BOOK OF PROCEEDINGS

9th CONFERENCE OF INTERDISCIPLINARY RESEARCH ON REAL ESTATE

SKOPJE, NORTH MACEDONIA

October, 2024

Inštitut za nepremičninske vede

9th CONFERENCE OF INTERDISCIPLINARY RESEARCH ON REAL ESTATE SKOPJE, NORTH MACEDONIA October, 2024

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Published:

Inštitut za nepremičninske vede, Ukmarjeva 6, 1000 Ljubljana

Edition:

Electronic version, PDF

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID 216785667
ISBN 978-961-95781-7-9 (PDF)

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Analysis housing market reports Achterhoek the Netherlands 2007-2023

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Purpose
Annual quantitative and qualitative developments of the housing market in the Achterhoek are reported in conjunction with administrative theme tables in which (new) themes are discussed and actions are set out. At most, the comparisons concern the year of reporting and the previous year. Now it is interesting to see whether, over a longer time horizon, patterns can be discovered from the figures and/or whether there is a trend break over a longer period. This as a further deepening and complement to the annual reports. Specifically, we sometimes looked at one municipality: Aalten for reasons of limiting the study to a particular area and because there is a specific demand for this. This has been placed in the context of the Achterhoek Netherlands.

Design/methodology/approach
The research took place from various public data of the government as well as from the public data of the Achterhoek Monitor. The starting point was the most recent publication of that monitor supplemented with underlying information and critical comments.

Findings
Based on the analyses, 11 conclusions can be drawn. The final conclusion is that in the reports studied and the corresponding data, the sources could not always be mentioned exactly or at all, while many (partial) conclusions are drawn. In this article, that is exactly what was done and cross-checks in tables were checked, corrected, re-tabulated and properly included in this article. For future reports, this is a clear point for improvement because otherwise conclusions will take on a life of their own without a scientific foundation.

Practical implications
The findings are directly applicable to municipalities and urban design practices and also to other specialists in city design practices.

Originality/value
Realizing a housing and property monitor is in itself not new in the Netherlands and is widely used. The question that can be asked, however, is to what extent such data are future-proof, safeguarded in new initiatives and remain comparable for years. This article is just one example of that.

Keywords
Housing market - analysis - longer period - patterns – regional

1. Introduction

Commissioned by the Achterhoek Board, which includes a theme table on housing and real estate, the Achterhoek Monitor has been realised for years; originally the reporting started in 2016 with the first results in 2017. This monitor is an overview of reliable and factual information on the economy and life in the Achterhoek. It is compiled by a team of independent researchers. This is guided by a steering committee of experts who monitor the scientific quality and independence of the interpretation. The Achterhoek Monitor aims to bring together a meaningful and useful selection of facts and figures in an annual publication and continuously consultable dashboard via the site www.achterhoekmonitor.nl with useful interpretation. Originally, the monitor thus started in 2017 with the 2017 Achterhoek Housing Market Monitor (Suurmond 2017) and continued in 2018 (Suurmond 2018) as per the description of the drafting of this monitor (Housing Market Monitor 2017).

The aim of this study is to show the underlying methodology of the dashboard, its content patterns, understand its operation and learn lessons from it. This takes place using the investigated area the Achterhoek in terms of the content of the dashboard as a case study, the underlying figures, the methodology and concludes with lessons learned.

Before moving on to the lessons learned, the geographical area of the Achterhoek is first pointed out, followed by the population dynamics, households, housing and finally the conclusions.

2. The Achterhoek region

The Achterhoek is a region in the province of Gelderland with a surface area of 1,475.97 km2 and with 406,261 inhabitants (2023) in the province, which is also called De Graafschap after the old county of Zutphen that in the broadest sense covers an area with the Overijsselian regions of Salland and Twente to the north, the German border to the east and south-east, the Oude IJssel to the south-west and the IJssel River to the west (Figure 1). Opinions differ on the exact border because there has been no clear historical boundary. The region offers a rich and complementary palette of housing (112,750 houses in 2023) and living environments: living with urban amenities in Doetinchem and Winterswijk, rural living on the edge of the Vennebulten or Wolfersveen, attractive living along the water of the Oude IJssel or village living in one of the close-knit communities in the villages and hamlets such as Beltrum, Mariënvelde or Toldijk. The varied and small-scale coulisse landscape in the Achterhoek countryside and rivers and streams such as the Aa-strang, the Oude IJssel, the Baakse Beek, the Berkel and the Slinge characterise and connect hamlets, villages and towns. The Achterhoek consists of the municipalities of Aalten, Doetinchem, Winterswijk, Berkelland, Oost Gelre, Bronckhorst and Oude IJsselstreek.

Figure 1: the Achterhoek green on the map of the Netherlands

2.1. Purpose theme table Housing and Property

Within the Achterhoek Monitor, one of the theme tables is Housing and Real Estate. In this article, we limit ourselves to this topic. The main objective of this theme table is to keep the region's residents' appreciation of liveability at least at the current average of 8.0.

2.2. Housing and real estate in the Regional Housing Agenda 2030

The Housing and Real Estate programme is described in the Regional Housing Agenda 2030 (Rutgers, de Vries, Janssen and van Os, 2023) and consists of four themes. To realise the ambitions from the Regional Housing Agenda (Rutgers, de Vries, Janssen and van Os, 2023), they work together on the housing challenges. They do so as municipalities in the characteristic Achterhoek way of cooperation between authorities, housing corporations, social organisations, the market and residents. In the coming years, they will structure this along four regional programme lines. Each programme line contains the regional policy goals and the approach they have in mind: (1) increasing the housing stock and accelerating production, (2) investing in the quality of the existing housing stock, (3) the Achterhoek, a place for everyone and (4) housing as an integral area task. The four programme lines have been fleshed out in terms of content as follows (Regional Housing Deal 2022-2030 Achterhoek, 2023):

Increasing housing stock and accelerating production

The ambition is to significantly expand the housing stock at an accelerated pace to 11,500 additional dwellings in the Achterhoek. Municipalities, the province and the state made agreements in the Regional Housing Deal[1] (Regional Housing Deal 2022-2030 Achterhoek, 2023) to build at least 8,390 dwellings out of the ambitious target of 11,500 dwellings in the Achterhoek up to and including 2030. From 2025 onwards, as many reused or bio-based raw materials as possible will be used in housing construction.

Investing in quality existing housing stock

[1] With the 35 signed regional housing deals in the Netherlands from 2022 and 2023, minister Hugo de Jonge aims to solve the national housing shortage. The deals form the basis for the public housing task in the 35 regions in the coming years. With the commitment of all parties involved, the number of houses will grow in a balanced way and at a higher pace. Two thirds of the housing to be built must be affordable. For each municipality, a fair share of the regional task will be taken up, matching the local task and the character of the municipality. Source: Woondeals | Home | Volkshuisvesting Nederland accessed 12.02.2024.

The municipalities want to improve the quality and energy efficiency of as many homes as possible. By improving, they mean making them more sustainable, life-proof and/or restructuring. They focus on the housing corporation stock yet to be improved and private owners who want to invest in improving their homes.

The Achterhoek, a place for everyone
In the coming years, municipalities will invest heavily in increasing affordable housing. Together, they are gearing up to meet the extra demand from young households, starters, the elderly, the workforce and attention groups. In doing so, they align as much as possible with the ambitions of the national government to add two-thirds of new construction in the affordable segment through 2030. For residents who need care and support in addition to a home, they see many opportunities in residential forms between 'home and nursing home': sheltered housing, service flats, courtyards and residential care farms.

Housing as an integral area task
In the coming years, they will make the shift from housing policy to integrated thinking and working. In this way, they can combine forces and link processes and investments.

Progress and developments in the housing market are monitored via the Housing and Real Estate Monitor (link: Achterhoek Monitor - Dashboard) as part of the Achterhoek Monitor.

2.3. Ambitions of municipalities

The municipalities have the ambition to realise 11,500 extra houses in the Achterhoek region. In doing so, they will expand the housing stock substantially and at an accelerated pace. Regional production in recent years has averaged 583 dwellings net per year. Production in recent years were (Rutgers, de Vries, Janssen and van Os, 2023: 10):

Year	Number of houses
2018	350
2019	590
2020	673
2021	718
Average	583

Table 1: Housing production 2018-2021 (Rutgers, de Vries, Janssen and van Os, 2023: 10).

The municipalities aim to double this number to over 1,200 dwellings per year. In the Regional Housing Deal, the municipalities, the province and central government make conditional agreements to build at least 8,390 houses in the Achterhoek region up to and including 2030 (see table 1 for the numbers per municipality). The conditions set for these agreements are: (1) investments in accessibility, (2) financing of unprofitable tops of rental and owner-occupied houses, (3) sufficient official capacity and (4) sufficient nitrogen space.

The 3,110 homes leading to the aspired target of 11,500 (Figure 1) will be developed through adaptive programming and with similar shares of affordable homes. Upon good progress of agreements in the Regional Housing Deal and proven need for these additional homes in the Achterhoek, the adaptive part will be discussed, including during the annual monitoring discussions.

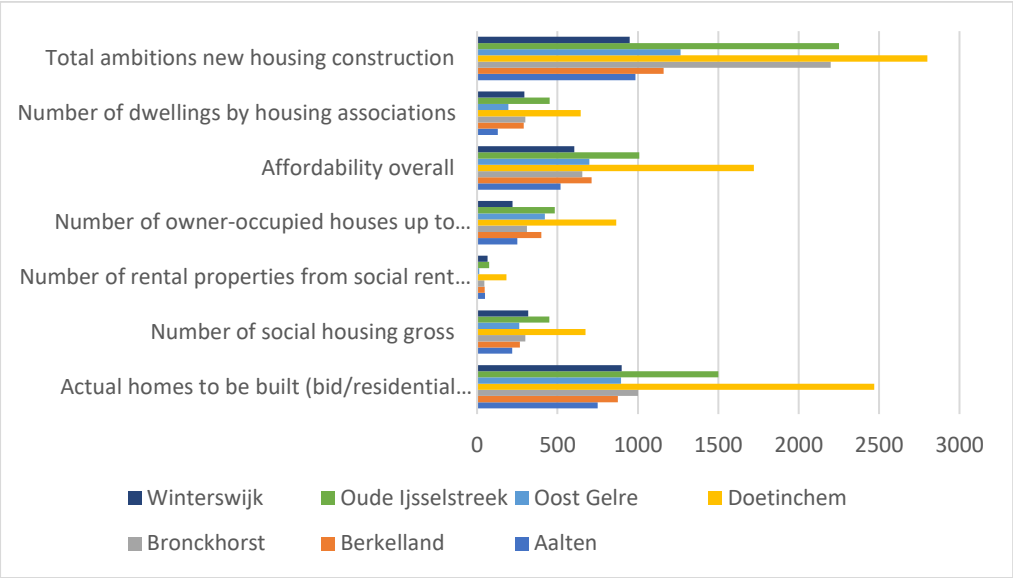

Figure 2: Housing numbers and affordability up to and including 2030 in the Achterhoek municipalities. Basis for bid agreements with province and state Stand 1 October 2022. Source: Appendix 1 - Housing numbers and affordability up to and including 2030 in the Achterhoek municipalities - Basis for bid agreements with province and national government Position 1 October 2022. Regionale Woonagenda Achterhoek 2023-2030 | Lokale wet- en regelgeving (overheid.nl) *Accessed 12.02.2024. Edited 2024 Jan Veuger.*

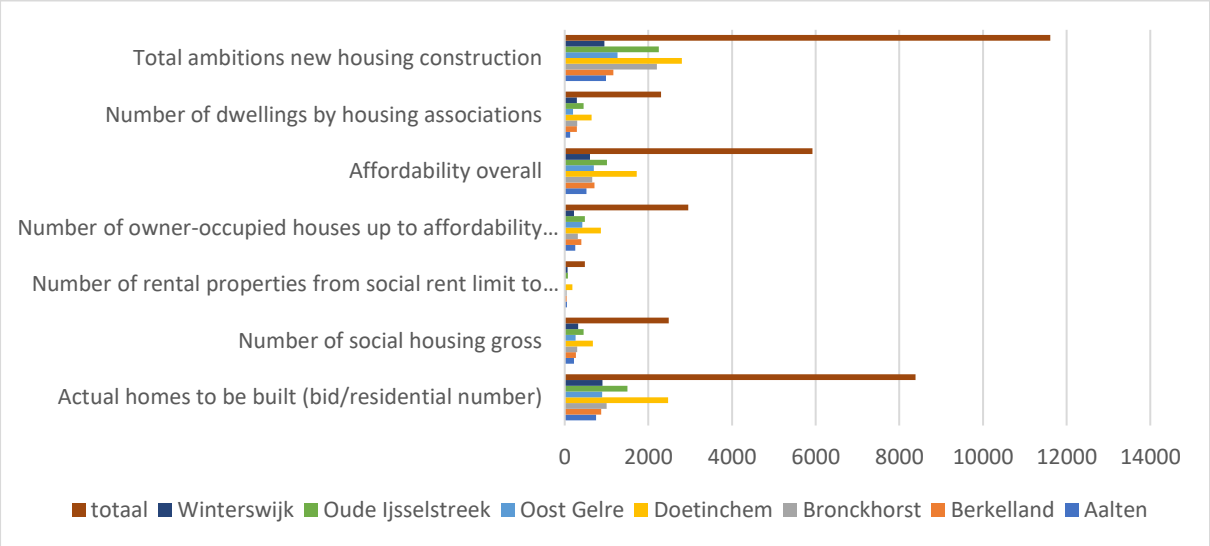

Figure 3: Housing numbers and affordability up to and including 2030 in the Achterhoek municipalities (the different colours) compared to the totals (red). Basis for bid agreements with province and state Stand 1 October 2022. Source: Annex 1 - Housing numbers and affordability up to and including 2030 in the Achterhoek municipalities - Basis for bid agreements with province and state Stand 1 October 2022. Regionale Woonagenda Achterhoek 2023-2030 | Lokale wet- en regelgeving (overheid.nl) *edit 2024 Jan Veuger. Accessed 12.02.2024.*

3. Population dynamics

The state and trends of the number of inhabitants in the Achterhoek region is described using population dynamics (Koster, de Vor and van der Wiel, 2023: 70). It expresses the attractiveness of a location as a place to live and work. Population size is important for liveability and economy and also forms a basis for regional labour supply. Finally, forecast figures give an impression of how the number of inhabitants might be expected to develop in the future, but depends on many economic and social factors, local, national and international.

3.1. Population growth

The seven Achterhoek municipalities together numbered 265,450 inhabitants on 1 January 2023 (CBS 2023), see Figure 4. This is 1,702 more than exactly on 1 January 2022. In percentage terms, this is a growth of 0.6%. The national growth rate over that measured period was 1.3%. The growth started since 2020 is accelerating, this after years of decline and a subsequent period of population stabilisation. This concerns the overall growth in the Achterhoek region. Per municipality within this area, the differences are larger and not entirely comparable. Over a measured period of 2007-2023, a period of 17 years, the entire area has 530 fewer inhabitants on balance, a rate of -0.2% (CBS 2023). When we put this alongside the total Dutch population, we saw it increase by 8.9% (CBS 2023). In conclusion, population growth in the Achterhoek is accelerating.

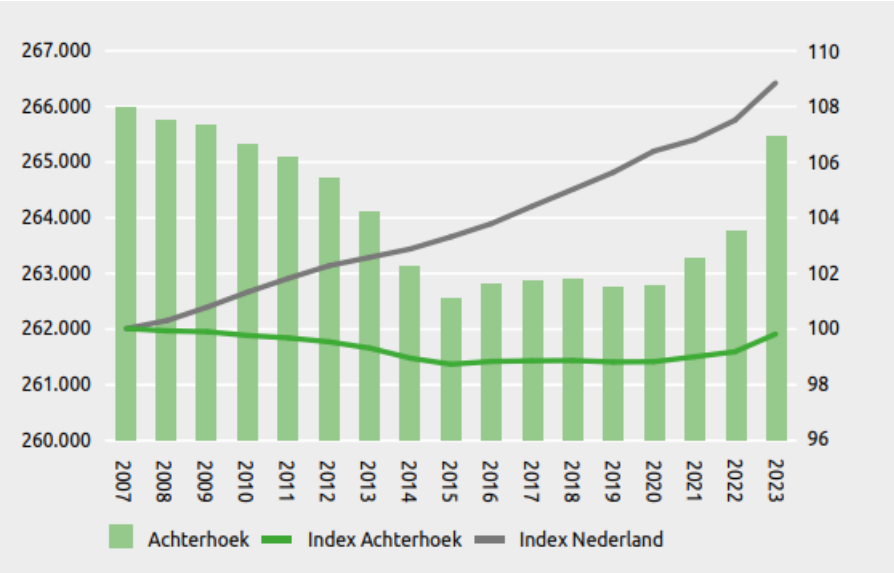

Figure 4: Population development region Achterhoek, index Achterhoek compared with Index Netherlands (source: CBS 2023). Left axis the absolute numbers and on the right axis the index 2007=100.

For example, when looking more specifically at demographic trends in a given municipality - in this example, the municipality of Aalten - and over a somewhat longer period, the following picture emerges.

3.2. Demographic developments municipality of Aalten specifically

The latest demographic analysis (Vreman 2020) presents the following picture in terms of population and household development over the period from 2015-2020, a 6-year period. The graph (Figure 5) shows a substantial upward trend. This does give a distorted picture in the sense that in absolute numbers of 200 inhabitants is only limited over the period 2018-2020. The number of households over the measured period has increased by 4.8% and is not as a result of the number of inhabitants, but the too different compositions of households, a general picture throughout the Netherlands.

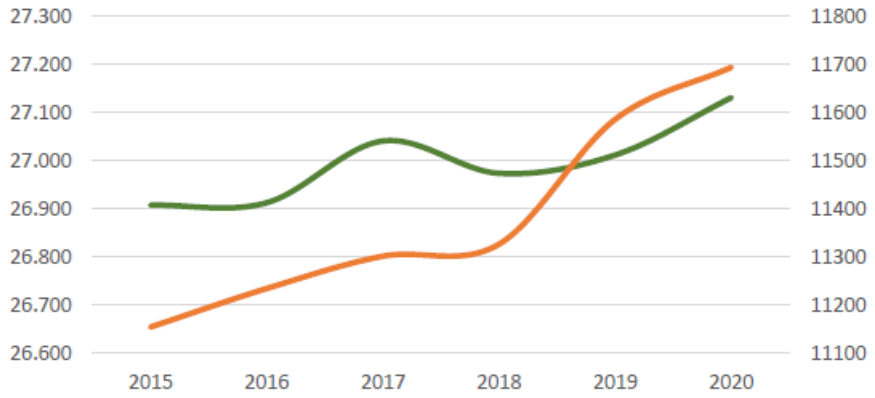

Figure 5: Development of inhabitants and households 2015-2020 in the municipality of Aalten (Vreman 2020: 3). The green line concerns the number of inhabitants. The red line the households.

Looking at the 2024 CBS figures for the period from 2005 to 2023 (Figure 6), a period of 19 years, we see a decrease from 27,476 inhabitants in 2005 to 27,308 inhabitants in 2023. This is a 0.6% decline in population size over a 19-year period. The difference in the 2011 and 2012 population decline is the largest in absolute numbers, at 223 inhabitants, a decrease in percentage terms of 0.8 in 2012 compared to 2011. For the total measured period of 19 years, this has no significant impact. It should be noted, incidentally, that the measured period 2002-2004 was disregarded given the significant differences and incorrect data was assumed here.

Aalten	Bevolking aan het begin van de periode	aantal	18811	18855	18998	27446	27476	27570	27568	27447	27500	27459	27305	27082	27013	26804	26912	27047	26962	27011	27121	27120	27100	27240	27213	27203	27229	27236	27229	27275	27286	27344
Aalten	Levendgeboren kinderen	aantal	216	215	211	287	324	319	298	316	290	250	256	241	227	249	234	219	220	240	254	257	237	15	23	21	17	21	24	22	22	219
Aalten	Overledenen	aantal	164	178	166	235	223	217	244	233	228	214	235	245	244	257	255	268	277	256	289	310	306	19	22	26	22	26	17	30	26	286
Aalten	Vestiging in de gemeente |Totale vestiging	aantal	614	681	510	834	887	752	797	811	763	803	661	637	679	789	1262	1171	944	950	824	916	969	52	82	94	93	79	95	71	96	954
Aalten	Vestiging in de gemeente |Vestiging vanuit een andere gemeente	aantal	452	576	462	764	787	654	675	695	588	638	600	566	595	684	974	1021	820	827	705	809	733	41	67	78	82	60	68	54	86	771
Aalten	Vestiging in de gemeente |Immigratie	aantal	162	105	48	70	100	98	122	206	175	165	61	71	86	95	288	149	124	123	119	107	236	11	15	16	11	19	27	17	10	183
Aalten	Vertrek uit de gemeente |Totaal vertrek (incl. admcorrecties)	aantal	642	595	618	856	891	867	972	844	892	976	916	703	773	774	1103	1208	836	823	780	882	756	75	93	63	81	81	56	52	70	823
Aalten	Vertrek uit de gemeente |Vertrek naar andere gemeente	aantal	577	534	496	725	680	743	865	747	745	797	823	650	687	682	1032	1109	720	725	710	750	626	55	68	50	73	70	50	44	56	678
Aalten	Vertrek uit de gemeente |Emigratie inclusief admcorrecties	aantal	65	51	122	131	211	124	109	97	147	179	93	73	86	92	71	99	116	98	80	132	130	20	25	5	8	11	6	8	14	145
Aalten	Overige correcties	aantal	0	10	0	0	-3	11	0	3	6	3	1	1	2	1	-3	1	-2	-1	0	-1	0								0	0
Aalten	Bevolkingsgroei |Bevolkingsgroei	aantal	44	143	-63	30	94	-2	-121	53	-61	-134	-223	-69	-109	8	135	-85	49	110	-1	-20	144	-27	-10	26	7	-7	46	11	22	64
Aalten	Bevolkingsgroei |Bevolkingsgroei, relatief	%	0,23	0,76	-0,33	0,11	0,34	-0,01	-0,44	0,19	-0,22	-0,49	-0,82	-0,25	-0,4	0,03	0,5	-0,31	0,18	0,41	0	-0,07	0,53	-0,1	-0,04	0,1	0,03	-0,03	0,17	0,04	0,08	0,23
Aalten	Bevolkingsgroei |Bevolkingsgroei sinds 1 januari	aantal	44	143	-63	30	94	-2	-121	53	-61	-134	-223	-69	-109	8	135	-85	49	110	-1	-20	144	-31	-41	-15	-8	-15	31	42	64	64
Aalten	Bevolkingsgroei |Bevolkingsgroei sinds 1 januari, rela...	%	0,23	0,76	-0,33	0,11	0,34	-0,01	-0,44	0,19	-0,22	-0,49	-0,82	-0,25	-0,4	0,03	0,5	-0,31	0,18	0,41	0	-0,07	0,53	-0,11	-0,15	-0,06	-0,03	-0,06	0,11	0,15	0,23	0,23
Aalten	Bevolking aan het einde van de periode	aantal	18855	18998	18935	27476	27570	27568	27447	27500	27459	27305	27082	27013	26804	26912	27047	26962	27011	27121	27120	27100	27244	27213	27203	27229	27236	27229	27275	27286	27308	27308

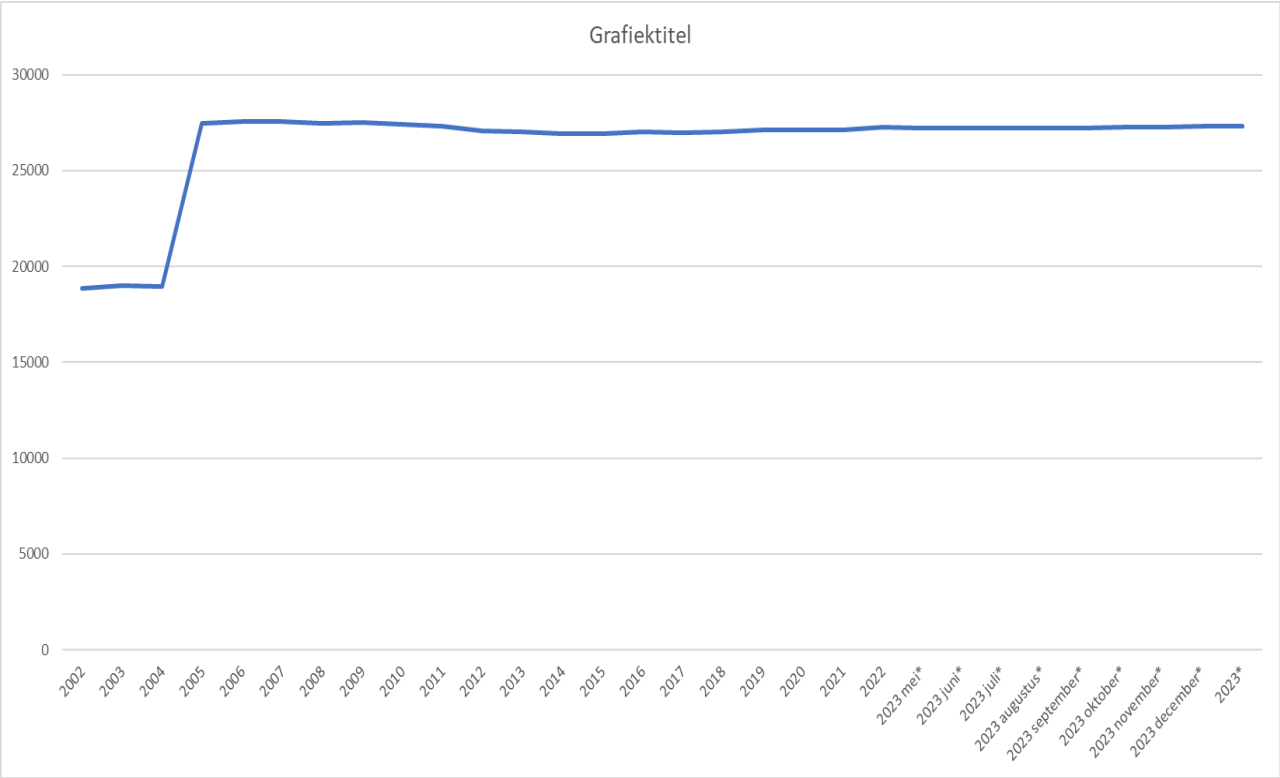

Figure 6: Population development Aalten 2002-2023 in figures (first table above) and graph where 2023 is further specified over different months (source: CBS 2024, editing Jan Veuger 2024).

