlighted both at the level of the county's seat and in its peri-urban areas.

Commute travel has consequently gained importance, as job opportunities did not follow the residences of those settling in the peri-urban areas. Thus, considering the data regarding commuting in 2017, extracted from the peri-urban study commissioned by the Cluj County Council, the study's main beneficiary, * (Faculty of Geography, Babe -Bolyai University, project director József Benedek, 2019). Extrapolating the mentioned data and taking into account the population increase in these areas, it can be estimated with approximate accuracy that the commuting population currently numbers around 47,000 individuals.

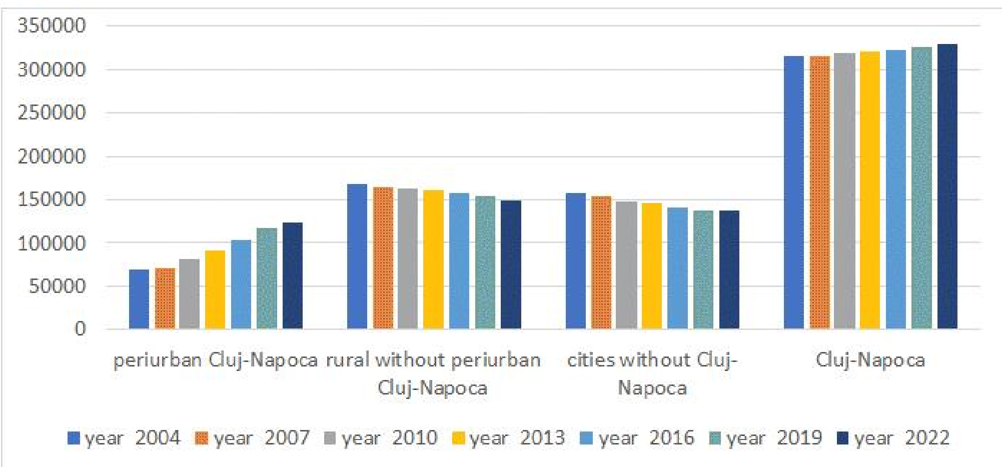


Fig. 6. Classification and evolution of population categories after residence

Table 4 – Commuting by settlements closed from main city Cluj-Napoca (INSSE and *)

UAT	2017 population INSSE	2017 commute*	% commute	population 2022	% 2022/2017
APAHIDA	13220	5044	38%	15581	18%
BACIU	11531	3577	31%	13045	13%
BONTIDA	4884	583	12%	4790	-2%
CHINTENI	3296	828	25%	3655	11%
CIURILA	1480	293	20%	1646	11%
FELEACU	3953	858	22%	4361	10%
FLORESTI	35152	25512	73%	46908	33%
GILAU	8870	1190	13%	9056	2%
JUCU	4454	979	22%	4932	11%
SAVADISLA	4131	589	14%	4079	-1%
Total	90971	39453	43%	108053	19%

Interurban Public Transport

Interurban road transport licenses specifying minimum transport capacities and their frequencies are managed by the County Council. These licenses should take into account both demographic data and commuting patterns. The analysis conducted is based on the weekly schedule of the Cluj-Napoca bus station. The data was processed according to travel directions (E - direction to Gherla, W - direction to Huedin, N - direction to Zalău, Na - Chinteni, S - direction to Turda). The database was acquired from the Cluj County Council in 2022 source: https://cjcluj.ro/compartiment-autoritatea-judeteana-de-transport/61dc155b-programul-de-transport-public-judetean-de-persoane-prin-curse-regulate-in-judetul-cluj-pentru-perioada-2023-2028/.

Based on Figures 7 and 8, it can be observed that 71% of journeys are made along the East-West axis. The time intervals with the highest intensity, between 7-10 and 15-19, also predominantly fall along this axis, representing the main commuting periods. However, the minimum transport capacities provided for these journeys are extremely low, as indicated in table 5.

Although commuting typically involves the use of private transportation, there is also the option of using the railway network. However, even when considering the need for these routes, they do not cover or offer a viable alternative for mobility, especially when excluding the Flore ti commune, which is connected to the urban transport network through CTP (public transport company).

In correlation with the commuting aspect, the interurban public transport function is relatively insignificant.

Rail Transport

Information regarding arrival and departure times, destination stations, and railway operators was obtained from the "train schedules" website. Data was processed based on time intervals, destination and travel directions, and types of operators.