In conclusion, population numbers are stable over a period of almost 20 years. A measured period over 19 years shows a more complete and accurate picture than over measured periods of 3 or 5 years. This allows for better longer-term steering rather than annual small fluctuations.

3.3. Migration

When we delve deeper into population trends, we see two things: attrition and migration. Natural attrition is the difference between birth numbers and death numbers. Migration - in this study referred to as the difference from and to the Achterhoek - where there is a distinction of domestic and foreign migration in the Netherlands. From 2011, this natural attrition is negative (CBS 2023), see Figure 7. From that year onwards, the death rate exceeds the birth rate. Looking at domestic migration, we see the following. Until 2017, there are more people leaving the Achterhoek region than those settling there. After 2017, domestic migration becomes positive as more people leave for other parts of the Netherlands than settle in the Achterhoek. In 2022, the number of new arrivals exceeds the number of departures by 1,486 (CBS 2023).
The Achterhoek has an ongoing foreign migration surplus that shows an erratic pattern over the measured period (Figure 7) and is caused by fluctuating refugee flows with peaks in 2015 and 2016 caused by the refugee crisis at the time. In 2022, there was an above-average foreign migration balance caused by sharply increased refugee inflows, particularly from residents of Ukraine. This movement was responsible for the foreign migration balance rising to 1,180 in 2022. Compared to the year 2021, this is an increase of ban 970% and thus an exceptional number determined by special circumstances (CBS 2023). In conclusion, domestic migration is growing steadily and the refugee influx is driving the foreign migration surplus.

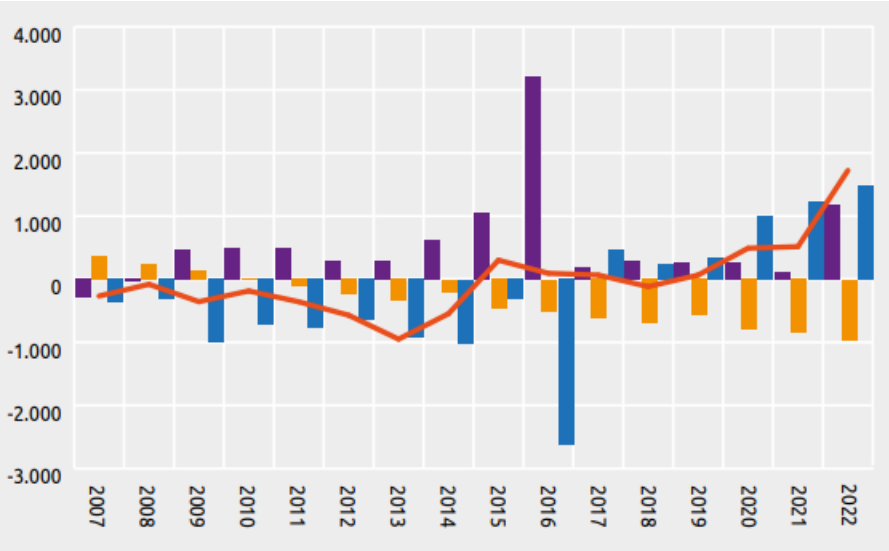

Figure 7: Population development by four components, Achterhoek region 2007-2022: (1, purple) foreign migration balance, (2, blue) domestic migration balance, (3, orange) natural turnover and (4, red line) population development balance (source: CBS 2023).

3.4. Population development by municipality

As indicated earlier, over the period 2007-2023, the total population in the Achterhoek declined by 0.2% (Woon en vastgoedmonitor 2023). However, there are clear differences between those municipalities in the Achterhoek. Looking recently at 2022 in which the total number of inhabitants increased by 1,702, we see that this development took place across the region. Compared to previous years, the growth is no longer mostly in Doetinchem. With an increase of 649 inhabitants in 2022, Doetinchem accounted for 38% of the Achterhoek population growth. In 2021, this share was still 57 %. The remaining 62 % of the total Achterhoek population increase in 2022 was distributed fairly evenly among the other six municipalities (Residential and Property Monitor 2023). The conclusion is that population growth is present across the region.

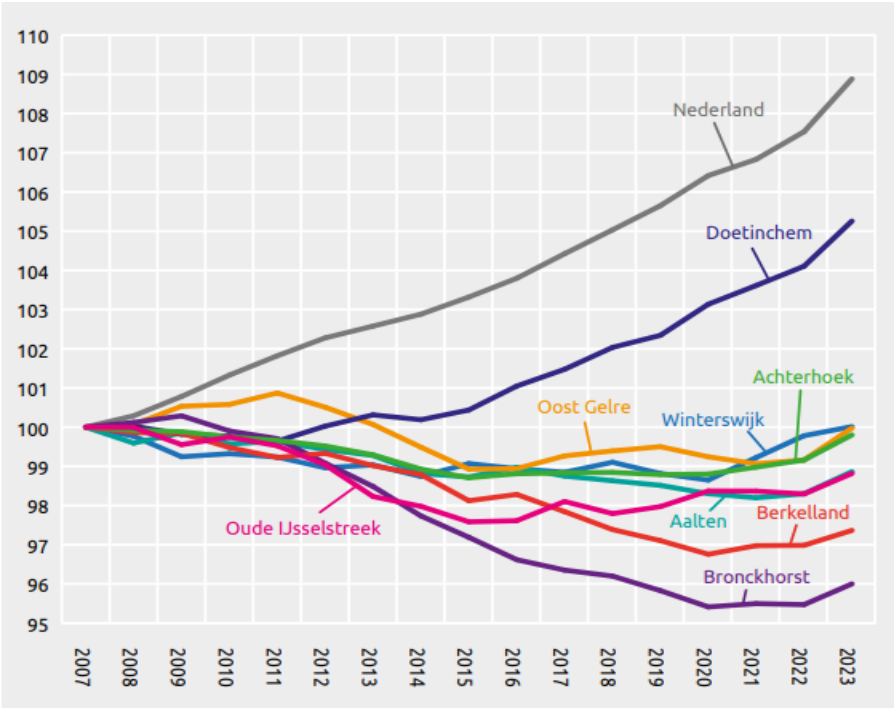

Figure 8: Population development by municipality (Oude IJsselstreek, Doetinchem, Oost Gelre, Winterswijk, Aalten, Berkelland and Bronckhorst) region Achterhoek 2007-2023 (index 2007=100). Grey line is the Netherlands; light green The Achterhoek (source: CBS 2023).

3.5. Population composition

The size of the Achterhoek population is changing as is its composition due to changes affecting the regional housing and labour market (Housing and Property Monitor 2023). In this area, there is a relatively strong increase in the number of elderly people. This development is taking place at a higher rate than compared to the national level of the Netherlands. The cause is the decreasing natural turnover of the population and increased life expectancy. In the Achterhoek, the share of the group 50 years or older increased from 37% to 48% in the period 2007-2023. In the Netherlands as a whole, this increased from 34 % to 41 %. At the beginning of 2023, a total of 128,500 people over 50 lived in the Achterhoek. This is more than 30,000 more than in 2007.

De-greening - the decrease in the proportion of young people - is decreasing in the Achterhoek and is similar to the national picture. The Achterhoek had 46,300 inhabitants aged up to 18 at the beginning of 2023. In 2007, the share of these young inhabitants was 23 %, in 2023 this had declined to 18 %. During the same period, the share of young people (up to 18 years of age) nationwide dropped from rounded 21 % to 19 % (Housing and Property Monitor 2023).

The conclusion is that the Achterhoek population is ageing and de-greening, changing the composition of the population and thus affecting the regional housing and labour market.

3.6. Forecast population development Achterhoek region and Netherlands 2025-2050

The population forecast (CBS, 2022) shows that the Achterhoek population will decline by 6.5% over the next 25 years. This represents a departure from the current growth trend. In 2050, the Achterhoek is expected to have a population of 244,000 compared to a projected population of 261,000 in 2025. With that - with a decline expected of 17,000 inhabitants - this is an opposite trend to the Dutch development. The Dutch population is expected to increase by over 9% until 2050. The Netherlands will then have 19.6 million inhabitants, 1.2% of whom will live in the Achterhoek. At the beginning of 2023, the figure is still 1.5 %. The conclusion is that in the long term a decline in the population is expected.

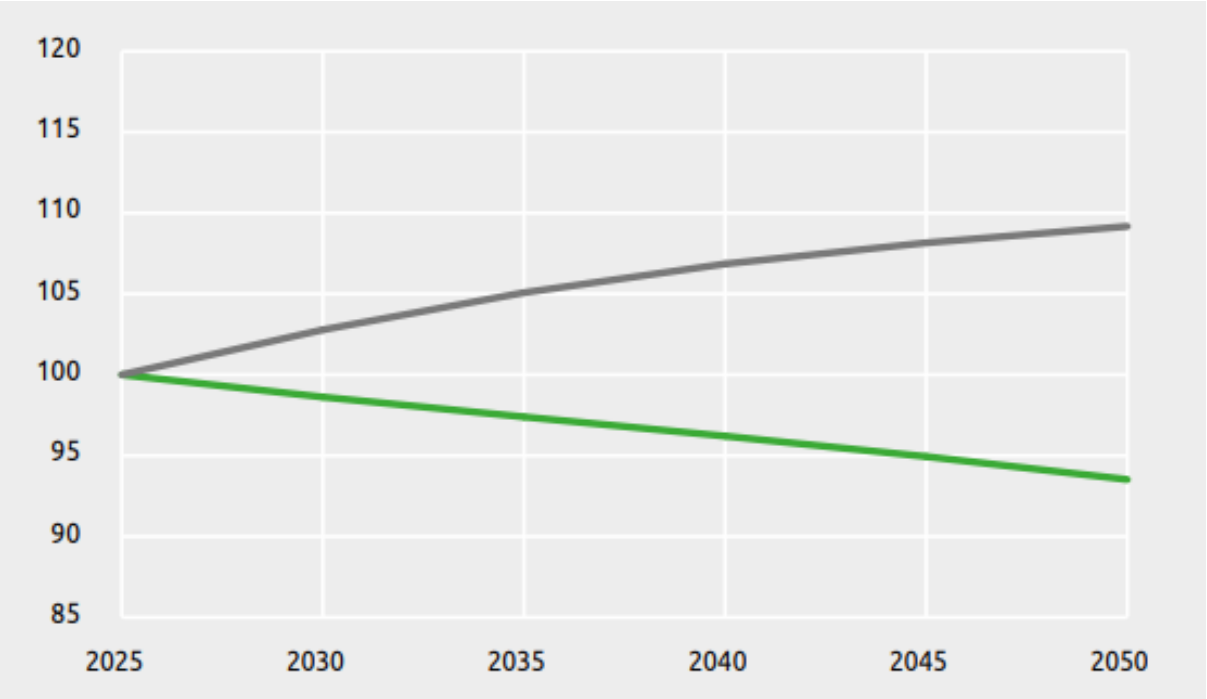

Figure 9: Forecast population development region Achterhoek and the Netherlands 2025-2050 (source: CBS 2022). Green line is the Achterhoek region; the grey line the Netherlands.

4. Households

Population and household development are interrelated. Understanding the development of numbers and different types of households is factor that is also relevant to the region and in particular to regional housing construction and planning.

4.1. Development of number of households region Achterhoek and Netherlands 2007-2023

The number of private households in the Achterhoek on 1 January 2023 totalled 116,094. This is 722 more than in 2022. Over the 2007-2023 period, the number of households in the Achterhoek increased by 8.4%. By comparison, in the Netherlands the number of households increased by 15.0 % over that measured period. In previous years, we saw that the population decreased by 0.2 % over the same period. More households and fewer inhabitants indicates a decrease in average household size.

Comparing the average household size in the Achterhoek with the Dutch average, the household dilution in the Achterhoek is faster than nationally. In 2007, a household in the Achterhoek consisted of an average of 2.48 people. Sixteen years later, it is down to 2.28 people. Nationally, the average household size developed from 2.27 to 2.15 persons during the same period.

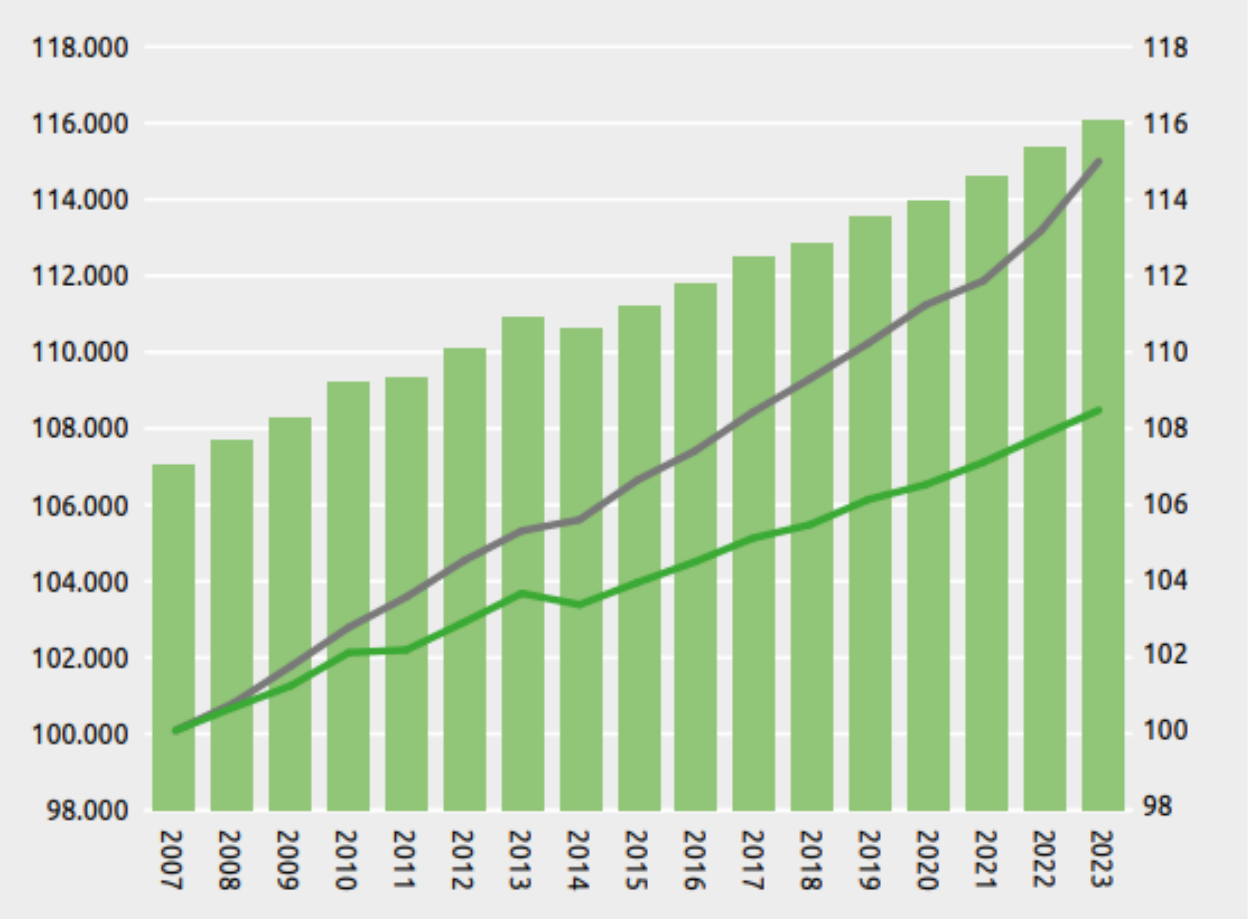

Figure 10: Development of the number of households region Achterhoek and the Netherlands 2007-2023. Left axis in absolute numbers and in the right axis the index 2007=100. Green bars are the developments in the Achterhoek region. Green line is the index region Achterhoek and grey line is the index Netherlands. (Source: CBS, 2023).

4.2. Development of average household size region Achterhoek and the Netherlands 2007-2023

The share of single-person households in the Achterhoek region has increased sharply, with a percentage of 26.7% in 2007 to 32.3% in 2023. As such, residents in the Achterhoek are increasingly living alone. When we look nationally at the Netherlands for the share of one-person households, it is higher than in the Achterhoek, but growing less rapidly over the period 2007-2023: from 35.3 % to 39.5 %. The conclusion is that Achterhoekers are increasingly living alone.

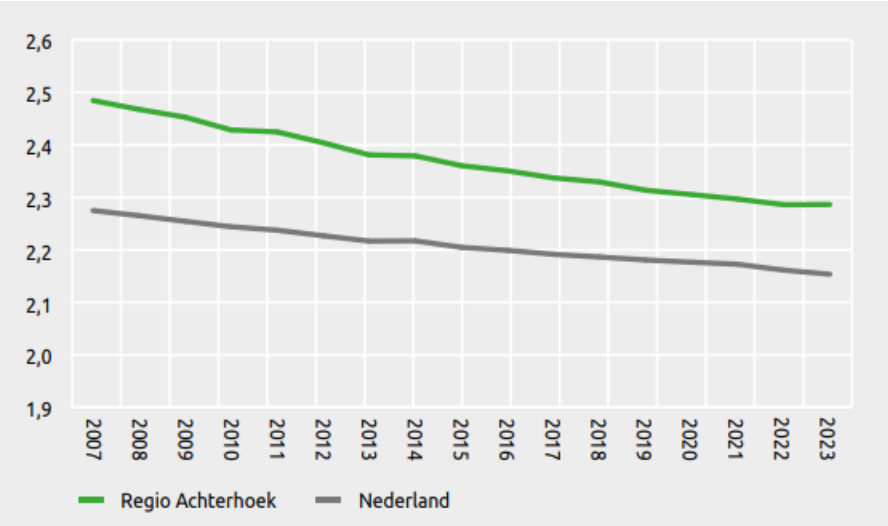

Figure 11: Development of average household size region Achterhoek and the Netherlands 2007-2023. Green line is the Achterhoek region. Grey line is the Netherlands. (Source: CBS, 2023).

Given the aforementioned development about more single living, it is justified to say that in the coming years, more people will be living alone. This is mainly due to a significant part of ongoing individualisation and to ageing (CBS, 2022). More people will live alone for shorter or longer periods, before starting a relationship, after a divorce, or after the death of their partner (CBS, 2022). The share of single-person households thus increased but decreased over the aforementioned measured period with the share of the household type couples with children. The shares of the other household types remained almost constant over the 2007-2023 period.

5. Living

There is a correlation between population and household development and housing market[2] developments. Below is a picture of the functioning of the regional housing market based on various developments on the demand and supply side of the housing market. This forms an important indicator of the region's attractiveness.

5.1. Households by compositions

The number of residents settling in the region in 2023 was high relative to 2021. On balance, more people settled than left. Since 2021, a proportionally high number of houses in the Achterhoek are occupied by settlers from outside the region. The largest increase, by comparison is in the municipality of Arnhem: 250 more people from Arnhem in the Achterhoek than left for Arnhem. There are also more people from Enschede and Montferland coming to the Achterhoek than leaving for these municipalities. More distant areas are not in the top five municipalities of where many people settle (Woon en vastgoedmonitor 2023). Households settling from outside the region in 2022 form a mixed group, see figure below. Those settling are continuing in the region.

[2] This paragraph is based on the recently updated Achterhoek Housing and Property Monitor (2023). The Housing and Property Monitor can be accessed directly from the Achterhoek Monitor dashboard environment, via the 'In-depth themes' entry, containing even more detailed information and data.

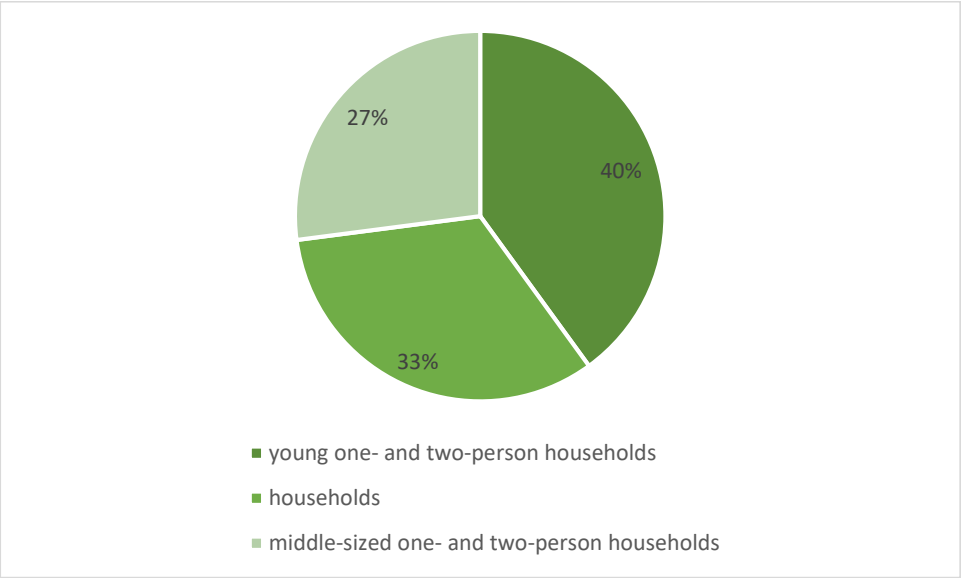

Figure 12: Households in 2022 based on compositions (source: Housing and Property Monitor 2023, edit 2024 Jan Veuger).

The picture is that opportunities to work from home have had a positive impact on this development since the COVID19 period from 2020. Senior citizens also settled in the region, especially those aged 60 to 75: 12% of those settling in the region (Housing and Property Monitor 2023).

5.2. Housing stock development

After years of policy in which no dwellings were added, housing is being boosted again. Gross 715 dwellings were added to the stock by 2022.

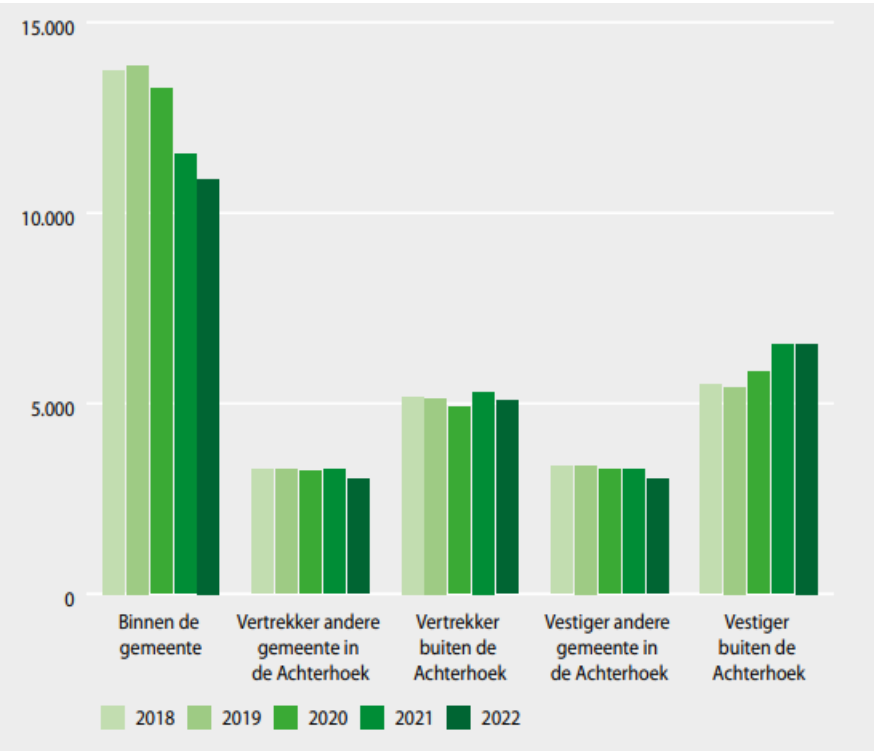

Figure 13: In-movers, settlers and leavers regioa Achterhoek 2018-2022 (source: Woon- en vastgoedmonitor 2023). Bars from light green to thunder green are from left to right consecutive 2018, 2019, 2020, 2021 and 2022).

Dutch	*Translation*
Binnen de gemeente	*Within the municipality*
Vertrekker andere gemeente in de Achterhoek	*Departing other municipality in the Achterhoek*
Vertrekker buiten de achterhoek	*Departure outside the Achterhoek*
Vestiger andere gemeente in de Achterhoek	*Settler other municipality in the Achterhoek*
Vestiger buiten de Achterhoek	*Settler outside the Achterhoek*

Table 2: Explanatory notes on Dutch text in figure 13.

Most homes were added in the municipalities of Doetinchem (193) and Oost Gelre (177). In the Woondeal period (2022 - 2030), according to the agreements, 7,675 more homes must be added to the total stock which means an average of 959 per year. This sets a hefty ambition for realisation. The critical question that can be asked is whether this is realistic and whether the targets can be achieved.

In 2022, 314 affordable housing units were realized in the Achterhoek region. This is 44% of the total realized housing and had a relatively heavy emphasis on the expensive segment. It should be noted that in the first year of the implementation of the regional housing agenda, it was mainly plans that had been in the development phase for some time that came to fruition. Making plans and actually realizing them has a long development period and can cause the final realization of housing to fluctuate greatly. To this end, the Netherlands' Environment Act (Central government, 2024[3]) is influential in making processes simpler and faster.

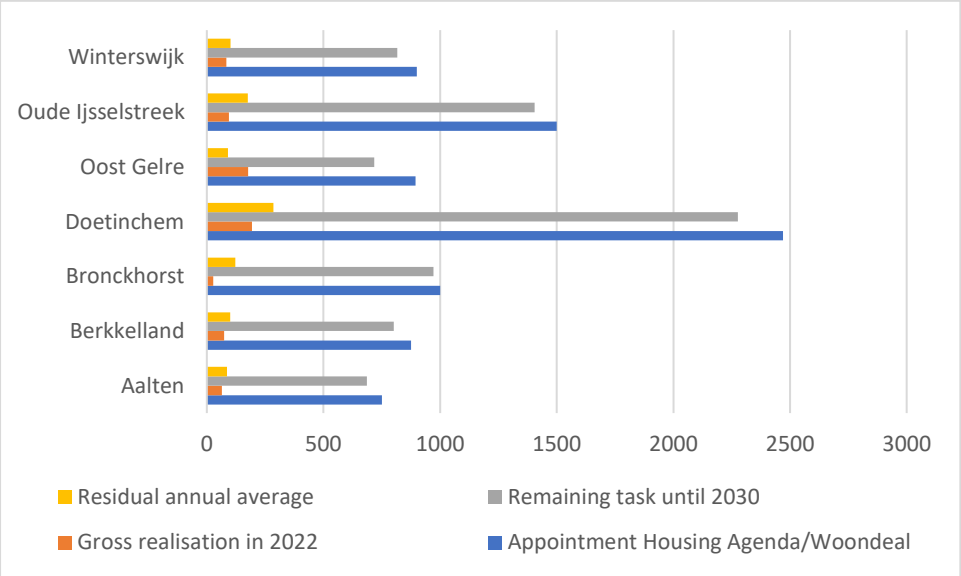

Figure 14: Realisation of dwellings in the municipalities involved in relation to the agreements on the Achterhoek 2022 housing agenda/deal region (source: Woon- en vastgoedmonitor de Achterhoek 2023, edit 2024 Jan Veuger).

[3] The Environment Act is a Dutch law that aims to radically simplify the system of legislation for the development and management of the living environment, by combining dozens of laws and hundreds of regulations into one new law.

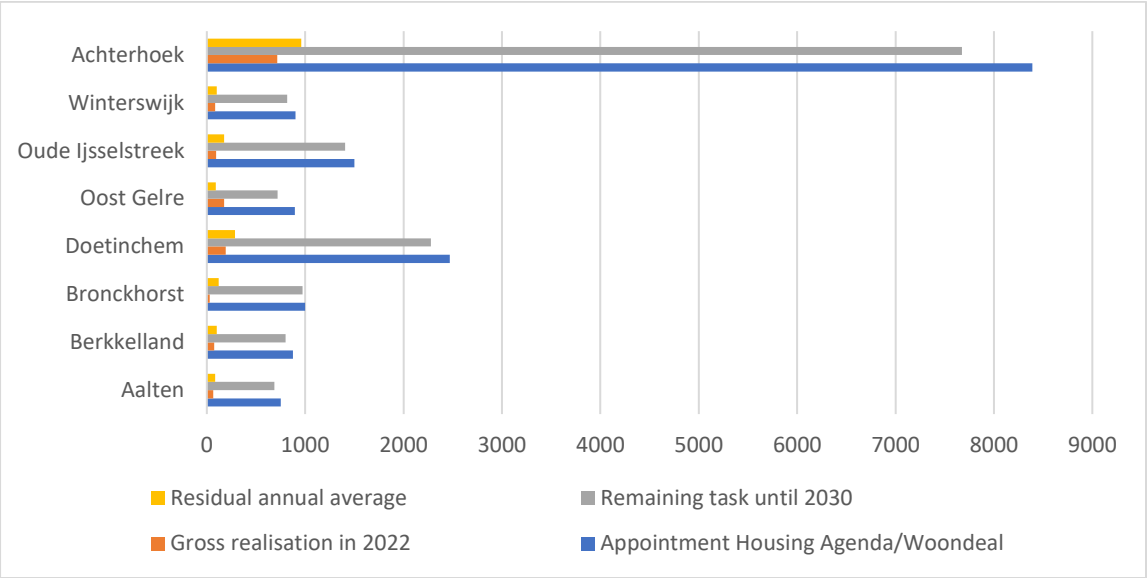

Figure 15: Realization of dwellings in the municipalities involved compared to the Achterhoek in total in relation to the agreements on the Achterhoek 2022 housing agenda/deal region (source: Woon- en vastgoedmonitor de Achterhoek 2023, edit 2024 Jan Veuger).

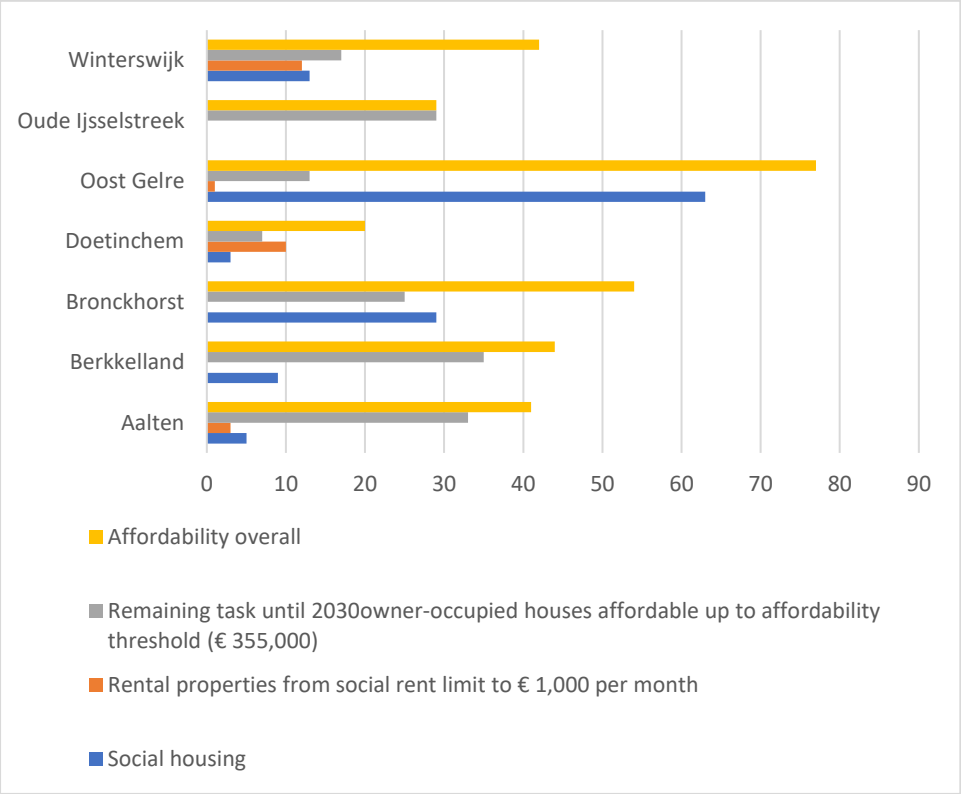

Figure16: Realised homes in % by affordability per municipality Achterhoek region 2022 (source: Woon- en vastgoedmonitor de Achterhoek 2023, edit 2024 Jan Veuger).

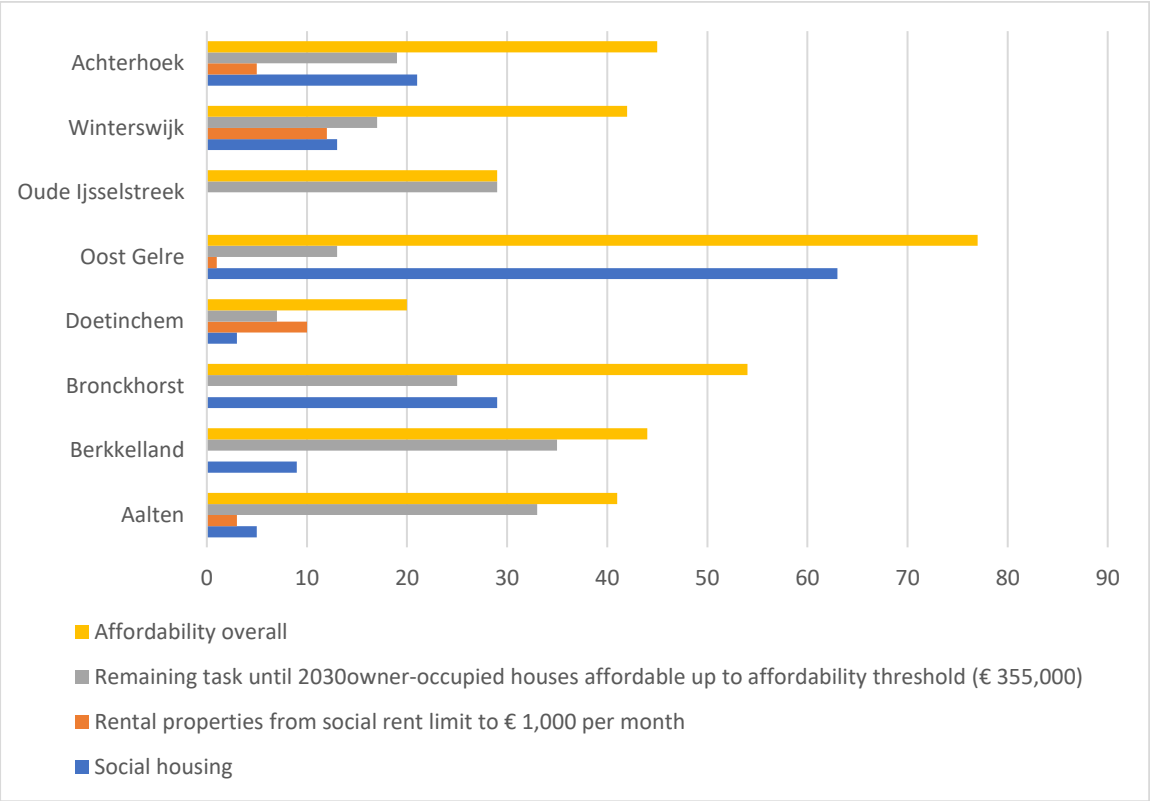

Figure 17: Realised homes in % by affordability per municipality region Achterhoek 2022 compared to the Achterhoek (source: Woon- en vastgoedmonitor de Achterhoek 2023, edit 2024 Jan Veuger).

Of the realised homes, 21% were social rented homes and 5% were rental homes in the middle segment[4]. 134 affordable owner-occupied houses were added, 19% of the total realised. In conclusion, housing stock development is still slow and the emphasis is mainly on the more expensive segment.

5.3. Number of choices of potential home buyers by municipality

Pressure on the owner-occupied housing market in the Achterhoek region is high (see Figure 18). Buyers have little choice. There was some relaxation in the second half of 2022. This relaxation did not continue in the first half of 2023. The number of houses from which a potential home buyer in the Achterhoek can choose was the same in the second quarter of 2023 as in the fourth quarter of 2022, at 2.7. In the second quarter of 2022, it was 2.2 thus showing a slight improvement. A guideline for healthy market pressure is a choice of 6-7 dwellings (Housing and Property Monitor 2023-2024). So there is still a (very) high market pressure in the owner-occupied sector (Housing and Property Monitor 2023-2024).

[4] Houses in the middle rent have a monthly rent between €763.47 (liberalisation limit 2022) and a maximum of €950. Homes with a rent below the liberalisation limit belong to the social or regulated rental sector

Figure 18: Number of choices of potential home buyers per municipality in the Achterhoek region (source: Housing and Property Monitor 2023-2024, Q2 2023).

In the municipality of Doetinchem, buyers could choose between 2.0 houses on average here. Pressure also remained high in Berkelland (2.4), Oost Gelre (2.4) and Winterswijk (2.4). In Bronckhorst (4.2), Oude IJsselstreek (3.7) and Aalten (3.3), there was slightly more choice for potential house buyers. With the above, it can be seen that demand pressure in the owner-occupied sector is still high.

5.4. Number of lettings in the social rented sector by housing type

The number of lettings by the housing associations was lower in 2022 than in the previous year and continued to fall in the first half of 2023. Incidentally, the mutation rate has been at a low level for some time. This is mainly caused by stagnating throughput in the housing association stock. As a result, few homes become available for households in need of social housing. For single-family dwellings in particular, the mutation rate has been very low for some time, but even for flats, the mutation rate fell again in the first half of 2023 (Housing and Property Monitor 2023).

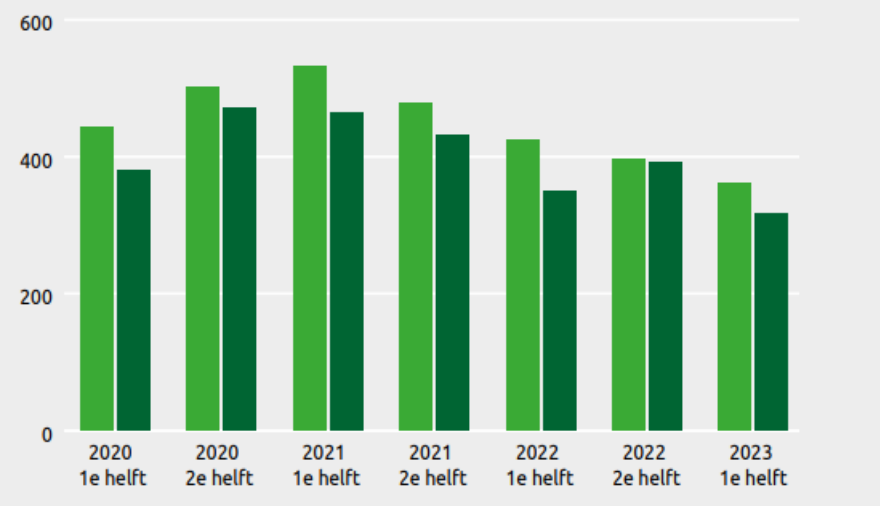

Figure 19: Number of lettings in the social rental sector by housing type Achterhoek region 1st half 2020 - 1st half 2023. Light green bars are single-family houses; dark green bars flats (source: Achterhoek housing and real estate monitor 2023-2024).

In the rental price segment between the quality discount threshold (€ 452) and the first capping threshold (€ 647), the average number of reactions to offered houses appears to be considerably higher than in the other price segments (Woon- en vastgoedmonitor Achterhoek 2023-2024). In this price segment, there was an average of 283 responses to a house on offer in the first half of 2023.

Of the social rental homes that became vacant in the first half of 2023, 5% were allocated to households with a declaration of urgency in 19% through direct mediation. This meant that about a quarter (24 %) of the vacant houses were allocated with priority (Achterhoek Housing and Property Monitor 2023-2024). In conclusion, the flow in the social rental sector continues to stagnate.

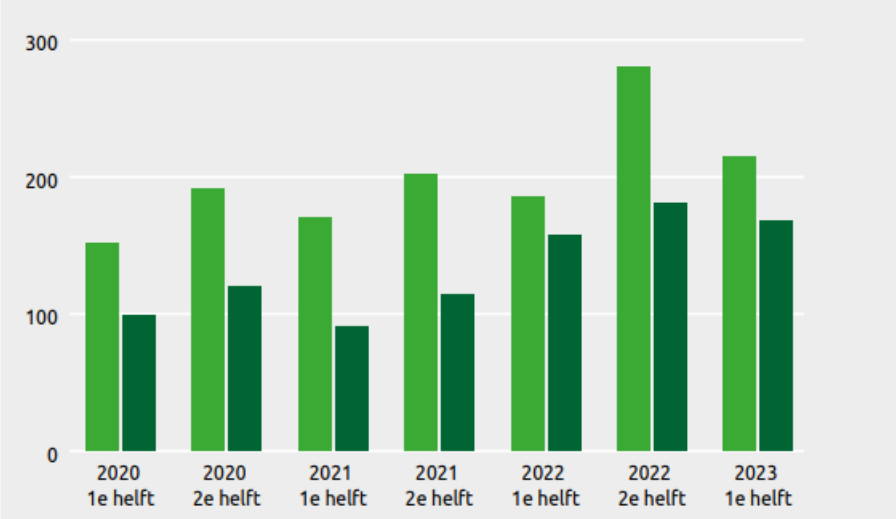

Figure 20: Average number of responses in the social rental sector by housing form Achterhoek region 1st half 2020 - 1st half 2023. Light green bars are single-family houses; dark green bars flats (source: Achterhoek housing and real estate monitor 2023-2024).

6. Conclusions

Based on the preceding analyses, the following conclusions can be drawn.

1. Population growth in the Achterhoek is accelerating.
2. Population numbers are stable over a period of almost 20 years. A measured period over 19 years shows a more complete and accurate picture than over measured periods of 3 or 5 years. This allows better longer-term steering rather than annual small fluctuations.
3. Domestic migration is growing steadily and that the refugee influx is driving the foreign migration surplus.
4. Population growth is present across the region.
5. The Achterhoek population is ageing and de-greening, changing the composition of the population and thus affecting the regional housing and labour market.
6. A population decline is expected in the long term.
7. More households and fewer inhabitants indicates a decrease in average household size. Comparing the average household size in the Achterhoek with the Dutch average, household dilution in the Achterhoek is faster than nationally.
8. In the coming years, more and more people will be living alone. The share of single-person households has thus increased but decreased over the aforementioned measured period with the share of the household type couples with children.
9. Since 2021, a proportionally high number of dwellings in the Achterhoek are occupied by settlers from outside the region.
10. Housing stock development is still slow and the emphasis is mainly on the more expensive segment. Demand pressure in the owner-occupied sector is still high.
11. Flow-through in the social rental sector continues to stagnate.

For the reports examined and the corresponding data, sources could not always be precisely indicated or were not mentioned at all while many (partial) conclusions are taken. In this article, that is exactly what was done and cross-checks in tables were checked, tables were recreated, corrected and properly included in this article. For future reports, this is a clear area for improvement because otherwise conclusions will take on a life of their own without a scientific foundation.

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Built Environment and Active mode of Travel: A perspective of bicycling in Trondheim

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Abstract:

Active modes of transport, particularly cycling is crucial for developing effective transportation system in cities. This purpose of this study is to examine how the built environment, especially the slope, influences cycling behavior in Trondheim, Norway. An open dataset obtained from Trondheim Bysykkel, a cycling solution in the city was analyzed to explore the influence of slope on the total number of cyclists and their travel behavior. A set of hypotheses was set up to understand the effects of slope of the cycling routes and the total number of cyclists that take the route. The findings reveal a clear preference for flatter and slightly inclined routes, with cyclist numbers significantly decreasing as slopes become steeper. A weak positive correlation between slope and travel time was identified, indicating that steeper slopes increase cycling effort and reduce travel efficiency. Hypothesis testing confirmed that slope type significantly affects cyclist numbers, with slight upslopes being preferred over flat routes. These findings underscore the significance of topography in the planning of bicycle infrastructure and imply that matching the preferences of cyclists can enhance urban mobility. The study has larger implications for city planners, and municipal mobility departments and helps decision-makers to design effective urban mobility solutions consistent with cycling as a mode choice for first and last-mile connectivity.

Keywords: Built Environment, Bicycling, Active Mobility, Slope

1. Introduction

Active travel generally refers to walking and cycling, and the use of other modes or forms of travel that are non-motorized requiring the physical input of the traveller to move from one place to another (Cook et al., 2022). Active mobility promotion and usage is the modern paradigm of sustainable and efficient mobility systems in cities. Micro-mobility and connected mobility systems, where walking, cycling, or other forms of transportation are developed in conjunction with public transport create the foundation for efficient transportation systems within cities. Intermodality and easy connectivity of one mode to the other is essential, and more so in cases of public transport and active mobility choices. The synergy of these modes plays an important role in the transportation system of cities (Kosmidis & Müller-Eie, 2024) and can solve the problems of last-mile connectivity. Moreover, the adoption of active mobility modes has major potential for reducing traffic congestion leading to lower greenhouse gases and carbon emissions ultimately contributing to a healthier built environment (Neves & Brand, 2019). As such, this promotion of active transportation also has a long-term positive implication for public health, the environment, and the economy (Gerike et al., 2019). Thus, cities around the world are trying to harness efficient mobility in cities via the adoption and promotion of active mobility (Gerike et al., 2019).

Bicycling is a preferred mode for solving first and last-mile issues of connectivity and improves accessibility (Zuo et al., 2020), as compared to walking and other forms of active modes of transport. Various studies performed on the adoption of bicycling as a mode choice relate adoption to factors related to socio-demographic characteristics, and modal attributes (Rodríguez & Joo, 2004) as well as land use and built environment (Kosmidis & Müller-Eie, 2024). In general, the local physical environment dictates the travel time, cost, and attractiveness of adopting a bicycle as a preferred mode for a journey (Rodríguez & Joo, 2004). Parkin et al. (2008), developed and tested a model with different infrastructure and socioeconomic variables across huge census data sets for England and were able to highlight that hilliness or slope of the route choice had significant influence on the level of cycling than other physical environment variables. Increased probability of bicycle as a mode choice was found associated with less hilliness by various studies (Broach et al., 2012; Byon et al., 2010; Chen et al., 2018; Winters et al., 2010).

Within this scenario, like other local-level authorities in Norway, Trondheim municipality also has invested heavily in cycling infrastructure and associated promotion of connected intermodal transport (Miljøpakken, 2024). Trondheim has adopted an urban growth agreement, where the municipality is funded by the state government if a "Zero-growth goal", referring to zero growth in car traffic target is reached. This has enabled Trondheim to adopt policies and frameworks that are consistent with the adoption of active modes of transport (Bardal et al., 2020; Tønnesen et al., 2019). Historically, as well Trondheim was a city with the first cycle lift for collective transport, to overcome steeper slopes within the city to help bicycles to overcome steep slopes (Matias & Virtudes, 2020). However, despite huge investments very little research has been undertaken to understand the implications of built environments particularly slopes in the local context of Trondheim. Hence, Understanding the influence of hilliness on the level of cycling by people can generate a pro-biking transport policy and act as a facilitator to promote the adoption of cycling and harness the potential benefits (Afshari et al., 2023).

To study this phenomenon a set of hypotheses was set up:

Null Hypothesis (H0): The slope of the cycling routes affects the number of cyclists Alternative Hypothesis (H1): The increase or decrease in slope of the cycling routes does not affect the number of cyclists

To understand the hypothesis better, the slope of the cycling routes means the elevation difference between the starting and ending points of the journey made by the cyclist divided by the total distance between them. For this, studies were identified that performed several permutations of elevation change, and slopes and categorized the best-performing slopes to be 2-4%,4-6%, and 6+% in a hierarchical manner (Broach et al.,

2012). A slope stress criteria was developed by (Furth et al., 2023), where they analysed the accessibility conditions of cycling in conjunction with slope. A steepness level comfort grade was developed with break points of 3.5%, 5%,6.5%, 8% and 9.5% being used. For this study, we would be grouping the number of cyclists according to the framework developed by Furth et al. (2023), adopted to the particular data of this study.

A statistical analysis was conducted as a methodology to understand the hypothesis, which in detail, has been presented in section 2 of this study. The datasets for the study were open data generated through the Trondheim Bysykkle, a cycling solution in Trondheim, which is presented in later sections of this paper. Analysis and results have been presented in section 3, followed by specific discussions and implications.

2. Methods

The dataset used in this analysis is data generated by Trondheim Bysykkel, which is the city bike system launched in 2018 by a collaborative effort of municipality, county, and road administration. The bikes have physical stations in different locations around the city and a ride can be made using their digital application. Every ride made is recorded digitally and updated daily on the website as open data. As it snows, and cycling as a mode choice is less adopted during the winter, the services remain closed and this year opened on 21 March 2024, so the April dataset was the complete monthly data used in this study. This study analyses the data from April 2024 which consists of 21997 observations. The data consists of Latitude and longitude data for the Start and End Stations, the duration of the Cycling, and the start and end times of the journey. The dataset consists of data from 63 stations placed all over the city.

R 4.3.3 was used for the statistical analysis. The elevation data was retrieved by converting the latitude and longitude data from the initial data from spatial package "*sf*", which were analysed using "*elevatr*" package dataset for elevation. The dataset was in the WGS84 coordinate system, so basic trigonometry was used to calculate the distances between the start and the end points. Slope was calculated by simply dividing the elevation difference between the stations by the distance between them.

3. Analysis and Results

Before analysing the data, data cleaning process was done to in several steps. Firstly, the dataset was checked for the false readings which may have been possible due to travellers just opening the app and using just the app for trial purposes which would be highlighted by the total duration of the journey being less than a minute, no such data were present. The dataset consisted of all the trips having a duration more than 60 seconds. Then to remove the extreme values for distance and duration, the outliers in these variables were identified using the Inter Quartile range method where extreme values before Q1/Q3(+/-)1.25IQR and subsequently were discarded from the data set. This yielded in 18248 observations, which is the used as a final dataset for further analysis.

3.1 Preliminary Analysis of Data

The data indicates that the average cycling trips in Trondheim lasts about 9 minutes, which are relatively short and typical for urban cycling. Longer trips of more than 1 hours represent the usage of cycle for recreational and leisure trips. The data indicates that 50% of the trips last between around 5 to 11 minutes, which are short urban trips between two to four stations, as shown in Table 1 and Figure 1 through histogram, which highlights the right skewed distribution of the duration of cycling in Trondheim.

Table 1 Description of Data

Description	Mean	Median	Min	Max	Q1	Q3	SD
Duration (sec)	521.66	463	62	1427	320	668	269.08
Distance (m)	1331.51	1219.2	58.21	3363.56	822.03	1760.32	657.73
	-1.05	0		56	-8	8	14.60

Elevation	-73 **Difference (m)**						
Slope (%)	-0.08	0	-8.1	11	-0.72	0.6	1.3

On average, the trips made in Trondheim are comprised of a little descent, many trips start and end at the same elevation. An important factor that shall be noted here is the elevation profile calculated is done through the process of assuming a straight-line difference between the stations, meaning, the calculation is based on difference of elevation from start station to the end station, ignoring ascents and descents in the middle of the journey. The trips made have an elevation difference ranging from -73m to 56m, referring some trips made have a highest descent of 73m but none of the trips made the journey the other way around, or to ascent the same route with 73m elevation gain. The distribution of the elevation is normal distribution with more trips occurring for negative elevation difference or decent as shown on histogram in Figure 1, a slight left skewed. The data for slope suggests most routes chosen for cycling have a very gentle slope, again explaining the favourable conditions for cycling in the city. The low Standard Deviation (SD) implies routes adopted have significant subtle slopes, like explanation provided by elevation difference. A maximum of 11% slope represents a steeper uphill for cyclists.