The times of arrival and departure, as well as the train frequencies, are crucial since the railway station serves both urban and interurban transportation, including air travel. Passenger traffic varies from day to day and is not quantifiable, with ticket sales as the only useful information, focusing on departures and arrivals at Cluj-Napoca station. Currently, there are three railway operators, making quantification a challenging task. Data interval of analysis is week 41 2022 – source: “Mersul trenurilor” https://mersultrenurilor.infofer.ro/ro-RO/Statie/Cluj-Napoca.

Table 5. Number of arrivals and departures, along with interurban transport capacities, by days and hours on the left, and by travel directions

-1	7	10	13	15	19	24	
departures	0-7	7-10	10-13	13-15	15-19	19-24	total
Monday	49	18	24	29	63	13	196
Tuesday	46	18	24	29	61	13	191
Thursday	46	18	24	29	62	13	192
Wednesday	46	18	24	29	61	13	191
Friday	46	18	24	29	62	13	192
Saturday	15	10	12	10	21	4	72
Sunday	9	8	9	8	19	3	56
total	257	108	141	163	349	72	1090
arrivals	0-7	7-10	10-13	13-15	15-19	19-24	total
Monday	36	51	14	18	61	16	196
Tuesday	36	47	14	18	61	15	191
Thursday	36	48	14	18	61	15	192
Wednesday	36	47	14	18	61	15	191
Friday	36	48	14	18	61	15	192
Saturday	11	19	4	11	24	3	72
Sunday	8	16	2	8	20	2	56
total	199	276	76	109	349	81	1090
passenger arivals	0-7	7-10	10-13	13-15	15-19	19-24	total
Monday	750	258	344	485	955	195	2987
Tuesday	720	258	344	485	922	195	2924
Thursday	720	258	344	485	945	195	2947
Wednesday	720	258	344	485	922	195	2924
Friday	720	258	344	485	945	195	2947
Saturday	241	139	185	191	314	66	1136
Sunday	142	119	129	145	307	43	885
total	4013	1548	2034	2761	5310	1084	16750
passenger departures	0-7	7-10	10-13	13-15	15-19	19-24	total
Monday	555	744	231	258	961	238	2987
Tuesday	555	691	231	258	961	228	2924
Thursday	555	714	231	258	961	228	2947
Wednesday	555	691	231	258	961	228	2924
Friday	555	714	231	258	961	228	2947
Saturday	188	268	66	175	383	56	1136
Sunday	145	238	33	119	317	33	885
total	3108	4060	1254	1584	5505	1239	16750

Table 5. Continuation

passenger departures	0-7	7-10	10-13	13-15	15-19	19-24	total
Monday	555	744	231	258	961	238	2987
Tuesday	555	691	231	258	961	228	2924
Thursday	555	714	231	258	961	228	2947
Wednesday	555	691	231	258	961	228	2924
Friday	555	714	231	258	961	228	2947
Saturday	188	268	66	175	383	56	1136
Sunday	145	238	33	119	317	33	885
total	3108	4060	1254	1584	5505	1239	16750

weekly frequency of bus lines	0-7	7-10	10-13	13-15	15-19	19-24	total
N	46	22	17	22	78	5	190
Na	25	18	5	5	31	0	84
E	206	140	78	122	280	42	868
V	105	136	61	91	218	59	670
S	74	68	56	32	91	47	368
total	456	384	217	272	698	153	2180
							2180

weekly passengers capacity	0-7	7-10	10-13	13-15	15-19	19-24	total
N	460	220	170	220	780	50	1900
Na	250	245	50	115	310	0	970
E	3620	2154	1222	1870	4633	641	14140
V	1661	2179	1156	1625	3662	1097	11380
S	1130	810	690	515	1430	535	5110
total	7121	5608	3288	4345	10815	2323	33500

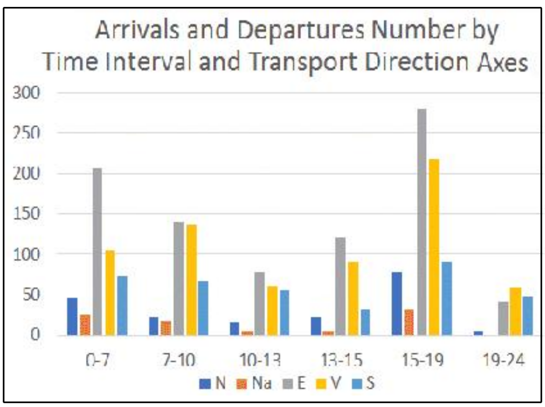


Fig. 7. Cluj Bus Station - 2022 weekly schedule by time interval above, and bellow, the transport directions