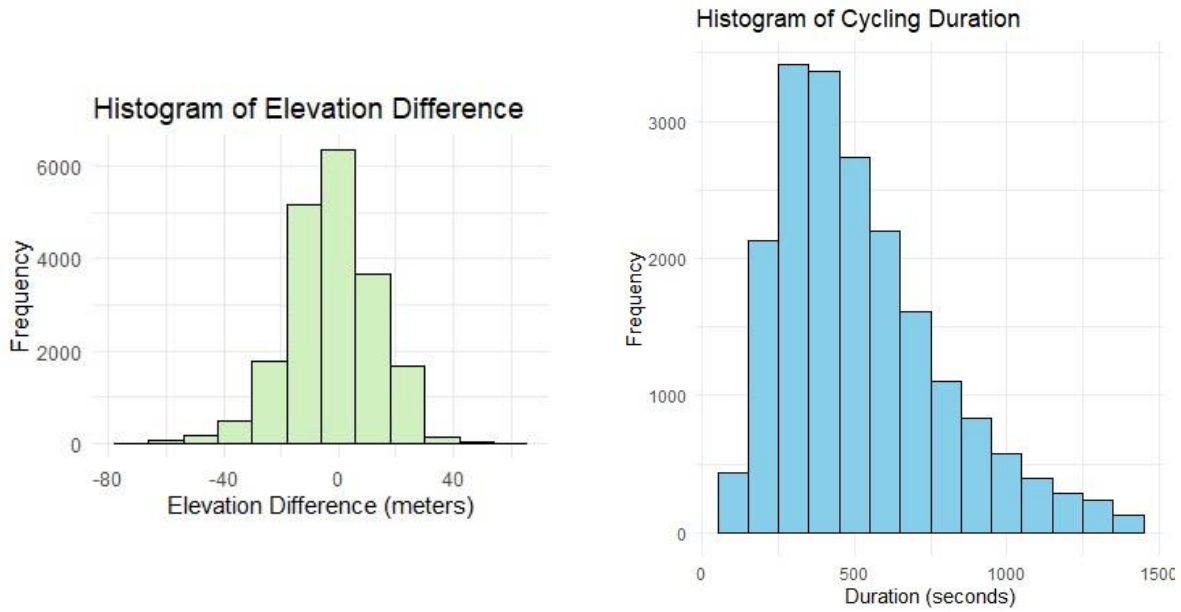

Figure 1 Histograms of Cycling Duration and Elevation Difference

3.2 Descriptive Analysis

A new dataset was generated for further analysis where route wise number of cyclists were calculated based on the start station and end station ids. Out of a total of 3696 routes from 63 different stations, 2719 routes were present in the dataset. Other variables like duration were averaged over the dataset for the particular route. Further, a slope group was defined where slopes from -0.5 to 0.5 were regarded as "Flat", Other categories like 0.5-3.5 were regarded as "slightly upslope", 3.5-5 as "moderate upslope", 5-8 as "steep upslope" and greater than 8 as "very steep upslope". A similar operation was performed for downslopes as well. A very popular route had 69 cyclists travelling from Skansen to St. Olavs gate which is considered as a flat slope in classification. Slope group flat had the highest number of observations, followed by slight down slope and slight up slope. Similarly, for distance travelled across the slopes (slope vs cycling distance), highlighted observations are higher for lower slopes than higher slopes. The significant drop in the number of trips made was evident to be reduced for both the upslope and downslope by around 3% (+/-) as evident.

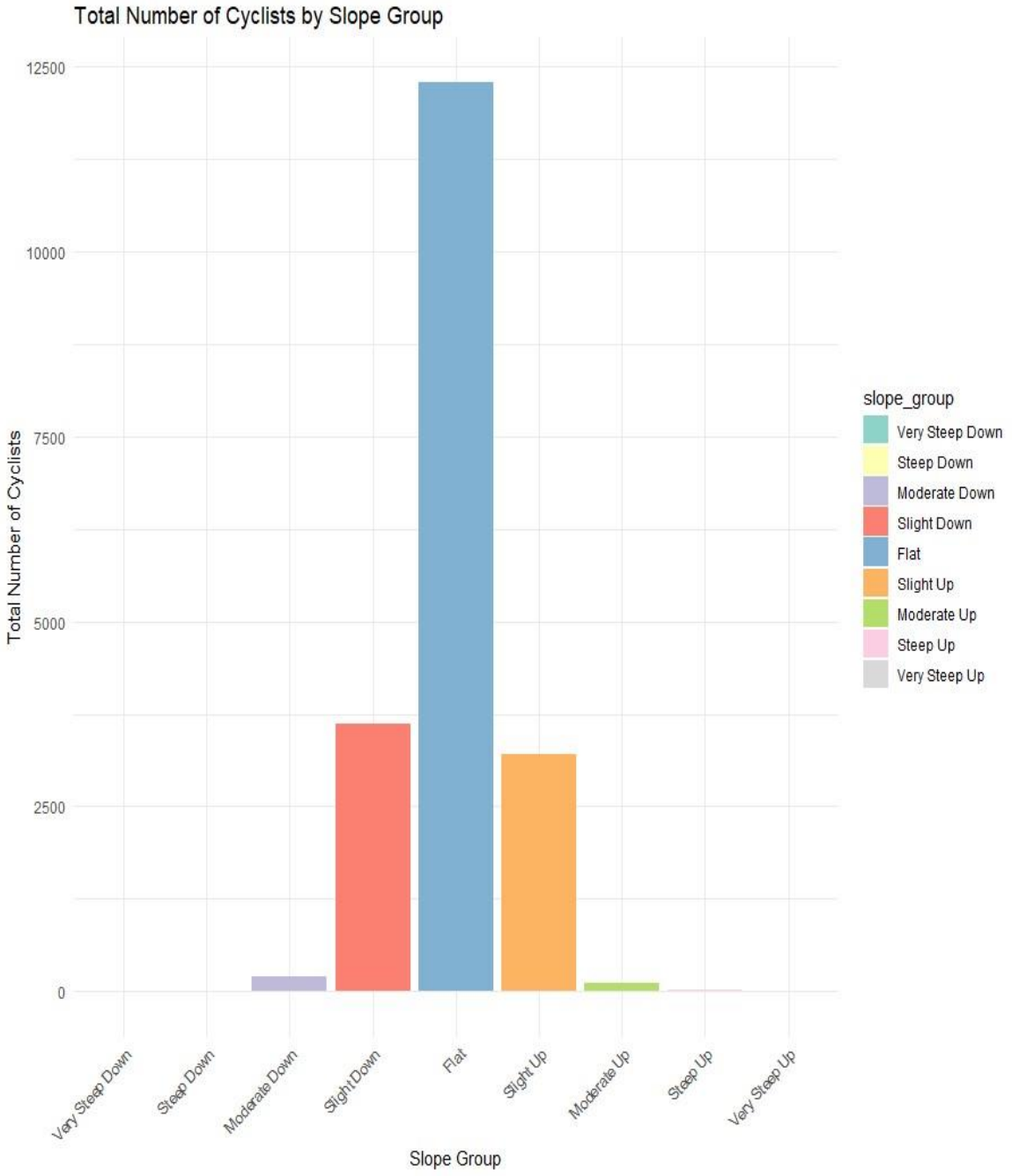

Figure 2 Bar diagram for the number of cyclists by the slope group

A correlational analysis was performed for analysing the effects of slope on the time taken by the cyclists to attain the same distance. The analysis was able to indicate a weak positive correlation (0.26) between these variables. This highlighted that effort for cycling and the travel time for covering the similar distance with increased slope would increase or in other words the cycling speed decreased. A similar analysis by Hood et al. (2011), showed for every average increase in upslope by 1%, is equivalent to the road length increase of 300m as compared to in general road conditions. Hence, this demonstrated that increasing slope increases the travel time and reduces the effectiveness of distance travelled.

3.3 Hypothesis Testing

A box plot was made for the number of cyclists for different routes by slope group, the box plot in Figure 3 highlights a median cyclist count of 5 to 10 with many observations extending beyond IQR for flat and slight up groups. Similar observation from Figure 2, fewer observations of cyclists can be seen as the slope

approaches extreme values, representing lower median values and reduced variability, with lower cyclist turnout. In summary, it is seen that cyclist numbers tend to be higher on flatter and slightly inclined slopes and drop significantly as the slope becomes steeper as seen on Figure 2. But it must be noted that the median values for the number of cyclists remain closer to one another.

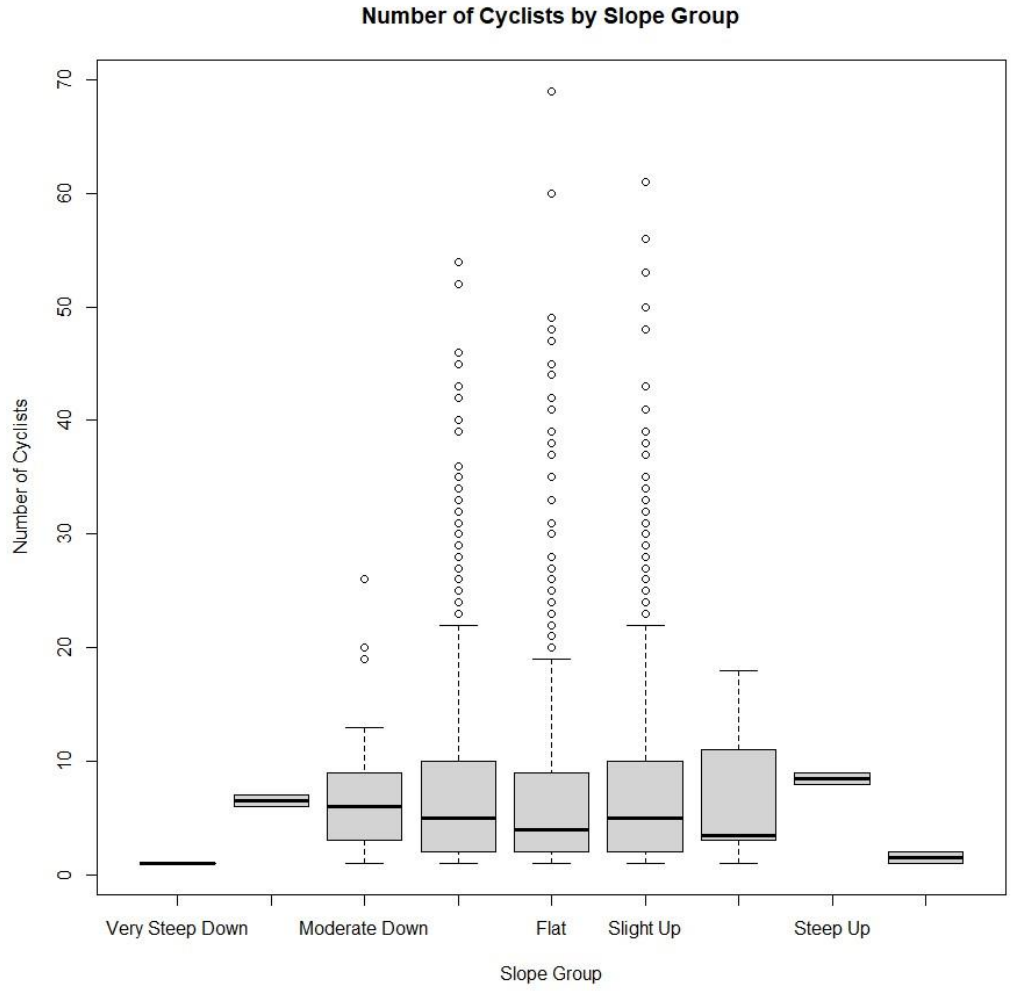

Figure 3 Box plot for the number of cyclists by the slope group

A regression analysis was performed with all the slope groups as dummy variables, the results for which are demonstrated in Table 2.

Table 2 Regression analysis (Linear model for Slope group vs Number of Cyclists)

Predictor	Estimate	Std.Error	t-Value	Pr(>|t|)	Significance
Intercept	6.52872	0.23243	28.089	<2e-16	***
Slight Upslope	1.36361	0.38518	3.540	0.000407	***
Slight Downslope	0.98749	0.36576	2.700	0.006980	**

Residual standard error: 7.998 on 2710 degrees of freedom
Multiple R-squared: 0.006039, Adjusted R-squared: 0.003104

Additionally, a one-way ANOVA test was performed to compare number of cyclists across the different levels of slope groups.

Table 3 Regression analysis (Linear model for Slope group vs Number of Cyclists)

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)	Significance
slope group	8	1053	131.64	2.058	0.0366	*
Residuals	2710	173340	63.96			

The results suggest that the model as a whole is statistically significant, but the effect size is small. Adjusted R-squared suggests that only a small portion of the variability in cyclist numbers is explained by the slope groups. However, analysing the significant portion of the analysis, (Other results that were found not significant are not included in Table 2, the study was able to observe an intercept of 6.53 which represents the average number of cyclists in the flat category, which is the baseline category for this analysis. Slight up and slight down slopes have a significant positive impact on the number of cyclist variables, indicating the assumption flatter slopes (-0,5% - 0,5%) have a higher number of cyclists that can be discarded. In overall summary ANOVA test suggests that the type of slope has a significant effect on the number of cyclists. Regression test highlighted that Slight Upslope and Slight Downslope have significant positive effects on the number of cyclists compared to the reference group (Flat), and further performed Post-hoc Turkey Test highlighted Slight Upslope and Flat was found significant, highlighting that Slight Upslope is preferred over Flat.

5. Discussion and Conclusion

This study presents an insightful study on how slope, as an attribute of the built environment influences cycling behaviour in Trondheim. The data obtained from Trondheim Bysykkel was used to explore the hypothesis that: The slope of the cycling routes affects the number of cyclists. Descriptive analysis and a regression analysis was performed in conjunction to ANOVA analysis to test the set of hypotheses.

The key highlights from the dataset revealed that the average cycling trip lasts about 9 minutes, with the most trips occurring in relatively flat terrain. The elevation differences between the start and end stations of all the journeys were found to be normally distributed, with a higher number of observations and preference for routes with gentle descents. A clustering of data points or trips made, also with higher distance travelled are seen near the zero-slope mark, which indicates that observations were from flat terrain. Similarly, the clustering can be seen diminishing in the graph after 2% (+/-), which can be seen to be consistent with previous studies performed by (Broach et al. (2012) and Furth et al. (2023). A correlation analysis between positive slope difference and travel time showed a weak positive correlation (0.26) which suggested steeper slopes increases cycling time and reduces travel efficiency.

Further route-wise analysis of data was done, where a clustered dataset consisting of the same start and end stations and the number of cyclists was extracted. The study tested the hypothesis that the slope of cycling routes affects the number of cyclists. The regression analysis suggests that there are some statistically significant differences in the number of cyclists across different slope groups as indicated by p-values in Table 2, but the overall model explains very little about the variation in the number of cyclists as shown by adjusted R squared. The regression analysis further indicated that both slight upslopes and downslopes positively impact the number of cyclists compared to flat routes. Further analysis suggest that slope type significantly influences cyclist numbers, with slight upslopes being preferred over flat routes.

However, the analysis done can be further explored with weather data, socio-demographic characteristics, infrastructure availability and other factors that are important to predict the cycling behaviour, which would increase model efficiency and provide better description of variation in the data of the number of cyclists. Moreover, this analysis considered two stations to be a straight line and the elevation difference to be linear,

using Google maps APIs and other possible solutions to find the exact route data with the number of ascents and descents in between the station would make the analysis better. Nonetheless, this study provides valuable information into roles of built environment on cycling behaviour and strategies for enhancing urban mobility and its essential role in solving the last-mile connectivity problem, whereby making it possible for people to harness the potential of active mobility.

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The Illusion and Reality of Trans-disciplinary Planning Regulation in a Democratic Society

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Abstract

The paper deals with necessary adaptation of spatial planning practices, that are made invalid by populist and un-democratic practices. These lead to loss of democratic control over spatial development decisions and shift decision-making outside the scope of responsible elected bodies. Several themes will be briefly presented in the paper, such as: transparency and efficiency of spatial policies, verifiable spatial data and IT support, use of technical contents in regulatory documents, execution of spatial regulation on the practical level. In conclusion the significance and illusion of design-based solutions in the prevalent western value system is discussed.

Key words:

Aarhus Convention, Directive 2005/36/EC, Directive 2006/123/EC, European Convention on Human Rights - 1st Protocol, Knowledge based decision-making, Spatial data,

Content

1. Introduction – the practice of spatial planning
2. Democratic control and legitimisation of planning decisions
2.1 Inventory of planning criteria for ensuring the public benefit
2.2 Evaluation of planning proposals in view of the public interest
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3. Significance of design-based solutions
3.1 The Services Directive
3.2 Recognition of professional qualifications Directive
4. Conclusion – The illusion of design in the planning context
5. Sources and literature

Driven by desire, the infatuated Zeus, took on the form of a beautiful white bull to approach the maiden Europa. When he got Europa's attention, he whisked her away on his back, all the way to Crete. Although blinded by passion that only the utmost beauty can inspire, in his wisdom he nevertheless took the form of a powerful, beautiful white bull to approach the beautiful, curious maiden. He had done this before, the master of deception, the Lord of the heavens. The act, even by a deity, surely can be termed profane or lustful.
Since the ancient times the story of Europa has been told as a warning against the dangers of succumbing to temptation and the dangers of being too trusting.

1. Introduction – The practice of spatial planning

In the ancient story, beauty is the celestial temptress, either inherently or as trickery. By our actions and with respect to the values that Europe and the European Union represent, spatial planners surely follow the banner of beauty, but it is worthless without conjunction to wisdom, stemming from knowledge, and strength in verifiable procedures of our democratic decision-making bodies.

Spatial planning is traditionally considered a public service devised for performance of common goals concerning spatial development and management, as well as accelerating or enabling commercial activities concerning spatial uses. It generally takes onboard societal values, whereby these are often conditioned by political circumstances.

Besides the mostly physical aspect of spatial planning, the latter implies an adopted legal basis for performing acceptable actions in space. As any legal framework, whether adopted by parliamentary procedure in elected democratic bodies or in the contractual sense, when it comes to private investment bodies, the legal setup and adoption of plans follow specified procedure.

The purpose of spatial planning is to codify possible actions in the physical reality that deal with development. They also inherently include the safeguarding of generally accepted and acknowledged societal and spatial values. Furthermore, they provide a legal framework, mainly about rights and responsibilities in the enjoyment, efficiency, and use of one's property, whether in the sense of gaining or maintaining its value or for compensation for loss of value, when this is the consequence of recognised public interest.

Such understanding of spatial planning stems from provisions of Protocol No. 1 to the European Convention on Human Rights (ECHR). As stated in paragraph 1 **"Every natural or legal person is entitled to the peaceful enjoyment of his possessions". The 'possession' can also be a property, and the 'peaceful enjoyment'** includes the right of access to the property.

In paragraph 2 of the Protocol specific alleviation is stated: "States may **control the use of property in accordance with the general interest or to secure the payment of taxes or other contributions or penalties**". Deprivation of the right, stated in paragraph 1 is permissible if it is lawful, in the public interest, in accordance with the general principles of international law, and is reasonably proportionate ("fair balance" test).

Figure 1: Lajtner, Martina (2008): Contemporary spatial planning. In: Stanič, 2008.

2. Democratic control and legitimization of planning decisions

Legitimization of spatial planning conditions is part of a planning task. Not only delivered by the planning consultant but also the administrative body in the local, regional, or national authority. Documents are generally prepared according to established procedure and adopted by democratic procedure in representative bodies – the municipal or regional council or Parliament after evaluation of initiatives for development.

Therefore, by definition, the planning document is a political document with technical elements, intended for spatial development and management, and has definite consequences on the possibilities for developing or using property which are foremost in the public interest.
The procedure, which relies on professional knowledge of all professions involved in spatial planning, has three integrative parts. The first two are mostly technical and inherent to spatial planning proper, which condition the third, which is political. They are:

– inventory of planning criteria for ensuring the public benefit,
– evaluation of planning proposals in view of the public interest,
– decision making in the public interest.

2.1 Inventory of planning criteria for ensuring the public benefit

To ensure the public benefit in any planning initiative, an inventory of available and necessary knowledge must be produced. The inventory provides a basis for considering planning initiatives that can condition various actions. Such an action is preservation/ safeguarding of recognized qualities of a place. Another is regeneration of areas with obsolete functions, social strife, dilapidated buildings, and infrastructure etc., by introducing new functions and intensified development. The opening of new development areas on former virgin land (green fields) is the most demanding, whereby a completely new function should be introduced to fulfil an otherwise unachievable strategic goal which is seen as a public interest.

In the checklist for spatial planners (2002) whose main objective is to prepare legally binding documents, needed for achieving sustainable development, environmental aspects of sustainable development, such as water, air, soil etc. are discussed, but also the necessary steps that should be taken to enable performance or achievement of the objective.

An inventory of necessary knowledge includes the following elements:

A) Environment: common values which ensure biological/ physiological existence, including and with respect to carrying capacity.
B) Technical infrastructure - *including costs*:
- Spatial quality: extant space is seen as an added value, as well as public access to recognised values,
- Land use: various land uses demand various specific locational qualities,
- Traffic (road, railroad, maritime, air): whereby environmentally more acceptable modes have the advantage (public transport, cycling, walking),
- Public infrastructure systems and objects: provision of energy (electricity, natural gas, heating, cooling), provision of drinking water and management and treatment of refuse water, as well as management and treatment of waste. Emphasis is on diminishing use of energy and emissions of glasshouse gases.

C) Social legitimacy: possible and probable social consequences of development, i.e. in general, whether the developments will cause satisfaction or dissatisfaction amongst the affected inhabitants, i.e. can cause deprivation, and whether the developments will affect improvement or the opposite of the living environment?
D) Economic viability: containing estimates of benefits for the national/ regional/local economy, economic lifecycle of the development, cost of operation and maintenance.

2.2 Evaluation of planning proposals in view of the public interest

Before the acceptance of a planning initiative requiring legal procedure and the adoption of a planning document or act, a process of evaluation must be performed. Evaluation should take onboard elements from the inventory and in this phase restrain from politically conditioned criteria. In view of achieving public benefit or meeting a public interest, the evaluation procedure should contain at least the following considerations:
- strategic evaluation of initiatives in view of environmental burdens,
- evaluation of initiatives in view of burdens on social infrastructure,
- assessment of implementation possibilities in view of physical circumstances,
- assessment of co-locational effects of the planned development on the value of neighbouring properties,
- estimate of necessary public funding for the initiation of the initiative (improvements of the public infrastructure, such as roads, district heating etc.),
- assessment of increase in property value because of the new planning condition and calculation of gain in property value – added value,
- assessment of decrease of property value because of the new planning condition and calculation of damage, i.e. indemnity,
- estimate of legal effects such as protection of present property rights and fulfilment of responsibilities.

2.3 Decision making in the public interest

States have a wide discretion over what is 'in the public interest', as mentioned in Protocol 1 to the ECHR. Provided a legitimate aim is pursued, for example, environmental remediation or social equity, it is acceptable that some people gain, and others lose. The **'fair balance test'** applied by the European Court of Human Rights is less stringent than the test of 'necessary in a democratic society' found in ECHR Articles 8 to 11. It however requires the legislative body to show it has met a fair balance between the person's right and the public interest. That will not be achieved if the subject must bear an excessive burden, or where there are none or few procedural avenues to challenge the deprivation.

Decision making in spatial planning should follow several principles, such as:
- transparency of planning procedures,
- efficiency of spatial policies,
- use of verifiable spatial data and IT support,
- use of technical contents in regulatory documents.

Transparency of planning procedures are of key importance in the adoption of planning decisions, especially where the initiative has consequences on the environment or can cause deprivation, i.e. negative changes to living conditions, negative effects of the environment (pollution, such as noise or dust particles, loss of natural lighting), etc. The latter implies parallel actions to alleviate the consequences of a planning decision, which is adopted in the public interest. Any initiative which doesn't include possible procedural avenues for appeals or possible indemnities for the planned deprivation cannot be termed as 'fair balance'.

Spatial policies should be efficient and the results measurable. Efficiency is a category related to time of delivery and acceptable spending of public funds. The gain can be merely financial, i.e. increase in property value of the neighbouring properties or improvement of a public infrastructure, meaning lower maintenance costs or improved performance. The gain can be a resulting diminishment of social inequity or actual resolution of social and economic strife. The measure doesn't necessarily have to be seen as financial gain, yet if public funds are necessary for a spatial policy to meet fruition, control of the public expenditure must be made possible.

Use of verifiable spatial data and IT support in post-industrial times is a contemporary condition of modern life. Spatial data which doesn't interfere with development decisions but is a general information about the character and qualities of a place must be available to all, i.e. the authority, developers, and local population. Especially spatial data, which is gathered in public registers, should be publicly available. With IT support the data can be processed and analysed. Verifiable solutions, that are prepared from such data, can support knowledge-based decision making. Furthermore, a public can exercise control over the proposed solutions and taken decisions, since the same data is available to all.

Spatial planning documents contain technical contents. Regulatory documents contain measures, described in general categories, such as permissible floor space index, land cover, regulations on curtilage, access to public thoroughfares (roads), share of unpaved land on a building plot, necessary planting of trees, etc. If a regulation factor doesn't relate to the carrying capacity of a place or the available technical infrastructure, the cost of improvement cannot be in the public benefit, unless specific provisions are provided in the sense of public-private partnerships of cost sharing.

Implementation of spatial regulation on the practical level can imply possible infringement on material rights of the owners of neighbouring properties. Possible effects of planning decisions can be anticipated, and necessary measures adopted beforehand. As such they can be included in planning documents before their adoption.

Setting the balance in the political phase of a planning decision process cannot go very wrong if it is knowledge-based and the decisions taken rely on argumentation from the available knowledge (inventory), new knowledge, developed for the purpose of the initiative, and the planning proposal is prepared after in-depth evaluation.

3. Significance of design-based solutions

Physical planning can be considered a service. Yet it is not necessarily a service performed on the market but is mostly a public service conducted in planning bodies in local, regional, or national authorities.

3.1 The Services Directive

According to Directive 2006/123/EC it is clearly stated that the Directive applies only to requirements which affect the access to, or the exercise of, a service activity. Therefore, it does not apply to requirements, such as road traffic rules, rules concerning the development or use of land, town and country planning, building standards as well as administrative penalties imposed for non-compliance with such rules which do not specifically regulate or specifically affect the service activity but have to be respected by providers in the course of carrying out their economic activity in the same way as by individuals acting in their private capacity (preamble 9). Furthermore, the Directive is consistent with and does not affect Directive 2005/36/EC of the European Parliament and of the Council of 7 September 2005 on the recognition of professional qualifications. It deals with questions other than those relating to professional qualifications. (Preamble 31)

As mentioned earlier planning and the preparation of regulatory documents relate to public interest. The Directive takes onboard the "public interest" moreover in 'overriding reasons relating to the public interest'. These have been dealt with in the Courts of Justice and amongst other have dealt with the protection of the environment and the urban environment, including town and country planning (Preamble 40).

With reference to the nature of physical planning which is a service performed in the public interest and is usually completed according to specified procedure with the adoption of a legal document, which in a democratic society includes involvement of the public, it is necessary for providers and recipients of services to have easy access to certain types of information. The obligation on Member States is to ensure that relevant information is made easily accessible to providers and recipients and that it can be accessed by the public without obstacles that could be fulfilled by making this information accessible through a website. Any information given should be provided in a clear and unambiguous manner. (Preamble 50)

In the context of physical planning this obligation closely relates to provisions of the Aarhus Convention, meaning that the service cannot be understood as a business secret, but information about the service must be publicly available. Unlike the service of architectural design, that can be seen as an intimate contractual relation between the customer and the service provider, the planning service must be publicly accessible, transparent and the procedure must be monitored.

Design is nevertheless an integral part of the physical planning process. Yet, many tasks must be performed before a commission for a design project is posted. Design is not the only service, as was explained earlier. Physical planning goes beyond the scope of execution of a design service and takes onboard various other necessary knowledge that must be obtained or developed before or parallel to the design solution.

The Directive implies connections to regulated services, meaning services that can be performed only with a special license, as specified in article 4, paragraph 11: ' regulated profession' means a professional activity or a group of professional activities as referred to in Article 3(1)(a) of Directive 2005/36/EC.

Furthermore, the Directive implies necessary activities that must be performed for execution of complex services. This is noted in article 25 – multidisciplinary activities, paragraph 1:
"Member States shall ensure that providers are not made subject to requirements which oblige them to exercise a given specific activity exclusively or which restrict the exercise jointly or in partnership of different activities. However, the following providers may be made subject to such requirements:
the regulated professions, in so far as is justified to guarantee compliance with the rules governing professional ethics and conduct, which vary according to the specific nature of each profession, and is necessary to ensure their independence and impartiality;
providers of certification, accreditation, technical monitoring, test, or trial services, in so far as is justified to ensure their independence and impartiality.

3.2 Recognition of professional qualifications Directive

The knowledge and skills, necessary for performance of the design service, which is a licensed or regulated profession and relates to the individual performer of the service, in this case relating to architecture and/or architectural design, are (Directive 2005/36/EC), art. 46):

- ability to create architectural designs that satisfy both aesthetic and technical requirements,
- adequate knowledge of the history and theories of architecture and the related arts, technologies, and human sciences,
- knowledge of the fine arts as an influence on the quality of architectural design,
- adequate knowledge of urban design, planning and the skills involved in the planning process,
- understanding of the relationship between people and buildings, and between buildings and their environment, and of the need to relate buildings and the spaces between them to human needs and scale,
- understanding of the profession of architecture and the role of the architect in society in preparing briefs that take account of social factors,
- understanding of the methods of investigation and preparation of the brief for a design project,
- understanding of the structural design, constructional and engineering problems associated with building design,
- adequate knowledge of physical problems and technologies and of the function of buildings to provide them with internal conditions of comfort and protection against the climate,
- the necessary design skills to meet building users' requirements within the constraints imposed by cost factors and building regulations.
- adequate knowledge of the industries, organisations, regulations, and procedures involved in translating design concepts into buildings and integrating plans into overall planning.

Performance of the spatial planning service goes beyond the described set of skills, needed to perform the architectural and/or design service, albeit planning and the skills involved in the planning process are mentioned. The necessary skills mostly refer to buildings as such, i.e. the necessary knowledge needed to design a building.

Yet, in spatial planning architecture is not the only academic discipline needed to perform the service. For example, spatial planning and landscape architecture which closely relate to the above-mentioned necessary skills are not specified in he Directive, although they are taught in academic institutions, degrees for the successful completion of studies are granted and services, stemming from the academic profile, are performed on the market, in public bodies or the authorities.

Many other skills and knowledge are necessary to provide a consistent and qualified planning service. These are available in engineering professions but also in the social sciences, economy, and law. Moreover, considering the public consequence of the service, generic and local skills of all people involved, i.e. citizen science, who will benefit or be deprived by a planning initiative, should be considered as worthy knowledge.

4. Conclusion – The illusion of design in the planning context

The architectural or design service as part of the physical planning process, often begins with a drawing at the beginning of the procedure, more as an illustration of the physical aspects of a vision or strategic goal to be met. It ends with a drawing of the physical object when the architectural plans for execution of the building are delivered. In between the process of planning or the procedure occurs, as has been briefly described, which in its entirety in most countries is not necessarily a regulated service, requiring a licence.

In the words of Luciano Laurana (XV. Century), the author of the famous painting ‘The ideal city’, “The daily practise of architectural creation is in imagining a building or city that will be built in the future and in visualising the image in perspective drawings”.

Is a design-based solution only a marketing tool to obtain a commission?
Is it an illusion or an act of wilful deception?

The design as such, albeit an important content of any plan with a physical consequence, is a part and not the only component of the physical planning process or the leading service, needed to achieve a public interest.

Figure 2: Lajtner, Martina (2008): Planning for the future. In: Stanič, 2008.

The planning process amongst other requires technical verification, obtainment of concordances from various regulating bodies, public companies, traffic governance bodies, heritage safeguarding agencies etc. It must undergo public hearings, meaning involvement of the public that must be informed about any planning initiative. It ends with a legal document, adopted by specified procedure in an elected representative body. The design as a licensed service occurs later.

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Sustainable management of settlements and nature-based solutions

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Abstract

The article deals with necessary adaptations to the delivery of sustainable development, which must stem from a knowledge-based planning process, but moreover from knowledge about a space, it's carrying capacity and natural environment. Focus is on actions by the governing body that takes into consideration elements of the environment, whereby the proposed solutions are nature-based and not solely technologically driven. Rather, the technological solution should be devised from knowledge about a space. The delivery of sustainable, nature-based solutions on the practical level is discussed.

Keywords:

Sustainable Development, Sustainable Spatial Management, Nature-Based Solutions

Buying fresh strawberries, when in season, at the local food market, is a grand way to prove ones' commitment to a changed life pattern. Even better is to grow your own in your garden or on your balcony. The garden or balcony have to be provide by planning and/or design.

1 Introduction – Sustainable Development Paradigm and Governance

Sustainable development is an approach to growth and human development that aims to meet the needs of the present without compromising the ability of future generations to meet their own needs. The aim is to have a society where living conditions and resources meet human needs without undermining planetary integrity. (UN, 2023)

Sustainable development aims to meet and balance ecological, economic, and social aspects of settlement development. In this regard spatial planning should be seen as the vehicle for delivering sustainability, as a concept for the future existence of animal and plant life on the planet, including humanity. This requires society to design activities to meet human needs while preserving the natural life support systems of the planet and the resilience of its infrastructure and global social order. Natural catastrophes, that have been occurring worldwide during the last decade with increasing intensity, reinforce the global strategic goal to plan our space with more respect for natural characteristics. Furthermore, technological readjustments to meet the present dangers and threats must be developed and past technical solutions that have been proven inadequate abandoned.

Sustainable spatial management is the process of achieving the goals of spatial development in daily practise, meaning the organisational framework of a society to meet the set strategic goals and the delivery of modern sustainable development solutions. This is coupled with provision of funding for obtainment and production of new knowledge and technological advancement.

2 Steps to achieve sustainable management of settlements

2.1 Visions and policies

A spatial planning vision relates to goal, policy, recognised deficiency of service, whether related to utilities, transport or required standard of delivery or any other structure, needed to fulfil the demands/requirements/desires of a given society. It can also relate to the old term “public pride”, prestige on the global, national, or regional level, economic precondition to take a particular economy forward or to maintain its position and vitality. It can also be a political statement, backed by ideology. (Stanič, 2024)

The vision encourages the formation of a self-image of the city, which shows what the city means to the inhabitants and what the real expectations are about its future. A positive image of the city, which derives mainly from its history, cultural traditions, and spatial specificities, therefore has a great influence on life in the city and is also a strong factor for its economic and social development. It helps to discover strengths and new development opportunities and is especially important in making fundamental strategic decisions that change the city.

A vision is achieved by following pertaining goals, elaborated as strategic goals. These are embodied in strategic documents, where strategic goals are set to be elaborated further in implementation phases all of which the spatial planning service provides, giving it a physical dimension.

The connection between vision, strategy and projects is a necessary condition for directing the long-term development of a city or region. The vision defines the main comparative advantages of a city or region and their absolute competitiveness in relation to other cities or regions. In relation to other cities and regions, the vision reveals the values by which they can stand out from their competitors. In relation to the residents, the vision seeks to create a shared awareness of the city and region as a historical beacon for achievement of strategic goals in the future.

A policy is adopted to give the advantage to the achievement of a specific strategic goal. The selection of a specific strategic goal as the primary goal however doesn’t mean that the other strategic goals can be

forgotten, or their achievement postponed indefinitely. Policies must be backed by budgeting, meaning the provision of funding, otherwise they are defunct.

2.2 Spatial planning

Spatial planning is a complex process of objectively and optimally formalising social and development goals in space that are above all in the public interest, with the aim of rational and effective operation. Spatial plans as a rule generally carry the spirit of the time and the current urban development paradigm. The spatial plan as such is also an aesthetic scheme, including engineering precision, which should also be sufficient for other purposes of public benefit, such as standards, which evolve with available or newly acquired knowledge.

Spatial plans are legally binding documents. In democratic societies planning legislature is adopted by responsible representative decision-making bodies, generally adopted by specified democratic procedure.

The necessary inclusion of technical features and measures is a translation of prevalent values in a society into the sphere of the physical or material. For example, a typical document of this type, i.e. a land use plan or spatial plan, of course doesn't cover all aspects of spatial uses and indeed shouldn't even attempt to bring aboard features that are contestable, conflicting, or temporary.

2.3 Confirmation of plans

A (strategic) spatial plan is a regulatory framework, which is a policy document with technical, economic, social, and legal content, that is adopted as an act in representative bodies through a democratic process. It contains a set of guidelines and operations concerning the tactics applied to meet a strategic goal (projects) and in the next phase independent projects, which are completed in the physical reality. The public interest in a democratic society, embodied in a formal development planning document is an elaborate and democratically validated scheme, which should take onboard the widest possible circle of interests, aiming to be universal, but also viable.

The public service in such a plan is the formulation of individual identifiable and tangible elements of such a scheme, as well as the passage to completion. This also implies, that the achievement of the scheme must be measurable through numerical and qualitative indicators, also with measurable responsibility and accountability criteria for the decision-making and implementation bodies.

2.4 Monitoring

Given the original societal character of the spatial plan, it is certainly more important to achieve proven and demonstrated overall social satisfaction. A completed project is a success, but in the spatial planning context it is not just the single achievement which counts. The more important question is whether a set strategic goal, stemming from the vision, and following the optimising and adoption procedure, that ensures viability and feasibility, has been achieved.

Monitoring relates to the achievement of strategic goals and execution of the plan. Here the key objective is the physical manifestation of a particular intervention – getting the project completed in the physical dimension. A product is a building, infrastructure, open space or whatever defines achievement of a strategic goal on the practical, material level. However, it is not only the material consequence that matters, although this can be easily established. Monitoring also closely relates to checks and balances, control over public expenditure for a given project or policy or meeting the budget of a commercial scheme.

3 Natural aspects of the sustainability of settlement management

If nature and the environment (natural and built) are seen as the mainstay of sustainable development, then the particularities forming the environment should be described first. Moreover, the specific nature of a region, city or even site, should be described by its' carrying capacity. In the term of anthropogenic nature, meaning our cities and towns, this also includes the traffic, utilities, and services infrastructure.

Most of the strategic goals mentioned in chapters 3.1–3.12, concerning natural aspects of sustainability, can be met simultaneously with well-planned developments (Table 1). In the last years nature-based solutions for planning and development of various urban utilities and services have been identified as the vehicle for providing less-damaging effects on the environment. They are also seen as the prime condition for providing the necessary infrastructure to maintain the settlement pattern, which should be increasingly more environment-friendly and resilient. (ECTP, 2002)

3.1 Nature and ecology

Safeguarding of nature and respect for ecology are resultants of various other undertaken measures since they are not strategic goals themselves. Presence and natural features of the environment are the mainstay of good environmental conditions and aesthetic values. Areas with specific and/or irreplaceable natural qualities should be excluded from development initiatives. Therefore, mechanisms and measures for safeguarding such areas must be included in planning policies and planning documents. Spatial planning has the capacity to deliver such safeguarding and can deliver increase in the number and size/area of such spaces. Of course, urbanisation cannot be prevented or stopped by simply excluding spaces from development. Doing nothing is however even worse than relying on obsolete solutions. Moreover, measures to prevent detrimental development patterns must be integrated in planning procedures.

The strategic spatial planning goals to be pursued by complex measures on the other themes from 3.2 till 3.12 are:

- safeguarding of complete ecosystems with uninterrupted flows and closed cycles,
- ensuring ecological cohesion, i.e. maintenance of large valuable areas, connected by corridors, also in relation to urban open spaces and open spaces in the countryside,
- provision of natural corridors for the permeability of natural areas for the passage of wildlife,
- respect for nature and ecology as the underlying value of any spatial plan or urban design, including selection of planting with native species.

3.2 Waters

Water is the basic element of any living creature on the planet. Most of life on planet Earth relies on water to exist. Water is therefore the prime existential condition. Not any water, sweet water. The importance of hydrological systems and the water cycle are well understood. Anthropomorphic spatial developments can disrupt these systems and cycles, not only concerning quantities but also qualities of water. Responsible spatial planning thus requires a broad understanding of hydrological aspects, i.e. how to plan with water? Clean water should be fostered and infiltration of wastewater or any other damaging element into the water shed prevented.

Past planning responses often didn't consider the diminishment or reduction of water qualities. Particular developments were mostly the results of political agendas. The drying out or flooding of areas, as was done in the past, are painful examples and warnings against developments that albeit facilitate the development of a specific project, but in the long run cause irreparable damage to the project as such but also the entire environment. For example, the changing of river courses to deliver a planned project, like the royal palace in Caserta, Italy (late 18th century). Another example is the exploitation of water resources to feed the needs of the city of Los Angeles, whereby the entire watershed of the Colorado River was depleted. A historical example is demise of the great Khmer kingdom and abandonment of Angkor Wat (14th century) because of climate changes. A human made disaster is the destruction and salination of the Aral Lake in Central Asia, which was purposely drained to irrigate the vast agricultural areas for growing cotton in Uzbekistan and Kazakhstan. Similarly, the damming of rivers to provide water reservoirs for hydroelectric power plants can also cause irreparable damage. In the latter case not only is the water course downstream compromised, but it also affects the ecological cycles within the water course itself, thus affecting the plant and animal life in the water, as well as life on the riverbanks. Political tension can also erupt if the river flows through several countries and the countries downstream are most adversely affected.

The same applies to cities, whereby the damming of rivers or culverting of water courses in the city inadvertently causes flooding or problems downstream, if done speculatively, for example to deliver a single service, without consideration of the entire system that it affects.

Sustainable water management, in cities seen as timely response to development issues, includes at least the following spatial planning strategic goals:

- uninterrupted systems of surface and underground water flows, whereby streams, rivers, lakes, and underground waters are seen as a comprehensive system, which shouldn't be interrupted; past engineering developments, which prevented the natural flow of water, should be regenerated/reversed wherever possible,
- enhancement of good water quality and maintenance of water quality everywhere, which implies strict protection of ground wells, ground water reserves and water courses; another aspect is urban agriculture and planting, whereby the selection of plant cultures and species of trees and greenery should follow the availability of ground water or its excess, as well as to introduce adequate planting to create natural water cleansing,
- natural infiltration in the largest possible areas, implies the diminishment of watertight paving, use of porous paving materials and understanding of the natural qualities of the ground for the management of storm water; another measure is diminishment of culverting of storm water, which can cause flooding downstream,
- surface waters as attractive elements in cities and landscapes, which are not only a visual experience, but also natural coolants of the air,
- containment of wastewater in differentiated and adequate sewers as well as the construction of adequate nature-based or industrial water treatment plants.
- promotion and implementation of nature-based solutions. (see chapter 3.13)

3.3 Air

Provision of clean air is a resultant of various other undertaken measures, since it is not a strategic goal itself. Air quality has been proven as an element of human well-being. Emissions are a threat to health. Spatial planning directly locates polluting activities and affects the quality of air and climate.
By appropriate planning of activities and traffic, as well as use of fuel for heating, energy production or waste matter treatment, reductions in measurable elements in the air, such as Co_2, No_x and dust particles, but also other emissions, even heat, can be reduced.

Air quality management which can be met by appropriate spatial planning, includes several strategic goals:

- reduction of air pollution, by promoting environmentally friendly means of transport and mobility (walking, cycling, public transport),
- use of less polluting fuels for heating and energy production,
- appropriate placement of potential pollutants downwind from sensitive functions,
- planting of trees and creation of green belts,
- Air cooling by planting of trees and creation of green roofs and facades to prevent heat islands.

3.4 Noise

Noise is a threat to health. Whether generated from traffic or production activities or even leisure activities and sports, noise affects the quality of the environment. Diminishment of noise in the environment can be achieved by reasonable placement of activities and integration of technical solutions in buildings (noise insulation). Enclosing of noisy linear infrastructure, such as roads and railroads, is another suitable measure. The latter applies to sensitive land uses, such as housing, education, medical services, and other residential uses. It also applies to sports grounds and playgrounds.

The strategic goals of spatial planning concerning noise are:
- planned land use, especially to prevent mixing of activities within an area or on its edges, operating at disturbing sound levels, especially in zones with sensitive activities,
- plan open and public spaces with consideration of present and planned noise levels.

3.5 Soil

Soil is a scarce commodity or asset and should be kept clean and unspoiled. Soil is the essential asset in agriculture, urban farming, and provision of clean green and open spaces in cities. However, soil is also the surface cover of land for development. Considering its scarcity, development should target redevelopment and regeneration of already built-up land, which has lost its economic and social, but also physical viability, meaning that built-up areas should also be the area of recycling. In this way use of agricultural land or forests for development can be avoided. Preservation of soil doesn't mean only reuse of built-up land. It also means minimisation of excavations and the reuse of removed soil nearby, if and wherever possible.

The spatial planning strategic goals concerning protection and safeguarding of soil imply:
- conservation of virgin land for agriculture, animal husbandry and forestry,
- preventing contamination and keeping the soil clean,
- minimal land take for urbanisation, promotion of re-use, regeneration and renewal of buildings and neighbourhoods,
- respect for geomorphological characteristics of the ground, which includes its seismic characteristics, resilience to ground movement (landslides), flooding and its load-bearing capacity (planning ground coverage and floor space indexes).

3.6 Transport and accessibility

Since the times of modernist functionalist ideas, mobility has been in the forefront of any development paradigm. Alongside dwelling, work and recreation, mobility was a prime theme. Mobility is essential, spatial development and spatial use inherently contain mobility. Mobility however isn't only a physical category, it is also a social category, meaning that a society that is democratic, social, and humane, will provide mobility for all social and demographic groups. (see also chapter 3.11)

Mobility that is based on the use of private cars, has proven itself unsustainable and detrimental for urban or spatial quality. Not only does it inefficiently cope with the demands for mobility that facilitate the urban function, but it also causes environmental burdens with congestion, fossil fuel consumption and various emissions, including noise.

The spatial planning strategic goals concerning sustainable mobility are:
- encourage placement of activities in compatible locations to prevent undesired or excessive trips,
- plan the roads according to the available space and not vice versa,
- shift from use of private cars to public transport on the regional level (daily commuting), and other slower modes (public transport, cycling, walking etc.) on the local level,
- provide park & ride facilities for cars and bicycles at major transfer points (railway stations and stops, bus stops)
- ensure good accessibility and freedom of movement for all social and demographic groups,
- relieve open paved or unpaved surfaces of streets and squares from parking and transform them into attractive public spaces for pedestrians and various urban uses,
- place the parking spaces underground,

3.7 Energy

Energy efficiency is one of the simplest and most cost-effective ways to combat climate change, improve the competitiveness of businesses and reduce costs for energy consumers. Before that, it is first necessary to identify and evaluate potentials, and secondly, it is necessary to find solutions and improvements from different angles. (Mušič, 2019)
Current energy consumption is leading to depletion of resources and pollution. Outdated techniques of energy production are wasteful and environmentally harmful. Siting, zoning, and mixing land uses can affect the use of energy leading to diminished energy needs. Even on the level of building design, energy use can be diminished by good planning and utilising natural or microclimatic conditions. Furthermore, the position of energy production plants for district heating or to produce electricity are determined in spatial plans.
The spatial planning strategic goals concerning energy are:

- organise settlements according to possibilities for passive insolation,
- increase energy production from alternative energy sources (geo-thermal, water, sea, solar, wind, etc.),
- minimise energy losses in buildings.

3.8 Waste

Selection of waste management technologies is a spatial planning theme since the facilities for treatment of waste can be environmentally burdening. Although landfills are not the best contemporary method of dealing with waste, these still carry the burden of household and even industrial waste.

The spatial planning strategic goals concerning waste are:

- minimisation of waste production,
- re-use and recycling – waste is considered a resource,
- management of waste to reduce environmental burdens, risks for ground water and human health in general.

3.9 Heritage and regeneration

Values generally accepted as contextual for a given place or society must be translated into physical terms and measurable to be applicable for regulatory purposes. They imply several basic principles that can also be seen as urban development policies:

- safeguarding of attained values by maintenance and renewal (preservation of place and identity, e.g. buildings as such, settlement heritage areas, characteristic urban patterns),
- improvements in the utility of a specific place (redefinition of use, image or level of services, redefinition of key spaces),
- complete changes to the physical appearance and programme of a given place (by regeneration, substitution, and renewal), also including production of completely new spaces (recycling and redevelopment or development from scratch).

When it comes to heritage and regeneration the planning decision is based on attitudes towards “place” as such, which is a complex relation to identity, spatial culture, prevalent values concerning the living environment, aesthetics, and societal collective memory.

In this context the term “robustness” must be addressed, which implies the capacity of a place or a building to take upon itself new meanings, functions, and uses. In terms of sustainability the regeneration or renewal of a building also means recycling of space and materials, thus diminishing the need for new, formerly unbuilt land for development, and the reuse of building materials. Even new developments must be designed to facilitate such future transition.

The spatial planning strategic goals concerning heritage and regeneration are:
- renovation of historical buildings and places as elements of identity and memory,
- re-use of existing buildings and urban structures, that have lost their economic rationale, by introducing new activities and functions,
- integration of existing, preserved extant elements into the urban fabric,
- safeguarding historical elements and structures as part of cultural heritage, including areas, neighbourhoods, and open spaces, that are not listed as monuments, but form the framework of intangible heritage in the sense of spatial identity.

3.10 Public spaces

A public space is a specific quality within the urban fabric, whether paved or unpaved, whether designed as a square, a park or a thoroughfare connecting individual open spaces or urban quarters. The term "public" implies general accessibility of the space to all users.

The spatial planning strategic goals concerning public spaces are:
- adequate regulation for plotting and replotting, thus ensuring sufficient space for public spaces,
- maintain extant paved surfaces and reuse of paving material (wherever possible) to maintain the identity and image of the place,
- compulsory provision of required open spaces in detailed plans, also by distinguishing between paved and unpaved surfaces,
- compulsory provisions about required planting of trees and other greenery in open spaces, as well as the standards for seedlings.

3.11 Social equality

Recently, in addition to the design themes of urban development, themes such as social justice and urban resilience have been increasingly at the forefront, which directly mean action towards increasing safety and reducing risks, both in physical and social space. In this sense, the understanding of the public benefit and the response through urban regulation is even clearer, since understanding the carrying capacity of space in the physical sense is an opportunity, a guide and/or an asymptote of planned spatial development.

Social justice is the rationale for promoting access to public goods, basic services, culture, economic opportunities and a healthy environment through fair and inclusive spatial planning and management of urban and rural spaces and natural resources. Such planning is aimed at achieving more equitable and socially sustainable communities with the full realization of human potential. Spatial planning has a special task in urban development, as it connects civil society, the public and private sectors, with the aim of achieving the set goals (Rocco, 2013), which also means that it is a depository of public information.

In settlements social inequality and social exclusion, which pertains to sex, age or ethnicity are unacceptable. The spatial planning strategic goals concerning social equality are:
- development of healthy, secure, and attractive environments, where people live, work, and stay,
- promote social cohesion and responsibility, also by empowerment of the people to take care of their neighbourhoods,
- provide easy access to services as 5' to 15' distances.

3.12 Risks

Managing risks and exploiting their potentials requires appropriate geological information and its integration into spatial planning. The latter is also associated with understanding the implications of professional evidence. Experience shows that spatial planning offers greater benefits or lower risks if the expert basis is included in the early stages of planning and in the dialogue with stakeholders. Natural conditions must be the basis of spatial planning, from which the vision of development is derived. An approach based on the belief that subsequent technical measures can manage risks that have not been considered in spatial planning is

irrational and leads to increased costs, which are often passed on to society. Professional bases and the regulations resulting from them must not be seen as a limitation to development, but as a basis for reducing the risks of investments and the conservation and sustainable use of natural resources.

Nature can be violent and detrimental for built-up space. Earthquakes cannot be prevented, but adequate planning responses to minimise damage, can be adopted. Landslides, flooding, and erosion become a hazard if spatial planning doesn't anticipate the possible risk of inappropriate land use planning. Extant spatial use can also be the source of risks, such as industrial hazards (chemical factories, fuel depos), transport facilities and installations, and traffic. The same applies to planned activities, whereby the ensuing risks can be anticipated beforehand and avoided. All risks and hazards can be anticipated by definition and appropriate responses to potential dangers must be adopted to avoid or at least diminish their consequences.

The spatial planning strategic goals concerning risks are:
- minimise potential risks, caused by nature by appropriate land use planning,
- provide a public data base on areas that are prone to landslides, flooding, seismic hazards, avalanches or are unstable.
- ensure buffer areas between traffic infrastructure,
- ensure buffer areas between residential and other sensitive areas and major industrial areas or areas with dangerous production processes,

3.13 Nature-based solutions and the interdependency of strategic goals

Strategic goals stemming from the natural environment can be achieved singularly, pertaining to a particular theme, but more efficiently if approached at the same time, i.e. by resolving two or more strategic goals simultaneously. In the themes, that deal with the physical reality directly and within a built-up environment require technological solutions, the strategic goals, stated in points 3.1 to 3.8 as well as 3.12 can be undertaken as nature-based solutions.

Table 1: Interdependency of strategic goals

Goals	1	2	3	4	5	6	7	8	9	10	11	12
2.1 Nature & ecology		x	x	x	x	x	x	x	x	x	x	x
2.2 Waters	x				x	x	x	x		x		x
2.3 Air	x					x	x	x				
2.4 Noise	x					x						
2.5 Soil	x	x				x	x	x				x
2.6 Transport	x	x	x	x	x		x		x	x	x	x
2.7 Energy	x	x	x		x	x			x			x
2.8 Waste	x	x	x		x							x
2.9 Heritage, regeneration	x					x	x			x	x	
2.10 Public space	x	x				x			x		x	
2.11 Equity	x					x			x	x		x
2.12 Risks	x	x			x	x	x	x			x	

The European Commission places such solutions within policies concerning green infrastructure (EC, 2021). This is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. The Natura 2000 network constitutes the backbone of the EU green infrastructure.