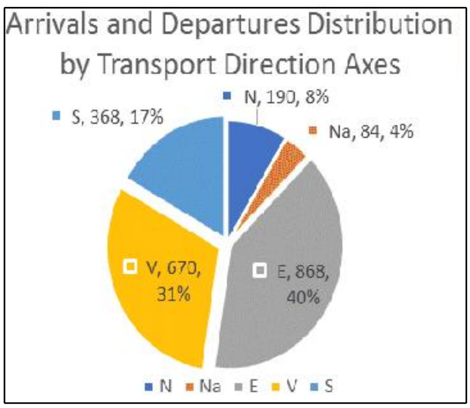
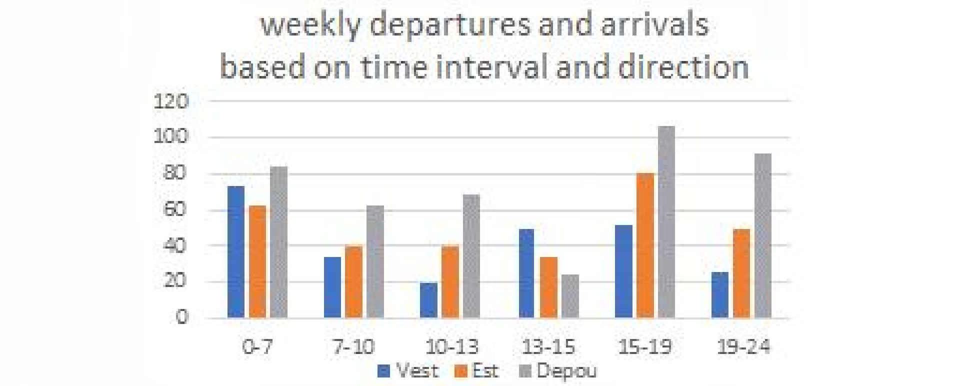


Fig. 8. Weekly passengers' volume, direction and minimum transport capacities provided for destinations



Daily and time distribution of train operating in Cluj-Napoca reilwai station

orar	0-7	7-10	10-13	13-15	15-19	19-24	total
luni	33	21	19	16	37	24	150
marți	33	21	19	16	37	24	150
miercuri	33	21	19	16	37	24	150
joi	33	21	19	16	37	24	150
vineri	33	21	19	17	37	24	151
sâmbătă	29	17	16	13	27	21	123
duminică	26	15	16	13	27	25	122

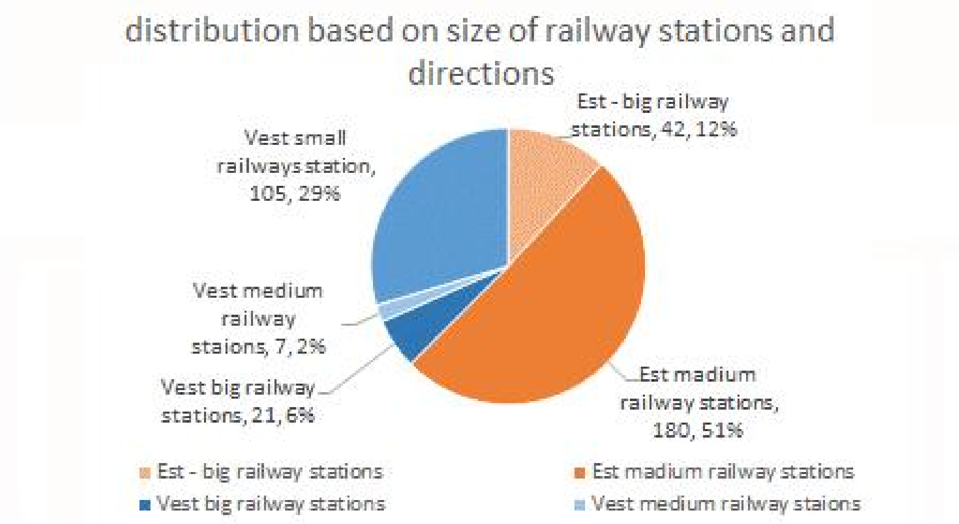


Fig. 9. Departures and arrivals at the station by time intervals,
according to operator types and travel directions

Classification of Localities based on population: Large cities: Oradea, Braşov, Valea lui Mihai, Satu Mare, Bucharest North, Timişoara North, Iaşi; Medium-sized cities: Satu Mare, Sighetu Marmaţiei, Câmpia Turzii, Bistriţa Nord, Târgu Mureş, Dej, Teiuş, Sighişoara, Jibou, Baia Mare; Small stations: Aghireş, Huedin, Stana Hm, Poieni.