Green infrastructure planning is a successfully tested tool to provide environmental, economic, and social benefits through natural solutions. In many cases, it can reduce dependence on (redundant) 'grey'

infrastructure that can be damaging to the environment and biodiversity, and often more expensive to build and maintain.

The European Commission has developed a Green Infrastructure Strategy that aims at ensuring the protection, restoration, creation, and enhancement of green infrastructure. Thus, it becomes an integral part of spatial planning and territorial development whenever it offers a better alternative, or is complementary, to standard grey choices.

Any development that inherently affects the natural condition of surface water and underground water, including land movements, can be dealt with by a nature-based solution. Anticipation of a natural hazard can lead to a nature-based solution that is less invasive and less damaging for the natural condition if the natural condition is researched comprehensively.

Of course, such solutions are not possible anywhere, geological, and other conditions vary from place to place.

Nature-based solutions are the contemporary approach to handling development projects on the practical level. Many nature-based solutions have already been developed for various purposes. Any improvement or new construction can contain nature-based solutions, such as selection of paving to allow infiltration of storm water, construction of underground passages or bridges for wildlife as additional features of major roads and railroads or the building of natural retention pools and swamps for cleaning of refuse water.

Handling of storm water on roads and railroads is a prime example. The modern phrase for such infrastructure is “blue infrastructure”. It refers to urban infrastructure related to water management. Instead of building pipelines to carry the water directly to a river or lake, that can cause flooding downstream, the storm water is kept on the land itself, whereby the land acts as a sponge. After the calamity is over, the water is slowly drained over filters into a natural recipient, the river or lake. The surface of the infrastructure is paved with hard, yet porous material, so that the water can seep underground. Dry surface reservoirs – lagoons are provided nearby to facilitate excess storage of surface water in case of heavy rain. These are designed as landscaping features with a definite function. (more in Vovk, 2021, Klemen, 2020)

Planting of greenery and trees or shrubs in regulated surface water courses, i.e. storm drains or canals, has been undertaken to prevent erosion of the new riverbanks. Furthermore, the angle of the riverbanks has been planned to withstand their erosion in case of increased water volumes.

Planting of trees and greenery on flat roofs and on facades of buildings have been undertaken to prevent heat islands and improve the micro-climate in buildings, in the Northern hemisphere especially on South and West facing facades.

Bridges and underpasses for wildlife have been built on roads and railroads on identified migratory routes of large wildlife, such as bears, deers, badgers etc. Even the lowering of curbs on pavements to help hedgehogs cross streets is such a micro-intervention.

Any selected nature-based solution is of course site-specific, meaning that it generally cannot be decided upon in early planning stages, but on the site itself in the implementation phase. If the infrastructure is planned on privately owned land, implementation of the project requires public participation, since even such infrastructure must be maintained, and the responsibilities shared, since it benefits all.

4 Conclusion

Comparison of estimated values of a space, seen in their capacity to generate income or profit, cannot provide correct conclusions or provide beneficial solutions for general infrastructure that relates to the benefit of all or the well-being of all, i.e. it is in the public interest. Space is not a set of specific non-related elements but a system of integrated and interdependent elements. Space is not a commodity, it is a value (Vrhunc, 2021). It cannot be monetised.

The idea of sustainable spatial management that puts nature and the environment in the forefront for planning and the use of nature-based solutions imply improvements to elements of degraded nature and the built environment, all at the same time. Any development on one, affects all the elements of the system at various levels of improvement or depreciation. Implementation of nature-based and environmentally beneficial solutions can also mean the complex achievement of more strategic goals at the same time with single well-thought-out projects.

However, such actions require obtainment of new knowledge, also implying provision of funding for research and testing new solutions. Furthermore, the imperative of introducing execution of nature-based solutions must find its way into regulatory documents, meaning that ineffective known technologies and solutions are abandoned and replaced by environment-friendly, hopefully cost-efficient ones.

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Driving societal transformation through integrating innovation competencies in the university setup

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Abstract:

Addressing catastrophic climate change and biodiversity loss requires significant societal transformations, as highlighted by various frameworks and initiatives, including the IPCC, IPBES, European Green Deal, CEAP, and the New European Bauhaus. Universities play a pivotal role in this transformation by leveraging research outcomes to drive sustainable development and societal change. This study investigates how developing innovation competencies within universities can bridge the gap between research and practical societal transformation. Research Question: How can pilot programs in innovation competencies serve as a bridge between academic research and societal transformation?
Methodology: This article brings a comprehensive review of innovation processes, competencies, and transformation frameworks. It utilizes theories of innovation management, organizational behaviour, knowledge transfer, and organizational learning. The Triple Helix model and open innovation concepts are used to understand the interconnections between university, industry, and government in fostering innovation.
Results: The study examines pilot programs at the Faculty of Engineering, NTNU (2021-2023), which aimed to enhance innovation competencies among students and staff. These pilots adopted a bottom-up approach, addressing specific needs within various departments. Key initiatives included innovation seminars, interdisciplinary collaborations, dedicated workspaces, and targeted programs for PhD students.
Discussion: The pilots demonstrated the effectiveness of fostering innovation competencies at different academic levels. For bachelor and master students, activities such as innovation camps and industry collaborations significantly enhanced creativity and problem-solving skills. PhD students benefited from courses on business potential and innovation environments, while employees gained from infrastructure improvements and strategic collaboration initiatives.
Conclusion: Innovation competencies are crucial in bridging the gap between academic research and societal application. The NTNU pilot programs showcased the potential of a structured approach to developing these competencies, promoting a culture of innovation that drives societal transformation. Future recommendations include specialized courses in innovation thinking, advanced workshops, leadership programs, and interdisciplinary innovation labs to further embed innovation into the academic framework.

Keywords:
Innovation Competencies, Societal Transformation, University-Industry-Government Relations, Triple Helix Model, Open Innovation

Introduction

Societal transformations, social innovations and better transfer of knowledge from academia to industry are mentioned as highly necessary to avoid catastrophic climate change, social inequalities, poverty or biodiversity loss. They are called for in the IPCC and IPBES frameworks, as well as the European Green Deal, *EU Circular Economy Action Plan (CEAP)* and *New Industrial Strategy* as well as the *New European Bauhaus,*

New European Innovation Agenda roadmap and many other Europeans and global initiatives and strategies ((Díaz et al., 2015),(Commission, 2020),(European Commission (EC), 2021) (European Commission (EC), 2023). Scholars are trying to play their part in investigating effective actions that could be taken to achieve a sustainable societal transformation that is needed to attain the Sustainable Development Goals (SDGs). Societies, their institutions, and individuals need to address underlying drivers of unsustainability and the universities through their research results and success are offering a route to achieving sustainable development.(Price et al., 2021).

The transformational process can catalyse societal transformation (Calderini et al., 2023) by initiating and facilitating changes in policies, practices, economy, technology use and behaviours that ultimately reshape society as a whole and create the societal transformation needed. There is a growing recognition of the need to harness research findings, innovative capabilities and competencies to address complex societal issues. Through a mapping of relevant literature on innovation processes, innovation competencies, and use cases, this essay explores how universities and individuals can leverage innovation skills, such as creativity, problem-solving, attitude, and adaptability, to translate research insights into products, services and solutions that drive positive societal transformation. (Organisation for Economic Co-operation and Development (OECD), 2005) (Etzkowitz, H. and Leydesdorff, 2000)(Tidd, J., Bessant, J., & Pavitt, 2005). Drawing on theories of innovation management, organisational behaviour, knowledge transfer, and organisational learning, the essay examines the frameworks and mechanisms through which innovation competencies can effectively utilise research outputs to address societal challenges.

Research question: How can pilot programs in innovation competencies serve as a bridge between academic research and societal transformation?

This essay will explore the role of innovation competencies developed for the individuals in the university set-up, such as master students, PhD students and young researchers to shorten the gap between academic research and innovation as new solutions to societal transformation and change.

Background and Theory

Higher education institutions (HEI) are facing many challenges in education, research, and innovation. The HEI is affected by the changes and innovations that take place in societies and economies globally. It is widely held that HEI should adhere to these changes and models, and innovate accordingly (Barber et al., 2013).

The Triple Helix model proposed by (Etzkowitz, H. and Leydesdorff, 2000) highlights the interconnection and correlation of university-industry-government relations in fostering innovation and societal development. This model highlights the university's role not only in generating knowledge through research but also in facilitating its transfer and application in practical settings and society. Frank Geels's model talks about the dynamics of innovation processes and the exploitation of research for societal transformation. Geels' model emphasizes the importance of understanding the internal and external forces that shape the innovation landscape. In his view, those forces could create windows of opportunity for transformative change and innovations evolve within a complex socio-technical system influenced by various internal and external factors. (Geels, 2005). Sociotechnical transitions accelerate when various innovations are interconnected, enhancing each other's functionality and collectively contributing to the restructuring of systems (Geels et al., 2017). Geels' model suggests that innovations mature over time, moving through different phases of development, adoption, and diffusion within the socio-technical system. As innovations reach a critical threshold of acceptance and viability, they can trigger broader systemic changes, opening up windows of

opportunity for transformative innovation. These windows of opportunity represent moments when the existing system is destabilized, creating space for new ideas, practices, and technologies to emerge and gain traction(Geels et al., 2017). Thus the universities can position themselves to take advantage of the opportunities given by the pressure point that are creating windows of intervention and they could drive some of the societal transformations and changes. The competencies that are cultivated among students, researchers and university personnel could add a role that the university can take in the society's transformation. Moreover, the universities can leverage their infrastructure, network and partnerships to bridge the gap between theory and application and create new models for accelerating the transformation and transition into society.

In the context of the societal impact that innovation could have the open innovation concept, introduced by (Chesbrough, 2003), emphasizes the importance of leveraging external sources of knowledge and expertise to drive innovation and highlights the role of innovation processes and competencies. According to the model the universities can create a culture of open innovation, where collaboration and knowledge sharing across disciplinary are encouraged. Considering this, the idea of cultivating innovation competencies among students and young researchers will contribute to the open innovation concept which will increase the societal impact of innovation.

The link between the innovation process in an organisation and the competencies that exist in the organisation goes back to the theory and Damanpour's meta-analysis on organizational innovation (Damanpour, 1991) providing insights into the determinants and moderators of innovation within organizations. Innovation competencies, such as creativity, managerial attitude toward change, technical knowledge resources, administrative intensity, problem-solving, communication and adaptability, are identified as key factors influencing the success of innovation initiatives.

Moving from the innovation process more towards the innovation competencies and the influence that they have in the development of the universities as an organisation several theories have been developed by scholars each offering unique insights into how innovations emerge, develop, and diffuse within society. One of the oldest social science theories, the Diffusion of Innovations Theory (Rogers, 1971) explores how innovations spread through society over time, from early adopters to the mainstream population. Innovation competencies such as communication skills, persuasion, and networking, play a crucial role in the diffusion process by influencing the rate and extent of adoption. The result of this diffusion is that people, as part of a social system, adopt a new idea, behaviour, or product (Roger 1971). The theory has its limitations as does not foster the participatory approach and it is focused on behaviour change so, individuals with strong innovation competencies can serve as opinion leaders and change agents, facilitating the spread of new ideas and practices within their social networks. Building on this foundation, later theories such as Absorptive Capacity (Cohen, Wesley & Levinthal, 1990) focus on an organization's ability to acquire, assimilate, and apply external knowledge effectively. Innovation competencies such as learning agility, information processing, and knowledge integration are essential for building absorptive capacity and leveraging external sources of innovation. Individuals with strong innovation competencies can serve as knowledge brokers, translating external knowledge into actionable insights and driving organisational innovation. Similarly, the model of the technology adoption lifecycle (Moore, 1991) categorises individuals within a population based on their willingness to adopt new ideas, new models and new technologies, ranging from early adopters to laggards and the pressure of transformation often comes from the local areas. In the business sector, the dynamic capabilities model (Teece et al., 1997) represents an organisation's ability to adapt and reconfigure its resources and competencies in response to changing market conditions and technological disruptions. This model could be used in the university set-up in the new era of change and transformation in roles that universities should have in society.

Moving closer to the university set up in relation to industry and society, the innovation ecosystems theories emphasize the connection and interdependence of various actors, organizations, and institutions within an innovation ecosystem. Rather than focusing solely on individual companies or technologies, this approach considers the broader socio-economic context in which innovation occurs, including factors such as culture, institutions, and networks. Innovation competencies such as collaboration, ecosystem literacy, and systems thinking are essential for navigating and leveraging the dynamics of innovation ecosystems (Adner & Kapoor,

2010). In the process of integrating the innovation ecosystem, one methodology adopted is the lean startup methodology an approach to innovation that emphasizes rapid experimentation, iterative product development, and customer validation. This approach involves creating minimum viable products (MVPs), testing them with customers, and using feedback to iterate and refine the product (Ries, 2011).

The complexity of societal transformation processes and their unintended consequences make knowledge and learning essential (Turnhout, 2024). Rather than setting goals, selecting KPIs and assessment systems it is required flexible knowledge infrastructures for learning, adaptability and innovation. The challenges of implementing innovation are multifaceted. On the one hand, innovation is often seen as taking risks and unpredictable, making it difficult to find the key stakeholders interested in buying or engaging in the development. On the other hand, innovation can be difficult to manage and measure, making it challenging to scale and sustain innovation initiatives over time, especially for universities where the traditional role was in education and research. To address these challenges, organisations need a comprehensive framework for innovation to guide their efforts and ensure that innovation initiatives align with the overall organisation's strategy and objectives. Creating ideas and developing innovation competencies is only one aspect of innovation to creating a culture of innovation and implementing a structured approach to drive sustained growth and competitive advantage.

Research method and results

Case study: Innovation Pilots Program at Faculty of Engineering, NTNU 2021 - 2023
Use-cases implemented at NTNU, Faculty of Engineering have enhanced the flow of ideas and technologies between academia and industry, thereby accelerating the innovation process. Central to this approach is the organic development of innovation competencies and innovation culture, grounded in a bottom-up approach methodology. The strategy was effectively implemented through tailored pilots, strategically designed to meet the needs identified within various departments and led by the departments themselves. These eight pilots, each with their yearly targets, evaluation and budget aimed to bridge the gap between academic research and practical innovation. They foster an environment where students, all-stage researchers, and staff can develop and apply innovation skills to drive societal transformation.

The pilots were conducted during the period 2021 to 2023, with basic funding from the Faculty and were structured as presented in the figure below (Figure 1). A bottom-up approach was employed, encouraging discussions and actions in building innovation competencies and driving societal change from the inside. These pilots served as strategic initiatives tailored to the specific needs of each department. The program aimed to increase innovation awareness, integrate innovation into PhD studies, and develop a robust innovation ecosystem within the faculty.

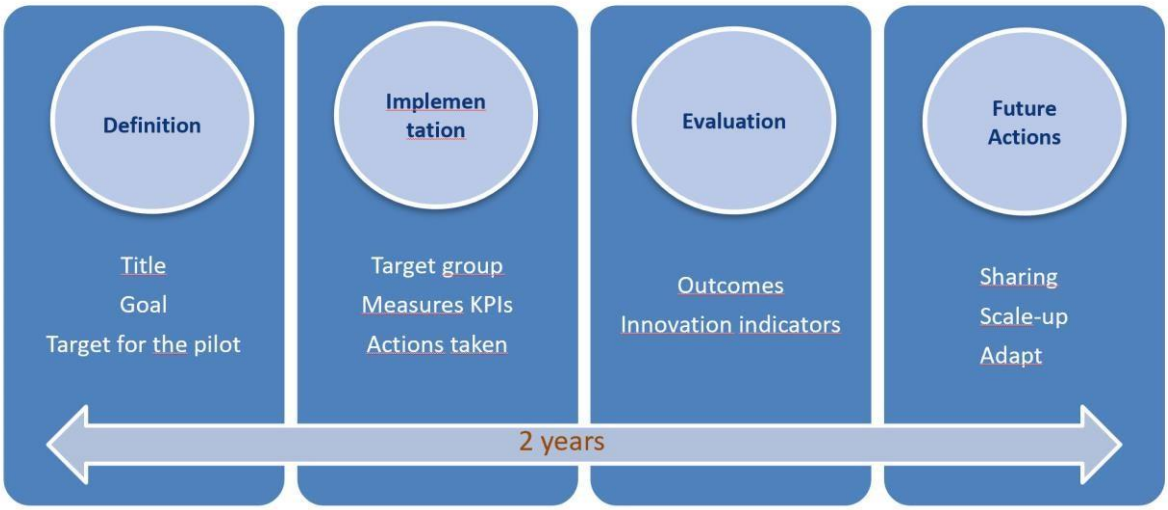

Figure 1 Innovation Pilots program

The development of the pilots has been based on innovation theories with a strong focus on building innovation competencies and innovation culture in the university sector. The aim of the Innovation Pilot Program was to identify the needs, the unique strengths and the gaps that the faculty departments have in contributing fully to the innovation ecosystem and bridging the gap between academic research and practical innovation.

The pilot programs at NTNU have produced promising results, demonstrating the effectiveness of a bottomup approach in fostering innovation competencies and driving societal change. The pilot's information is in the table below (Table 1). The pilots offered the possibility to reach the target group with other methods than the standard pedagogical practices. While standard pedagogical practices prioritise structure, theory, and individual learning, the pilots have used a more dynamic and flexible approach, offering a blend of experimental learning with hands-on bootcamps or workshops, collaborative activities and mentorship, oneto-one meetings and real-work exposure to innovators, inspirational talks and open and interactive communication.

Key achievements of the pilots include a rise in registered innovation ideas, enhanced visibility of sustainable innovation activities, and the exchange of good practices and lessons learned between the departments

Tabell 1 Pilots description

Dep.	Title	Goal	Target for the pilot	Target group	Innovation indicators	Actions taken	Outcome	Sharing with others
1	Increase innovation awareness	Innovation and entrepreneurial thinking should be developed and integrated into all bachelor's, master's and PhD programs.	Increase innovation skills of BSC, final year, increased number of ideas, DOFI registered and accepted at TTO.	150 BSc students, M&D program	No. Innovation thesis, DOFI, Start-up	Innovation camp; Industry; Degree of innovation	Innovation Camp yearly No. DOFIs	Seminar for students focusing on innovation in their dissertations
2	Innovation as an integral part of the PhD study	Increase and highlight your innovation activity and your contribution to sustainable innovation.	Increase results on innovation indicators	PhD candidates	No. DOFI, License, Start-up	PhD mid-term evaluation; Innovation course, Engage, (1/2 -2 days)	No. DOFIs Utilization of research	The concept is relevant for all departments. IFEL + PhD course
3	Ecosystem of Innovation	Increase knowledge, competence, scope and culture for innovation	Increase innovation among employees and students.	BSc, MSc and PhD	No. industrialoriented BSc& MSc& PhD; industrial mentor; DOFI, License, Start-up	Industry–seminars, panel discussions, guests, student network, Innovation talks with PhDs	No. DOFIs; 90% Master or PhD thesis with industry innovation awareness	Innovation system: cooperation&business & student organizations – brand, promote & outcome-tailor incentives – share.
4	Description of innovation in typical research projects	To establish an increased awareness of innovation activities within the group of permanent scientific staff, and to describe and potentially quantify innovation activities.	Develop a system for culturing innovation	Scientific staff, KT employees, students	Patent; License; R&D&I; TTO; Start-up; Media; NTNU ownership	Implementation of a registration form whenever an innovation action has been carried out	Innovation awareness 2 innovations registered in 2023	Innovation registration system Make a definition of 'innovation' that fits the scientific activity in the department
5	Promotion of a culture of Innovation	Laying the foundations for a more comprehensive culture of innovation	Release the innovation potential	PhD, Postdoc	Proposals for student innovation prizes, No of DOFIs	Seminars for PhD – tested concepts to increase level of competencies	Identified lack of competencies	PhD course: business/ market potential & innovation environment & developing innovation from A-Z & pitching & writing
6	Creating an infrastructure facilitating innovation in teaching (and research)	Establish a 24-7 'makerspace' innovation arena where students and professors can work on common 'projects'	Creating an innovation ecosystem with a basis in current teaching and courses	BSc, MSc, PhD, employees	No. of prototypes, company seminars/WS, project activity, new project ideas, and DOFIs	Investment in innovation workspace for students/employees	Integrated in 3-4 courses, projects and research	Collaboration on project-specific issues across departments and study program

7	Innovation Platform - Communication Bridge	Establishing a communication bridge between the researchers at NTNU, and engineers, researchers and decision makers in the industry	Innovation pitch - media training, formulating the message, presenting to the industry. Promotional videos.	PhD candidates, Postdocs, students, scientific staff	Increased industry interest No of innovative outcome	Communication and media training seminars for PhD; Booklets and recorded videos	1 new PhD/postdoc project funded by the industry.	Through the Innovation IV faculty meetings, LinkedIn posts
8	Inventor's role in innovation	Develop an innovative culture, what lies in the role, what requires effort, and what is required of support functions	Transferable knowledge at an early stage; assess the potential for moving forward with an innovation race.	PhD, Postdocs, students, scientific staff position	No. DOFIs. New Ideas.	Lunch talks about innovation	Low level of participation	The event is shared.

Discussion

As shown in Table 1 the Innovation Pilot Program at the Faculty of Engineering has provided a comprehensive framework for enhancing innovation competencies among bachelor, master, PhD students, and employees. They acted as a crucial bridge for the exploitation of academic research and future societal transformation. Each pilot was focused on specific actions tailored to different target groups, and the program, aimed to foster a culture of innovation and translate academic research outcomes into practical and impactful applications. When checking the KPIs and outcomes of the pilots' common points have been found as in Figure 2 below. It was noticed that three clusters have been formed: actions towards the Bachelor and Master students, actions towards the PhD students and actions towards the employees.

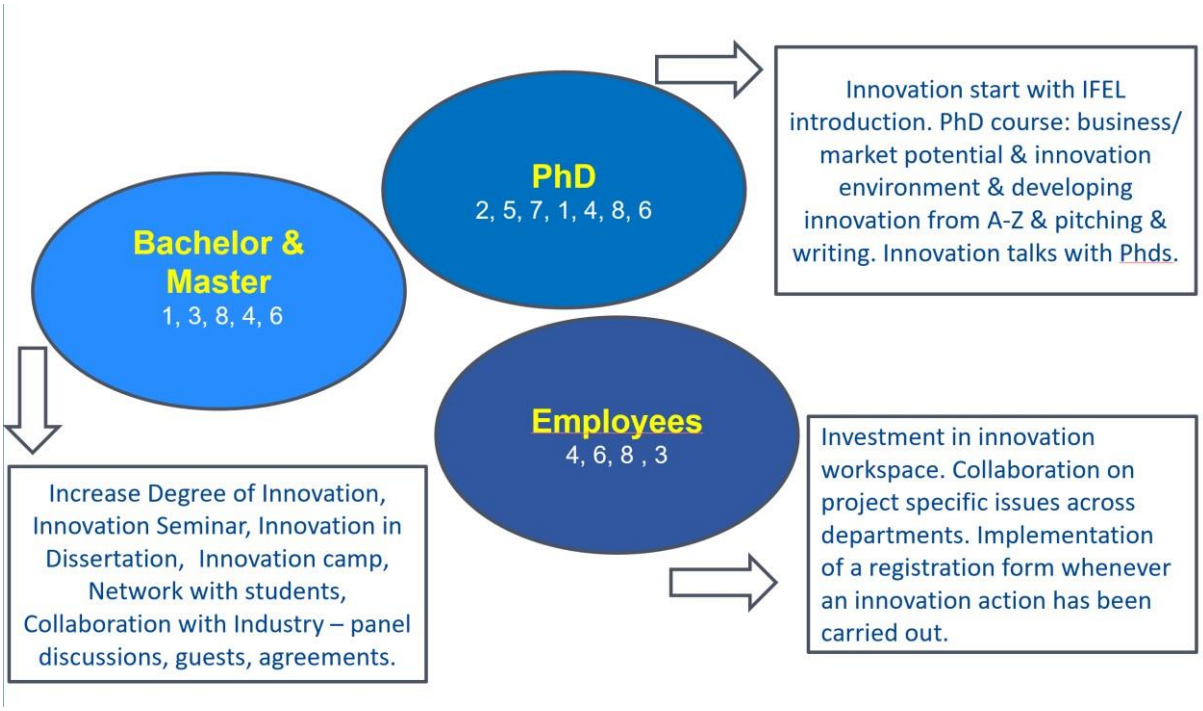

Figure 2 Innovation Pilot program outcomes and KPIs

Bachelor and Master Students: For bachelor and master students, the pilots emphasize the need to increase the degree of innovation. To answer the need the pilot developed various initiatives such as innovation seminars, innovation bootcamps, and collaborative projects with industry. The integration of innovation into dissertations and regular networking with industry professionals through panel discussions and guest lectures significantly enhances students' exposure to real-world challenges and innovative thinking. Following the activities of the pilots from 2021 and 2022 in motivating students and creating opportunities for innovation, in 2023 eleven students applied for the Innovation competition with ideas from their Bachelor and Master. The competition ended with 3 students (groups of students) getting prizes and the winner's project was selected by an industry partner to be developed further. Consequently, at the same competition in 2024, sixteen students applied, and the results are under evaluation. As a result of the activities from the pilots towards this target group, we noticed both a positive change in students' behaviour and an increase in the second year. Another activity implemented was the Innovation Bootcamp in October 2023 in Ålesund, with a follow-up on the 2024 Innovation Bootcamp in Gjøvik. The format of the event was to have 30 bachelor and/or master students from the Faculty of Engineering with an equal split of 10 from each campus that will be working together in mixed teams to solve challenges that came from industry. The students had access to small lectures about the innovation path, mentors both from academia and industry, lab materials and direct contact with the businesses that brought the challenges. The outcomes of the 2023 bootcamp were: the winning product

has been taken further in development by the industry partner and also both the students having the idea and the students coordinating the bootcamp have found jobs in the areas of their research and interest.

By offering this type of activities the pilots have tried to build essential innovation competencies such as creativity, problem-solving, and collaboration, which are critical for transforming academic knowledge into viable industrial products and societal solutions. In a study about teaching through Innovation bootcamps the scholars found out that students become more motivated to form startups and think about the innovation of their research, once they have developed their first minimum viable product and worked closely with the external stakeholders (Cico et al., 2020).

PhD Students: The PhD students benefited from targeted programs such as IFEL introduction, courses on business and market potential, and innovation environment seminars. In evaluating these initiatives, it has been observed that participation in courses such as IFEL800 is mandatory for students, the course has only one small lecture on innovation, so separate workshops and seminars have been developed with the potential to provide the PhD candidates with a deep understanding of the innovation landscape, including the processes of developing and pitching innovative ideas. The participants in those seminars involved 1520 students per event, therefore confirming the need for a different program in innovation than the standard and traditional courses and practices. As a result, two actions have been taken: first action was the development of live and online innovation talks by external and internal innovators showing best practices and innovator paths and encouraging the young researchers to align their research with industry needs and societal challenges; the second action led to developing of a special course on Innovation and innovation process and societal impact. The PhD course is to be implemented starting in Autumn 2024. The course focuses on the student's role as an innovator, the academic cornerstones of innovation and entrepreneurial behaviour relating to the skills needed to contribute to innovation within an engineering context. Contemporary innovation is multifaceted, cross-industrial and multi-disciplinary. It can take place in startups, within companies, or in close interaction between academic institutions and industry. The course is based on the participants' research goals and will use these as basis for developing an innovation case for each participant. The course has been structured to provide both theoretical foundations and practical applications. It starts with basic thematic knowledge, explaining innovation theory and research directions within innovation, along with the innovation processes. The second part of the course explores research-based innovation, focusing on alternative approaches and methodologies, and the contrast between knowledge-based (push) and problem-based (pull) approaches. In the third part of the course the students will also learn about securing value through IP management and ensuring ethical and sustainable innovation practices. Building on this foundation, participants will define their innovation cases or products by developing individual value cases and, finally, they will learn how to communicate their innovation and results to other stakeholders and various audiences.

Employees: For employees, the pilots focus on creating an infrastructure that supports innovation, such as investment in innovation workspaces and fostering collaboration across departments. During the pilots it was started the implementation of a registration system for innovation actions to ensure that innovative activities are documented and promoted, creating a transparent and supportive environment for innovation. During the pilots have been recommended measures to develop competencies in strategic thinking, interdisciplinary collaboration, and innovation management among employees, empowering them to contribute to the university's broader innovation goals and societal impact. The pilots focusing on this target group, have organised events where TTO and other innovators have been invited to share their path. As a result, the departments could see an increase in the declaration of innovations submitted to TTO and a rise in interest in similar events.

Analysing the shared areas and actions across these target groups we have seen the importance of a holistic approach to innovation competencies development. The pilots have addressed the specific needs of students, young researchers and staff at various levels, creating the possibility to scale the actions and findings at other faculties and university levels.

While the Innovation Pilot program and the pilots' implementation demonstrated significant success in increasing innovation awareness and innovation competencies, certain departments encountered resistance to the program across diverse groups. For example, in some departments where actions for PhDs have been promoted, some of the supervisors mentioned that it is a waste of time for the candidate to participate in such events. In other departments, even though the employee's needs through the questionnaire were in increasing innovation awareness when events or actions to meet the need were created, they did not attend them. So, this raises questions about the scalability of the program, across different faculty and also the need to embed more activities or communication tools.

The theoretical foundation for the innovation pilots draws on the contemporary frameworks in innovation studies. Central to this is the Triple Helix model (Etzkowitz, H. and Leydesdorff, 2000), emphasizing the synergistic interactions between universities, industry, and government in fostering innovation, thereby highlighting universities' pivotal role in generating and applying new knowledge. Additionally, (Chesbrough, 2003) concept of open innovation underscores the importance of external collaboration and knowledge exchange, principles that the pilot programs integrate to enhance the flow of ideas and technologies between academia and industry, thus accelerating the innovation process. Further enriching this framework is(Geels et al., 2017) model on fostering innovations, which posits that internal and external forces pressure existing systems to realign around maturing innovations.

Answering the research question " How can pilot programs in innovation competencies serve as a bridge between academic research and societal transformation?" the KPIs reached and feedback from the Innovation Pilot Program demonstrate that fostering innovation competencies at all levels of the academic community is essential. These competencies enable individuals to navigate the journey and context from research to innovation and society, ensuring that innovative ideas do not remain confined to academic papers, but are developed into solutions that address real-world problems.

Conclusion and recommendations

The Innovation Pilot Program at the Faculty of Engineering, NTNU have effectively demonstrated the role of innovation competencies in bridging the gap between academic research and societal transformation. By targeting bachelor, master, and PhD students, as well as employees, these pilots have fostered a culture of innovation that could support in the future the translation of research. The tailored initiatives, including innovation seminars, talks, interdisciplinary collaborations, and dedicated workspaces, have acted collectively to enhance creativity, problem-solving, and strategic thinking across the departments where they have been implemented.

However, despite the positive feedback regarding workshops, seminars bootcamps, some faculty members expressed their concerns over the alignment of the activities with the existing academic curricula and suggested a need for better integration. In long term, the sustainability of the Innovation Pilot Program remains a key concern, especially given the reliance on temporary funding and volunteer-driven effort from the appointed pilot leaders. Without institutional support, there is a risk that the momentum gained may decline once the pilot phase has ended.

Developing further on the successes of the Innovation Pilot Program, the next steps involve developing specialized courses in innovation thinking to further grow innovation competencies. These courses will be designed to provide deeper insights into various aspects of innovation, tailored to the needs of bachelor and master students and embed them in their study program curricula. At the same time, other actions will be defined for different academic levels and professional backgrounds. The initiatives could follow the same three clusters that were found in the pilots' evaluations: bachelor and master students, PhD students and employees.

Other recommendations could be the organisation of advanced innovation workshops that could cover topics such as design thinking, lean startup methodologies, and strategic innovation management for the

group of researchers and employees and the leaders and future innovators the universities could develop leadership programs focused on fostering innovation leaders who can champion and drive change within their organizations. One more recommendation is to give a bigger focus on interdisciplinary research and innovation. The emphasis on rapid prototyping and commercialization could lead to prioritize market driven solutions over those that address more complex, systemic societal issues, such as social inequality or environmental sustainability. There is a need to establish interdisciplinary innovation labs where students and researchers from different fields can collaborate on real-world projects. These labs could serve as incubators for innovative ideas, providing resources and mentorship to bring concepts to fruition. We believe in the role of the university to build a comprehensive ecosystem that not only nurtures innovation competencies but also ensures their application in driving societal transformation. The future role of universities will be enhanced with innovation education, preparing the next generation of innovators to tackle global challenges with creativity and resilience.

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Adapting Settlements to Climate Change: Transforming Former Industrial Areas Along Rivers in Germany into Resilient Mixed-Use Real Estate

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Abstract

Climate change poses numerous threats in urban areas, such as heatwaves, reduced air quality, ecosystem disturbance, etc. For city areas located along rivers there is an increased risk of more frequent and intense flooding. Various riverside industrial zones in German cities were redeveloped into mixed-use areas in the post-industrial era. Therefore, this paper investigates the challenges faced by these new settlements, such as flood management, ecosystem protection, water pollution reduction, provision of public spaces, enhancement of urban aesthetics, and their connection to the real estate market on the local level. For research purposes, three projects from the German context are elaborated: Hamburg (HafenCity project), Heilbronn (Neckarbogen project), and Basel-Huningue-Weil am Rhein (3Land project). This qualitative research applies a case study approach to analyze historical documents, scientific literature, planning documents, and urban and architectural projects, thus identifying correlations among historical, spatial, social, and economic factors that influenced these redevelopments. To collect context-specific data, case study visits were conducted. Findings indicate that flood and social resilience are issues addressed in riverbank settlements through multifunctional public space design. Equal efforts are made in architectural innovation in the design of the buildings, which is highly important when adapting settlements to climate change effectively. A significant contribution is the improvement of connection of the redeveloped areas to the broader urban fabric of the respective cities. Furthermore, the newly redeveloped areas play an important role in improving the city's overall image while successfully integrating elements of its industrial heritage. Finally, this research develops valuable recommendations for policymakers, urban planners, and stakeholders involved in the development of real estate in riverside areas.

Keywords: climate change adaptation, flood risk management, riverbank settlements, urban resilience

Introduction

Waterfronts have historically evolved through several stages. This morphodynamical development of waterfronts is correlated with five historic periods of industrial development from 1801 to the introduction of the EU Water Framework Directive (EU-WFD). Each period exhibits a distinct influence on the watercourse, driven by human intervention. As a result of deindustrialization in recent decades, industrial zones, ports, and transportation routes have been relocated with brownfield sites being left behind. These areas are predominantly located in central city areas, and frequently, along rivers as remains of former ports. Brownfields near rivers are a result of economic restructuring as well (Hersh et al., 2012). Both architects and the real estate industry support transforming these former ports into promenades that can attract residential developments, offices, and cultural facilities (Schubert, 2010). Furthermore, transforming these areas along rivers could potentially help in adapting and mitigating climate change threats.

In the 1960s, brownfields were replaced with new facilities, which was a trend that first emerged in North America. By the early 1980s, large-scale mixed-use developments began to take place on these brownfields which were often characterized by weak planning. In the early 1990s, participative planning and design competitions became more common, often accompanied by events like the Olympics or flagship architectural projects, particularly in Europe. Finally, in the new millennium, projects were increasingly characterized by public-private partnerships and professional planning management. These kinds of redevelopments often served as city marketing strategies. Mixed-use developments and luxury housing became dominant on the riverfronts (Schubert, 2010).

The restructuring of waterfront brownfields is unique because of their proximity to existing infrastructures and their complexity in terms of land use, historical, economic, and other factors (Hersh et al., 2012). Revitalizing old port areas involves a complex web of stakeholders and interests as they present opportunities for sustainable development. Successful waterfront regeneration requires attention to creating a master plan that involves communities and developers from the earliest stages, public-private partnerships, collaboration between public authorities and private organizations and overseeing by an independent development agency (Wang, 2002). Riverfront redevelopments in brownfield areas in Europe and especially in Germany are leveraging the growing awareness of climate resilience, sustainability, and environmental responsibility to create projects that meet modern real estate demands while also addressing environmental challenges. Many riverside industrial zones in German cities were redeveloped into mixed-use areas, with residential use often being dominant (Wolf et al., 2021).

The objective of this paper is to analyze riverfront redevelopment projects in Germany, the challenges they face in the process of planning and implementation and the role of real estate in that process. The research examines three different case studies positioned in different contexts and with different objectives. However, all these projects share the common goal of implementing sustainable practices in shaping contemporary settlements by the river. The projects under study are still in progress: the HafenCity project in Hamburg, the Neckarbogen project in Heilbronn, and the 3Land project in the border area between the cities of Weil am Rhein in Germany, Basel in Switzerland, and Huningue in France. The paper will introduce each of the case studies, beginning with an exploration of the historical context that initiated these redevelopments, and the goals of each project. Furthermore, the important innovations in planning, design and governance will be analyzed. The paper will conclude by presenting key insights and recommendations drawn from the analysis.

Methodology

This research was done through a qualitative case study approach. The data on the specific projects was collected through a review of historical and planning documents, scientific literature, and documentation on the selected urban and architectural projects. Furthermore, site visits were conducted with the goal of familiarizing oneself with the specific context that the projects are set in. Finaly, for two of the case studies semi-structured interviews were held with urban planners included in the plan

development. The analysis of the gathered data identifies correlations between the specific objectives and processes in which these redevelopments are being conducted so final conclusions could be drawn.

Case studies of riverfront redevelopments

Neckarbogen, Heilbronn

Heilbronn was a key player in Württemberg's economic development in the last century and the analyzed area in Heilbronn holds a historically strategic position along the Neckar River. The area's spatial significance understandably came from its proximity to the river and railway lines. The Wilhelmskanal, which made the Neckar River navigable, was constructed in 1821 and a terminus station was established in 1848, which connected Heilbronn to Stuttgart by rail. The discovery of rock salt in the 1880s spurred the growth of the local chemical industry (Rösch, 2007). Over the years, the area saw the creation of harbors and the relocation of railways to accommodate growing traffic. Since 1935 the Neckar was blocked off by steep embankments and roads and was only visible as an element in the urban space in a few places in the area. Despite significant wartime damage and industrial use, the Wilhelmskanal and the former terminus station still remain in the area (Stadt Heilbronn, 2009). As transportation modes evolved and industries began to relocate or decline, the area along Neckar faced spatial challenges. Some of those challenges were the underutilization of the railway infrastructure and the port facilities. Therefore, this area was set to be repurposed into mixed-use developments with residential, commercial, and service-oriented activities.

Development plan

In 2009, an Urban Development Competition was held for the master plan of the area. The competition area covered approximately 100 hectares, and the task was to create a master plan that would serve as a guiding framework for the area’s development. The transformation was driven by the need to better integrate the Neckar River into the city's urban fabric. An important aspect was the reconnection of the east and west districts that had been historically separated by industrial infrastructure. Key objectives of the competition included the conception of an urban quarter with around 750 residential units, the development of mixed-use spaces that would combine living, working, culture, and leisure, and the development of riverbanks as open spaces. The master plan was expected to address several critical factors such as ensuring protection against emissions from adjacent industrial areas, integrating higher-level transport requirements, and creating sustainable infrastructure. The overall goal was to create a district that meets the needs of the current population and also serves as a model for future urban development, that integrates green spaces and sustainable practices into the urban landscape while revitalizing a historically industrial area (Dokumentation Modellquartier Neckarbogen, 2017). Steidle Architekten from Munich, in collaboration with t17 Landschaftsarchitekten, won the competition. The competition's results led to a framework plan that included a distinctive triangular settlement figure, green landscape strips, and bridges to connect different parts of the area. The plan integrated the garden city model and served as the basis for decisions related to the Federal Garden Show which was a project that was being parallelly developed in the same area. Several development plans are further derived from the Neckarbogen framework plan.

Figure 1: *Neckarbogen district area in Heilbronn. Source: author, 2023*

Figure 2: *Neckarbogen public spaces. Source: author, 2023*

*B*UGA 2019

he 2019 Federal Garden Show in Heilbronn, known as BUGA 2019, combined a garden exhibition with a city exhibition, transforming a 40-hectare area called Neckarbogen. In preparation for the show, an open space planning competition was held in 2011, based on the 2010 framework plan for Neckarbogen. The competition was won by sinai Gesellschaft von Landschaftsarchitekten mbH in collaboration with Machleidt GmbH. The project was set to revitalize the underused land, connect districts across the Neckar, and improve the city's image by integrating existing structures like the ABX Hall. The garden exhibition featured green spaces, horticultural art, and urban block development. The exhibition also included the construction of three blocks of mixed-use buildings up to nine floors, that would create a mix of urban living, shopping, and leisure opportunities, ultimately forming a the new Neckarbogen district in Heilbronn. The three construction sites were located between Stadtsee and Altneckar, bordered by the canal and Westrandstraße. The first construction phase of Neckarbogen was completed for the event, making the Neckarbogen an integral part of BUGA 2019. The new quarter was visible to visitors along with other important features like the city and leisure lake that would later become part of the district. The BUGA 2019 served as a catalyst for urban development in the area. It was a decisive instrument in driving the implementation process, linking to the theme of sustainability and acting as an ambassador for this idea. It provided a platform for stakeholders as users or exhibitors, by the realization of high-quality living spaces (Stadtplanung & Landschaftsarchitekten, 2015).

A model for integrated urban development and sustainability

In the wish to make the Neckarbogen a model neighborhood, there was a question on what Neckarbogen can serve as a model. To explore this, potential model aspects were divided into levels, such as: urban development (which includes integration, mix, diversity, layout, and strategy), open space (which includes community gardens, public spaces, street designs), architecture/typology (which includes rooftop terraces, cooperatives, sustainable construction), mobility (which includes car sharing, public transport, cycling, pedestrian traffic), and energy/sustainability (which includes water management, energy supply, energy-efficient buildings). These model aspects were further categorized into three types: Heilbronn New Standard 2019 (implementation of current standards in the district by the 2019 BUGA), Heilbronn Innovation (introduction of innovative projects by combining or evolving existing ideas) and Heilbronn Lighthouse (forward-thinking projects as experimental research). A matrix was developed to guide decisions on these aspects as the Neckarbogen develops.

One of the important aims of the Neckarbogen district is to create a diverse mix of functions, housing types, ownership models, and sponsorships, which would promote social sustainability. This urban mix includes diverse functions (combining living, working, leisure, and services within each area); variety in housing (offering different types of housing, such as perimeter blocks, row houses, and urban

terraced houses); mixed ownership (including rental, ownership, and leasehold options); sponsorship diversity (involving investors, housing associations, cooperatives, and individual builders) (Dokumentation Modellquartier Neckarbogen, 2017). Finally, the framework aims to create a city of short distances, where living, working, and leisure is closely integrated. This means achieving inclusivity, as people with varying income levels can live near their workplaces and participate in the community.

Planning process, governance and stakeholder collaboration

The development of the Neckarbogen area has followed a clear, integrated planning process since the 2009 urban planning competition, including early and ongoing citizen participation. The 2010 framework plan was updated to refine existing plans, achieve a density that would allow for a critical mass to form in the district, and was closely aligned with the BUGA 2019 mission statement to maximize synergies between these complementary projects (Dokumentation Modellquartier Neckarbogen, 2017).

For the implementation of the plan a design manual was provided to ensure the design outcomes for the district. The Design Manual serves as a guide for future developments and ensures that the Neckarbogen becomes a unique and recognizable urban district. It provides guidelines for coordinating different construction projects. The manual is not rigid but serves as a flexible guide to create a unified and distinct identity for the area to achieve coherent overall picture. This gives all involved a clear direction for future developments (Dokumentation Modellquartier Neckarbogen, 2017). The Design Manual helps all involved in the planning process to coordinate between each other. The selection of developers for the properties is done through quality criteria and not through price. Furthermore, the allocation is made by parcel, so interested parties can apply for a maximum of two plots for a building with the same architect that are not directly adjacent to each other and at least one building cooperative/building group should be provided for each construction site. With the creation of building groups, the private builders collaborate to create properties. These projects, which include participatory planning and long-term self-use, often result in innovative and eco-friendly housing (Dokumentation Modellquartier Neckarbogen, 2017). The idea is to create a mixture of sponsorships (Pressestelle, n.d.).

Furthermore, a special building commission reviews all the projects. The building commission is a city-appointed group of urban planners, landscape planners, and architects, reviews construction projects based on the design manual, energy, mobility concepts, and the development plan. Finally, competitions where at least five architectural firms are participating are mandatory for key buildings and areas. The awarding authority is the plot owner or, in larger proceedings, the city of Heilbronn (Stadtplanung & Landschaftsarchitekten, 2015). This kind of planning and implementation contributes to a collaborative design context, where investors and builders are given the greatest possible scope for their individual needs.

HafenCity, Hamburg

is the third-largest seaport in Europe and remains one of the busiest in the world (Bruns-Berentelg et al., 2022). HafenCity is a district in Hamburg-Mitte, situated on Grasbrook Island along the Elbe River, where the former Port of Hamburg was located. The analyzed redevelopment area is situated south of the historical Speicherstadt district which served as a port warehouse, built between 1883 and 1927, and was added to the UNESCO World Heritage List in 2015. This warehouse complex, built on oak piles over demolished 16th-18th century residential buildings, isolated the port from the city center. Following extensive damage during World War II, when about 70% of the warehouses were destroyed, and the rise of container shipping in 1956, the old port basins near the city became too small and shallow. As a result, the harbor quickly shifted to the south banks of the Elbe River (Prinzleve, 2023) and post-war, Hamburg's development had focused away from the Elbe (Gelfond, 2021). After World War II, many German cities prioritized urban reconstruction with separating industrial, office, retail, and residential areas. Hamburg created a 75 km² city center zone dedicated solely to harbor use (Bruns-Berentelg et al., 2022). During the third Industrial Revolution, HafenCity's significance as an industrial hub further declined. By the

fourth Industrial Revolution, driven by cultural and creative industries, the area's industrial facilities were no longer in use (Bruns-Berentelg et al., 2022).

By the early 2000s, the port facilities had moved west to accommodate large vessels (Gelfond, 2021). Because of this, Hamburg undertook two major regeneration projects: HafenCity (initiated in 1997) and Wilhelmsburg Island by IBA-Hamburg (which begun in 2006). Both projects were a part of the Hamburg Spatial Vision 2020. The HafenCity project is Germany's largest urban reclamation initiative aimed at expanding downtown Hamburg by 40%. The area of the projects spans approximately 155 hectares, stretches from Speicherstadt to the Elbbrücken and transforms former port facilities into a mixed-use area (Petrow, 2011).

Figure 3: *Mixed use district in HafenCity. Source: author, 2023*

Figure 4*: Mixed use district in HafenCity. Source: author, 2023*

Development plan

The concept of HafenCity was initiated in the 1990s and unveiled in 1997. In the competition held in 1999 the "Hamburgplan" and Kees Christiaanse / ASTOC design was selected as winning. The plan aimed to turn the area of 157 hectares into a mixed-use urban area that preserves the historical and natural features of the context while adding socio-economic value to it (Gelfond, 2021). The Masterplan integrated residential, commercial, leisure, retail, and cultural facilities, and maximized land use with a high building density index of 2.5 to accommodate Hamburg's limited development space (Alpay, 2012). The initial Masterplan proposed in 2000 faced significant public criticism, as it was overly rational and failed to preserve elements of the site's industrial heritage. The Masterplan also outlined a phased development of HafenCity, which was set to move from west to east to ensure controlled construction across the area. A zoning plan for the first phase was established in 2000, and the first buildings were completed by 2004 (Schubert, n.d.). The project's phased implementation also ensures connection with broader urban goals. This approach contrasts with the piecemeal redevelopment of other European port cities, as it also integrated HafenCity into a larger city-wide and regional strategy (Deubig, n.d.). HafenCity framework plan encouraged experimentation and adapted to emerging opportunities, such as nurturing creative hubs in historic warehouses. This approach exemplifies Hamburg's shift from managerialism to entrepreneurialism in urban policy.

A model of sustainable and resilient urban development

There are five key points of sustainable development strategy for the HafenCity: reuse of the former industrial area and achieving high density; providing mixed use and sustainable land use in the redevelopment area; including sustainable mobility and implementing the concept of walkable city; achieving high efficiency and use of renewable energy and certification of buildings (Deubig, n.d.). Waterfronts have become key locations for city marketing, featuring iconic architectural projects. Similarly, HafenCity project features design by renowned architects such as Rem Koolhaas, Massimiliano Fuksas, and Herzog & de Meuron and also aims to showcase a blend of high-class housing,

tourist attractions, and public events to build its image and integrate it into Hamburg's identity (Petrow, 2011).

HafenCity is located between the Norderelbe and the public flood protection line, placing it within the Elbe's flooding zone. Unlike other parts of the Elbe Estuary, which are protected by embankments and levees designed to withstand storm surges predicted for 2085, HafenCity requires unique flood protection solutions due to its geographical positioning and the nature of its development. The key flood protection measure in HafenCity involves elevating buildings on artificial mounds or plinths that reach 8 meters above mean sea level (msl) (Ge et al., 2014). This strategy allows for the integration of HafenCity with Hamburg's existing urban fabric by implementing innovative adaptive architecture. Finaly, this resilient building principle enables phased development from west to east and north to south.

HafenCity is designed as a "walkable city" where everything is easily accessible without a car, thanks to its mixed-use layout, a dense network of pedestrian streets, car lanes, and bus lines, the U4 subway line (operational since 2012) and an extensive quayside promenade. Parking is heavily restricted, and most parking spaces are hidden underground to integrate with flood protection measures. Finally, the HafenCity eco-label from 2007 was Germany's first to set high energy standards for all building types and requires annual performance verification. The district also features various tourist attractions distributed throughout its area (Bruns-Berentelg, 2014).

Planning process, governance and stakeholder collaboration

The HafenCity project reflects the complexities of urban development in port areas. Early in the planning process, dialogue and interdisciplinary collaboration were established to build consensus on the objectives of the plan (Alpay, 2012). The Hamburg Port Authority (HPA), not the Ministry for Urban Development and the Environment (BSU), oversees planning in the port, which complicates collaborations (Schubert, n.d.). By 2004, Corporation for Harbor and City Development was transformed into HafenCity Hamburg GmbH, a public company, which took over the development process (Bruns-Berentelg, 2014) and soon owned most of the land. The company uses its influence to ensure that investors adhered to the broader planning vision. This approach balances immediate land sale profits with long-term planning goals, incorporating mixed-income and mixed-use neighborhoods (Bruns-Berentelg et al., 2022). In this way public ownership in the area was maintained. Instead of charging the highest possible price for land, they require investors and developers to contribute to the overall planning goals of HafenCity, which in turn raises the value of new land plots.

A specific example of the original form of governance in HafenCity is the new Elbphilharmonie concert hall. The idea for a new iconic concert hall on Hamburg's redeveloped waterfront came from a local developer who had commissioned famous architects Herzog & de Meuron to design it. The planning and building process of the indicates a shift in the governance of iconic flagship projects at least in Germany and reveals new discourses and practices of a place-specific neoliberal governmentality. Uniquely, this project relied heavily on local civic commitment and patronage, as a new form of governance in urban development that blends public and private interests (Balke et al., 2018). Another aspect of the project that relies on private stakeholders is the flood preparation for privately owned buildings meaning that the owners pay higher price for real estate in the area because the funds go in flood protection and maintenance of the buildings (Mees et al., 2014).