Table 6: Fast transit trains has station times between 12 and 39 minutes - distribution by travel direction and destination type

Number of trains in railway station by time interval and destination							
	0-7	7-10	10-13	13-15	15-19	19-24	total
Vest	14	0	0	7	7	0	28
Est	14	0	0	7	7	14	42
Big railway stations	21	0	0	14	14	14	63
Medium railway stations	7	0	0	0	0	0	7
total							70

From the data analysis, it is evident that rail transport, operating mainly along a single axis, is dominant in the East direction. Access to localities west of the city is less efficient due to the relief and the distribution of these localities, with road transport being the predominant mode. Cluj-Napoca station is not congested, and it could potentially create metropolitan routes to the east, up to Gherla, which is an area that could collect and distribute commuters more efficiently. The western area lacks stations and efficient demographic distribution.

Regular Passenger Air Transport at Cluj-Napoca Airport

Flight information for week 41 was collected from websites that provide information about landings and take-offs at Avram Iancu Cluj-Napoca Airport (source https://www.avionio.com/ro/airport/clj). Data was processed by hourly intervals, day of the week, direction, and airline operators, excluding charter flights. Below are the results extracted from the 392 records (Fig. 10).

The specific nature of airport activity is that night flights are limited, and the balance between arrivals and departures is relatively equal. The majority of flights, 79%, are within Western Europe, with 24% in southern regions (Italy, Spain, Malta). The total of flights to northern and eastern destinations accounts for 8%. The peak slot allocation period for landings and take-offs is between 13:00 and 18:00, leading to airport congestion during check-in and road traffic congestion in the airport area due to the lack of dedicated common transport lines and an intermodal transport station.

The estimated traffic for this year is 2,500,000 passengers, including charter flights. A weekly passenger traffic estimate, based on aircraft types with capacities of 140-170 passengers, and taking into account the number of flights over a year with a total of 2,440,000 passengers, results in the following table estimating arrival and departure flows by hourly intervals (Tabele 7).

Just like the train station, the geographical orientation of flights predominantly heads west, with those to the north and east typically serving as transit or business flights (Istanbul, Abu Dhabi, Warsaw). Many of the southern-bound flights are related to Mediterranean beach destinations.

The significant passenger flows during specific hourly intervals highlight the need for a dedicated road transport line operating between the airport and the railway station, which is in close proximity to the bus station

Table 7: Estimated passenger flow at Cluj Airport for week 41, 2022

Time interval	0-7	7-10	10-13	13-18	18-21	21-24	total
Monday	1680	1200	600	2760	1560	0	7800
Tuesday	1680	600	840	2280	1440	240	7080
Thursday	1440	720	480	2040	1320	240	6240
Wednesday	1200	480	720	1920	1560	240	6120
Friday	1680	720	480	2160	1440	240	6720
Saturday	1680	360	840	2040	1320	240	6480
Sunday	1560	480	960	1440	1560	600	6600
Total	10920	4560	4920	14640	10200	1800	47040

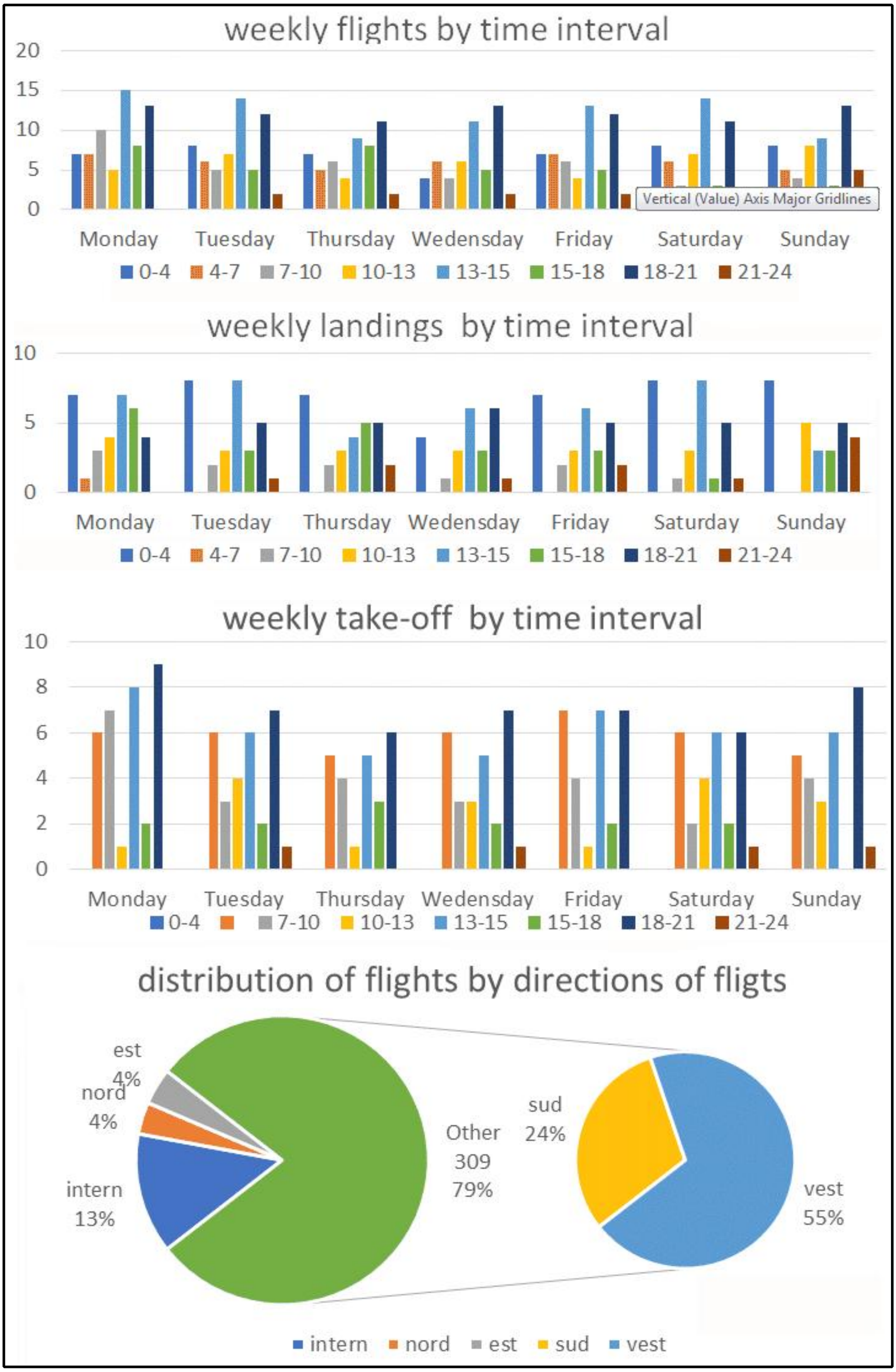


Fig. 10. Distribution of flight arrivals and departures by hourly intervals,
days of the week, and flight direction

Conclusions and Opinions

This analysis explores previously unexamined topics in mobility studies in Romania. Existing studies, such as the mobility study (Civitta Strategy & Consulting SA TTL Planing srl, 2022) only provide general information about the bus station, railway station, and airport or others doctoral theses assuming information's for Cluj-Napoca city (Harangus, 2022).

This article analyzes focal infrastructure elements of mobility, specifying their distribution by hourly slots and destination types for the train station, bus station, and airport, thus providing an understanding of mobility needs, especially in relation to the city's geographical location.Mobility is effective when it is functional.

Dysfunctional mobility creates problems for quality of life and is hindered by the lack of functions within accessibility zones. In many cases, improving mobility can be achieved by implementing lacking functions within an area of accessibility. For example, it is more useful, efficient, and cost-effective to build schools and kindergartens in an area where this urban function is lacking than to create road infrastructure for commuting to a location where this urban function is accessible. This is a specific example in which commuting for access to education disrupts sustainable urban mobility. Jahn Gehl, the author of "Cities for People," is one of the key figures in sustainable mobility literature, suggesting that improving urban spaces will enhance the quality of life (Anon., 2022) and emphasizing that the post-pandemic period has become a pivotal moment that should not be missed.

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