3Land, Weil am Rhein – Basel – Huningue

The municipalities of Basel, Weil am Rhein, and Huningue form a historical border triangle on the river Rhine. These areas have gradually become a continuous urban space through uncoordinated growth. Before 1840, the Rhine between Kembs and Breisach was a broad, branching floodplain. From 1842 to 1876, the river was narrowed into a deeper, more controlled bed and became less navigable until 1962 when the Rhine Lateral Canal was built. In that time Basel was known internationally as a "factory city" with a high number of workers, a trend that continued until the 1980s (Team LIN, 2015a). The Hafen-Stadt port in Kleinhüningen, Switzerland, evolved from a fishing village into a vital industrial and residential area. Originally it was the most important port in Switzerland, whose growth was spurred by key developments such as the construction of the St. Johan port in the early 1900s, the opening of the Maritime Station in 1926, and a second port basin in 1946. This expansion influenced the growth of the pharmaceutical and chemical industries in the region. The early 2000s saw the beginning of a new transformation phase with the development of the Novartis Campus, which was later extended to connect

Figure 5*: 3Land area in Basel. Source: author, 2023*

Figure 6: *3Land area in Huningue. Source: author, 2023*

with the Rhine (ENSURE - EuropeaN Sustainable Urbanisation through Port City REgeneration, 2019). A significant cross-border protest occurred in 1986 after a chemical spill polluted the Rhine. By 2000, the Rhine had become clean enough for swimming through Basel's city center. The national borders have shifted over the centuries and today they have significant marks on the urban landscape. Over time, the cities have expanded towards these borders, resulting in a complex mix of urban areas and a closely connected cross-border region (Team LIN, 2015a). Despite its well-developed infrastructure—proximity to the port, airport, railway stations, and main roads—the 3Land area has not fully realized its potential, with infrastructures often acting as barriers rather than connectors. The region had a fragmented urban space while people's access to the Rhine was limited, with residential areas often located behind industrial zones. Despite its urban and industrial nature, the 3Land area also includes ecologically valuable habitats and biotope networks that are crucial for maintaining local, regional, and supra-regional ecological networks (IBA Basel, 2020).

Before the project, the Rhine was mainly seen as a border, especially for Huningue and Weil am Rhein, while Basel viewed it as central to its identity. Basel's growth is limited by land availability, so it needs cooperation with nearby municipalities in a polycentric agglomeration. Furthermore, the development of the Swiss Rhine ports, including relocating the harbor station, is a focal point of Basel's urban strategy (Team LIN, 2015c). Huningue, though not the initiator, sees the project as a significant opportunity for its own development (Team LIN, 2015c).

Today, efforts are underway to restore some of the Rhine's original floodplain to create sustainable habitats for endangered species. Rhine is now also viewed as a central figure in European cross-border identity, which offers opportunities for multifunctional, transnational urban development (Team LIN,

2015a). The cities of Basel, Huningue, and Weil am Rhein, along with the Saint-Louis Agglomération and the Conseil Général du Haut-Rhin, joined forces to develop this area into dense, sustainable urban districts. A 2012 planning agreement led to the creation of a joint development vision and spatial concept (IBA Basel, 2020). The 3Land project is situated in a 430-hectare cross-border area and aims to reconnect the cities with the Rhine, while providing green and open spaces, particularly in Friedlingen. The transformation of port and industrial areas in 3Land is freeing up space for new urban districts (Team LIN, 2015a). The idealized lifestyle—working in Switzerland, shopping in Germany, and living in France—is being reevaluated for sustainable development across the region (Team LIN, 2015c). The reintegration of the port with the city and EU funding were key catalysts for regional economic development and cultural exchange (Le Den et al., 2019). This development aims to maintain each city's distinct identity while merging them into a unified space with potential for 20,000 jobs and residents over the coming decades.

Development plan

The initial concept for the Rhine Island, was also known as "Rheinhattan," proposed by MVRDV and faced criticism for its perceived luxury focus which led to fears of displacing existing residents. Therefore, the newly proposed planning concept of the area aimed for a gradual and careful transformation rather than exclusivity. In November 2013, Team LIN was tasked with developing a spatial concept for 3Land. After consulting with politicians, planners, and experts from Germany, Switzerland, and France, they proposed the framework. The 3Land spatial concept is a preliminary framework, not a final master plan. The concept of the framework was refined based on feedback. In the process of citizen involvement, demands for diverse and flexible living arrangements were discovered, with 45% of respondents valuing a variety of housing types and 50% demanding flexible building designs. Many prefer renting over ownership and asked for affordable and cooperative housing (Team LIN, 2015b). The 3Land project aims for a mixed-use approach and envisions three cross-border hubs: Campus Labor (education and research functions, new industries), Urban Vis-à-vis (living and working functions), and Vis-à-vis across the Rhine (residential and leisure functions). Approximately 900,000 m² of space was set to be developed (Team LIN, 2015d).

The project implementation is divided into four phases, each addressing specific goals and timelines. The pre-project phase focuses on laying the groundwork with flexibility to adapt plans as needed, while coordinating land release, and implementing temporary uses in preparation for future development. Phase 1 (2015-2020) focuses on the area's visibility through temporary projects, improvement of accessibility with new bridges and public transport, and hosting trinational events. Phase 2 (2020-2025) intensifies urban redevelopment with the introduction of an express bus line, transformation of Huningue South, construction of a northern bridge, and residential projects in Weil am Rhein. Phase 3 (2025-2030) is planned for developing the previously started areas and improving public transport connections, including a direct link to EuroAirport, while further constructing bridges and advancing urban projects. The final, Phase 4 (2030-2035), focuses on completing urban development in Huningue South and Basel's southern port area, and exploring potential long-term projects with BASF and Novartis (Team LIN, 2015d).

A model for cross-border sustainable urban development

3Land seeks to achieve a unified riverfront experience that respects the varying cultural approaches to the Rhine in each country. Furthermore, 3Land will support a new educational institution focused on language acquisition and international schooling in order to aid cross-border communication and education. The newly redeveloped area is set to provide flexible spaces for start-ups, small businesses, and innovative enterprises. This includes business incubators and adaptable office spaces, complementing traditional commercial areas. Leveraging the area's rich cultural backdrop and its unique border location, 3Land will accommodate both permanent cultural facilities and temporary events such as festivals and markets.

The 3Land area is designed for high flexibility, allowing further subdivision of plots as needed. Shore areas will be publicly accessible. Development will incorporate buffer zones between different uses and connect new and existing districts through open spaces and harmonized urban planning (Team LIN, 2015d). In the 3Land project, a catalog of criteria was implemented to guide private and non-profit investors, developers, and landowners across the three participating countries. This catalog, known as the "Trinational Criteria Catalog," aims to exceed current standards and awards the "Sustainable 3Land Durable" certificate to those who meet its rigorous requirements. The catalog has five overarching goals: creating green and open spaces by opening previously closed areas, enabling user-oriented and cooperative development, ensuring accessibility for all city residents, prioritizing walking, cycling, and public transport, and implementing environmentally friendly transformation processes. For instance, one key indicator under energy efficiency is the reduction of gray energy, which involves upgrading existing buildings with minimal intervention and designing new buildings for flexibility (Expertenhandbuch, n.d.).

Planning process, governance and stakeholder collaboration

In the context of 3Land, governance represents a pragmatic and adaptable approach to managing complex cross-border interactions among three countries. The project impacts a wide range of stakeholders, including architects, conservationists, neighborhood groups, and businesses. While traditional governance might seem inadequate, especially in regions with varied administrative systems and national traditions, governance in 3Land is viewed as a complement to existing structures. It employs direct interaction between citizens and decision-makers rather than relying solely on democratic representation (Team LIN, n.d.).

Out of the 430 hectares in 3 Land area, a significant portion is privately owned, particularly by Novartis, BASF, and other companies in the Huningue South zone. Public ownership is limited, mainly in France. Effective planning for the 3Land project requires strategic negotiations with the private landowners. The Port Company is a key partner, and as port areas transition to the Canton of Basel-Stadt, gradual land releases are anticipated. However, the planning process for 3Land remains complex and evolving (Team LIN, 2015a). The cities and local authorities of the Basel agglomeration have a long history of cross-border cooperation as shown by the establishment of the Trinational Eurodistrict Basel (TEB) (Team LIN, 2015a). Despite Switzerland's non-EU status, the TEB allows it to benefit from EU funding.

An open space and nature conservation concept was also developed for 3Land. While implementation is primarily managed at the municipal level, certain bi- and trinational projects will be jointly developed. It will guide future planning in each city, serving as an orientation and regulatory tool. The concept also outlines tasks for each city, categorized into short-term (until 2025), medium-term (until 2030), and long-term (from 2030) goals to inform future planning processes, such as Basel's Klybeck-Kleinhüningen district development plan and Weil am Rhein's Integrated Urban Development Concept (ISEK) (IBA Basel, 2020). Finaly, the 2012 "Strategy 2030 Trinational Basel Agglomeration" also presents a vision for a compact city-region that is complementary to the 3Land vision (Ohgai & Toda, 2013).

Discussion and conclusion

New settlements along rivers in Germany have faced multiple challenges in the process of development, like flood management, balancing public-private responsibilities, resolving land ownership conflicts, preserving industrial heritage, addressing social and environmental justice issues, maintaining environmental ecology, integrating with the existing urban fabric, achieving critical mass, implementing sustainability practices, navigating urban policy complexities, designing effective public spaces, enabling citizen involvement, developing adaptive infrastructure, and ensuring economic viability. These challenges arise in the context of climate change, and urban growth that seek sustainable and resilient practices in city building. This paper presented three riverfront redevelopment cases: two in Germany and one in a border region between Germany, France, and Switzerland. All three case studies

were envisioned as future models for urban development, each with a different focus. The HafenCity aimed to serve as a model for flood resilient and sustainable settlement; The 3Land focuses on improving connections and ecological status of the district and the river area and the Neckarbogen project focuses on improving social resilience while building sustainably. A key objective across all three projects was to improve the respective city's image, particularly given their prominent riverfront locations. This was achieved through strategies like building iconic architecture by renowned architects, preservation of industrial heritage, creation of high-quality public spaces, and the implementation of compact, sustainable, and innovative architectural solutions.

Comparing all three case studies helped identify some similar objectives and sustainable practices that were given a priority in each of the planning frameworks. Firstly, riverfront redevelopment projects should be part of a long-term integrated vision, like, for example, Hamburg's Spatial Vision 2020 or Basel's Vision 2030, which would effectively connect them with other individual projects. Various sustainable concepts were identified in the planning frameworks for these districts such as "cities of short distances," that would enable the residents to reach necessary function in their neighborhoods and which adds to social resilience of those neighborhoods. Furthermore, walking and cycling are prioritized modes of mobility. The plans also favor green interventions, and design of multifunctional spaces along the rivers that accommodate both social events and flood management.

The analyzed case studies demonstrated several innovative approaches in implementation processes and building processes that contributed to their success so far, and that can provide valuable conclusions and recommendations for stakeholders involved in similar processes. The planning and implementation processes, as shown, are highly complex. Each of the three case studies developed a flexible planning framework in the beginning, followed by either a design manual, or a design handbook, or eco-label certifications for buildings, that could help in behavioral change necessary for achieving long-term sustainability and that would give some restrictions to the existing flexible frameworks. The development process is typically phased so it can adapt to possible changes. Finaly, new governance models, public-private partnerships, and funding mechanisms proved crucial for project implementation. To familiarize the public with the projects and public events and exhibitions such as BUGA 2019 or IBA Basel were held.

Finally, real estate plays a key role in these redevelopments. One of the key objectives across all projects was achieving sufficient density to reach critical mass. However, while estate development brings economic benefits, it can also lead to gentrification by displacing lower-income residents. This is reflected in the higher price for properties in Hafencity as private real estate owners are also the ones providing crucial funding for flood management in privately owned buildings. On the other hand, the 3Land and Neckarbogen projects incorporate affordable housing to offset social resilience concerns.

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Environmentally Conditioned Needs and Their Impact on Human Motivation and Well-being: A Dynamic Model

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Abstract

This research explores the concept of environmentally conditioned needs and their impact on human motivation and well-being, integrating contemporary psychological theories of needs and motivation, particularly Maslow's hierarchy of needs and the Self-Determination Theory (SDT). The traditional frameworks emphasize the role of intrinsic human needs—such as autonomy, competence, and relatedness—in fostering personal growth and satisfaction. However, this study introduces a novel approach, highlighting how environmental factors shape and influence the fulfillment of both basic and higher-level needs. The paper examines the interplay between individual actions and environmental contexts, using hypothetical models to illustrate how different needs can be fulfilled through engagement with the environment. These models are empirically validated using a modified version of the Satisfaction of Needs questionnaire, developed to measure the satisfaction levels of various needs in specific environmental contexts. The findings reveal that the fulfillment of these needs is dynamically interrelated and influenced by environmental variables, challenging traditional hierarchical perspectives and advocating for a more fluid understanding of human motivation. The study concludes by suggesting that understanding and addressing environmentally conditioned needs is crucial for enhancing overall well-being and offers a comprehensive framework for future research on sustainable urban development, environmental psychology, and public policy aimed at improving quality of life in diverse settings.

Keywords

Human needs; environment; urbanism; sustainability; wel-being

Introduction

In recent years, there has been growing interest in how environmental factors shape human motivation and well-being. Urbanization and the associated social, economic, and environmental factors play a crucial role in shaping living conditions and impact an individual's life satisfaction. Many authors, such as Baumeister and Leary (1995) etc. emphasize the need to consider needs; under any conditions, needs must influence thinking, feelings, and behavior; if needs are not met, negative consequences must be considered. The authors also pointed out that needs must be common to all. The analysis of needs serves various purposes, including the assessment of social infrastructure. Identifying needs is a process of describing the "problems" of the target population and possible solutions to these problems (Vaznonienė and Pakeltienė 2017). Therefore, needs analysis focuses on the future, on what should be done, rather than on what has been done (Omodan and Abejide 2022; Vaznonienė and Pakeltienė 2017).

Maslow's Theory of Needs and Motivation

Maslow's hierarchy of needs is one of the most well-known theories of motivation in psychology, first introduced by Abraham Maslow in 1943 in his work *A Theory of Human Motivation* (Maslow, 1943). The theory posits that human needs are organized hierarchically, and basic needs must be satisfied before an individual can focus on fulfilling higher-level needs. Maslow identifies five categories of needs or motivations: physiological needs, safety needs, belongingness needs, esteem needs, and the need for self-actualization. He illustrated these in a hierarchical pyramid, commonly referred to in psychological and motivational studies.

At the base of the hierarchy are physiological needs, which are essential for survival. These include the need for food, water, oxygen, sleep, and maintaining a stable body temperature—fundamental homeostatic requirements. These needs are the most basic and powerful, as they are directly linked to survival. Until these are met, individuals cannot move to higher levels of the hierarchy. When unmet, a person’s behavior revolves around satisfying these needs, often disregarding other aspects of life.

When physiological needs are fulfilled, safety and security needs emerge. These include physical safety, financial security, health, and well-being, as well as the need for a stable and secure environment. These needs involve protection from physical and emotional threats and achieving a sense of stability in life. Following these are social needs, such as the need for love, friendship, and belonging. This category includes interpersonal relationships, family bonds, intimate connections, and a sense of belonging in social groups like workplaces, communities, or religious organizations. Satisfying these social needs helps individuals develop social skills and build strong relationships.

After social needs are met, individuals seek esteem, both self-esteem and the esteem of others. This need involves self-respect, recognition from others, achievements, and status. It is a motivation for accomplishment, recognition, and prestige, as well as a need for self-respect and self-worth. According to Maslow, these needs can be further divided into lower-esteem (recognition, status) and higher-esteem (self-confidence, personal power). A lack of esteem can lead to feelings of inferiority.

At the top of Maslow's hierarchy is the need for self-actualization, which refers to realizing personal potential, achieving personal meaning, creativity, and personal growth. Self-actualization is about reaching one’s full potential, pursuing personal goals and interests, and finding purpose and meaning in life. A summary of these needs is often presented in figures like this:

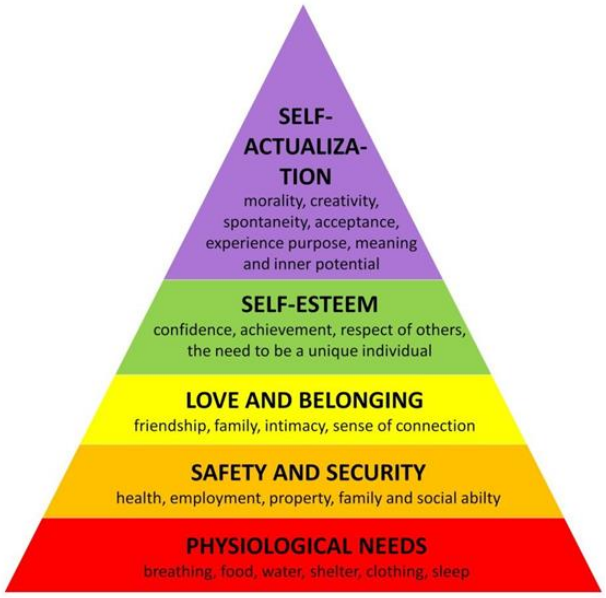


Figure 1
Maslow's hierarchy of needs

Despite its widespread appeal, Maslow's theory of hierarchy has not been extensively empirically tested (e.g., Fallatah and Syed, 2018; Wahba and Bridwell, 1976; Yu et al., 2018).

Environmentally conditioned needs

In this paper, we introduce a new concept of so-called environmentally conditioned needs, which we believe are linked to life satisfaction. We are interested in the extent to which the environment in which we live can satisfy the basic and higher needs of residents and how this affects their life satisfaction. We draw on Maslow's revised theory of needs and motives (Ghaleb 2024; Kernick et al., 2010; Kobal Grum and Musek 2009).

If we generally define needs as basic motivational forces that guide individual behavior and emerge in response to a lack or surplus of something in the body or environment, we can similarly define environmentally conditioned needs. In this context, we define environmentally conditioned needs as motivational forces that guide individual behavior in a given environment and emerge as a response to the lack or surplus of balance between the person and the environment. Environmentally conditioned needs are those that are shaped and conditioned by the social, cultural, economic, and technological factors of the environment in which the individual lives. These needs adapt according to changes in the environment and may vary between different social groups or cultures. This means that environmentally conditioned needs can be found in all the previously mentioned categories of needs: physiological, safety, belonging, esteem, and perhaps even self-actualization. We believe that the satisfaction of these needs leads to higher well-being and satisfaction, with each category of these needs enabling the achievement of a specific goal or well-being.

We argue that access to basic survival resources is not uniform across all environments. Environmental degradation, economic disparities, and unequal access to natural resources significantly affect the ability of individuals and communities to meet their survival needs. For example, populations in regions facing drought or severe pollution may struggle to meet these basic physiological requirements, which in turn affects overall health and motivation. Safety and security are deeply tied to an individual's environment. For example, living in a war-torn area or in a community with high crime rates can significantly undermine a person's sense of physical security. Economic factors, such as job security or housing

stability, also play a role in shaping psychological safety. Additionally, environmental threats such as natural disasters (floods, earthquakes) can heighten feelings of insecurity, making safety needs more pressing. Belonging and community needs are shaped by social structures and environmental conditions. Urban environments, for instance, can either facilitate or hinder social connections depending on how public spaces are designed. Dense, impersonal city environments may create feelings of isolation, while thoughtfully designed neighborhoods that promote interaction (parks, community centers) can foster a sense of belonging. Social and cultural contexts heavily influence esteem needs. Societies that prioritize competition and individual achievement (e.g., Western capitalist societies) may place significant pressure on individuals to meet high performance standards, linking self-worth to professional success or social status. Conversely, societies that value communal contributions may derive esteem from cooperative efforts or social harmony. Physical environments directly affect well-being. Access to clean air, green spaces, safe recreational areas, and pollution-free surroundings all contribute to physical and psychological health. Social environments, such as supportive communities or workplaces, also play a crucial role in enhancing well-being.

The primary objective of this study is to build a model that addresses the influence of social, cultural, economic, and technological factors on motivation and well-being.

Methodology

Concurrent Research Approach

The study utilized a Concurrent Research Approach, which combines both theoretical and empirical work simultaneously, allowing for a dynamic interaction between data collection, analysis, and theoretical development. This approach emphasizes a holistic integration of different methodologies, with an iterative process of refinement that allows for continuous improvement of the model. The concurrent research approach is characterized by several key aspects. First, it is grounded in pragmatism, focusing on finding practical solutions by combining both qualitative and quantitative methods to gain comprehensive insights (Creswell, 2014). This pragmatic stance allows for a flexible and adaptive research process. Additionally, the study utilized Grounded Theory for qualitative analysis, enabling theoretical frameworks to emerge directly from the data. The theory was developed from data collected through interviews, surveys, and case studies, and it was continuously refined as new data were gathered (Glaser & Strauss, 1967). Action research was another significant component, actively involving participants in the research process, especially when adapting environmental factors to the specific needs of various social groups. This participatory approach allowed researchers to implement changes and immediately observe their impact on participants' motivation and well-being (Reason & Bradbury, 2001). Furthermore, the study engaged in simultaneous theoretical and empirical work, unlike traditional linear research models. This allowed for real-time testing and refinement of theoretical models as empirical data were being collected, ensuring that the evolving framework on environmentally conditioned needs was rooted in actual observations. The dynamic interaction between theory and data was a central feature of this approach. As data was collected, it continuously informed the theoretical framework, and as the theory was refined, it guided further data collection. This iterative process ensured a responsive and adaptive research model (Bryman, 2016). Lastly, the holistic integration of multiple methodologies, including qualitative interviews and quantitative surveys, provided a comprehensive understanding of how environmental factors influence human motivation and well-being. This integration was crucial for capturing the full complexity of environmentally conditioned needs (Patton, 2015).

Participants and Measures

To further support the Concurrent Research Approach, a quantitative study was conducted, involving a sample of 502 Slovenian adults. Of these, 48.0% were female, and 49.2% of participants were between the ages of 18 and 34 years.

Several standardized instruments were employed in this study:

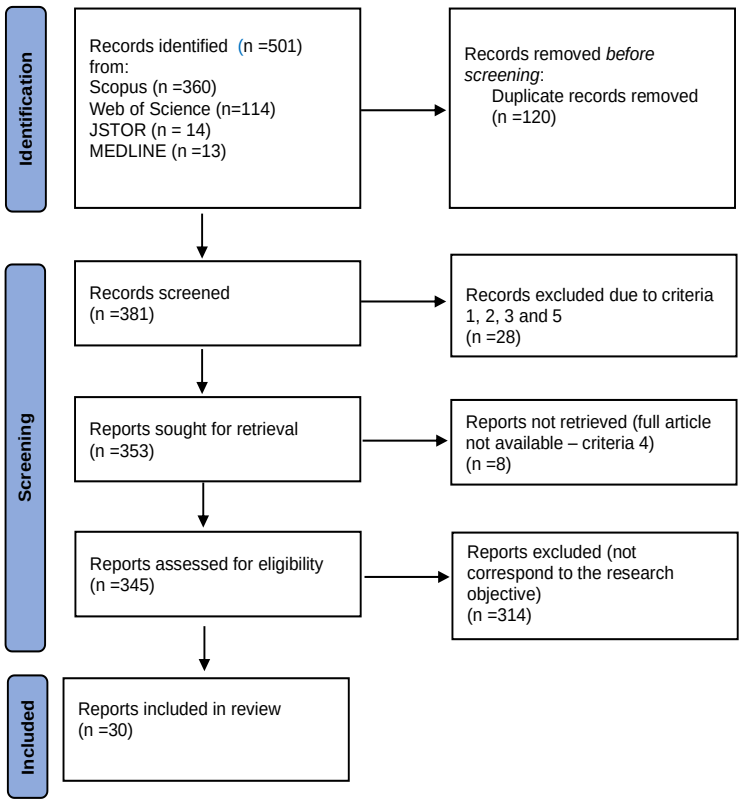
- Adapted Satisfaction of Needs Scale (SNS) (Taormina & Gao, 2013), which measures satisfaction across physiological, safety, and self-esteem needs.
- -Brief Sense of Community Scale (BSCS) (Peterson et al., 2008), which evaluates participants' sense of community and social belonging.
- Mental Health Continuum Short Form (MHC-SF) (Keyes, 2007), which assesses mental health across emotional, psychological, and social well-being dimensions.

The concurrent research approach offers several advantages. One of its key strengths is its flexibility and responsiveness, as it allows for adjustments to be made throughout the research process in response to emerging data. Theoretical frameworks are not rigid; they evolve alongside empirical evidence, leading to a more accurate and context-sensitive understanding of environmentally conditioned needs. Additionally, this approach promotes a holistic understanding by integrating both qualitative and quantitative data, enabling researchers to capture the complexity of environmental influences on motivation and well-being more comprehensively than if they were relying on a single method (Creswell, 2014).

Results and discussion

The first phase of study followed a systematic review process in accordance with the PRISMA (Page et al., 2022) guidelines. Initially, a total of 501 records were identified from multiple databases: Scopus (n = 360), Web of Science (n = 114), JSTOR (n = 14), and MEDLINE (n = 13). After removing 120 duplicate records, 381 records were screened based on predefined inclusion and exclusion criteria. During the screening phase, 28 records were excluded due to failing to meet criteria 1, 2, 3, or 5, leaving 353 reports for further evaluation. Of these, 8 reports were not retrieved because the full text was unavailable (criteria 4). Following an in-depth assessment of eligibility, 314 additional records were excluded as they did not correspond to the research objective. Ultimately, 30 reports were included in the final review. This process ensured a comprehensive and methodologically rigorous approach to identifying relevant literature for analysis. The whole process and extraction of articles is shown in Figure 2.

Figure 2
PRISMA diagram of the protocol for searching, inclusion and exclusion of reviewed articles



The findings of the second, quantitative phase of the study indicate that environmental factors play a crucial role in fulfilling basic human needs such as safety, belonging, and esteem. Participants who reported higher levels of satisfaction with their environmental needs exhibited stronger overall well-being and positive behavioral patterns. A significant positive correlation was identified between participants' sense of community and their overall well-being, aligning with the findings of Peterson et al. (2008). This suggests that a stronger sense of belonging within a community contributes to enhanced emotional and psychological well-being. Furthermore, participants who experienced higher levels of need satisfaction also demonstrated better mental health outcomes, as assessed by the Mental Health Continuum Short Form (MHC-SF) (Keyes, 2007). These individuals reported greater emotional, psychological, and social well-being, further supporting the link between environmental satisfaction and mental health.

Based on the results of both study phases we hypothesized several models of environmentally conditioned needs which seek to understand how environmental factors shape and influence basic human needs, impacting motivation and well-being. ECN emerges from the interaction between the individual and their environment, covering several key areas of needs influenced by social, cultural, and economic factors.

Environmentally conditioned physiological needs are satisfied if the environment in which we live provides easy access to clean air, drinking water, and nutritious food that is ecologically produced and safe for consumption. Environmentally conditioned factors, such as pollution, access to natural resources, and food quality, directly influence the ability to meet these basic needs (Pradhan et al., 2018). Access to food, water, and healthcare can be strongly conditioned by geographical, economic, and political factors. For example, in technologically advanced societies, people have better access to

healthcare and diverse diets, while in less developed areas, basic necessities may be lacking The implementation of clean water solutions globally addresses the goal of achieving universal access to safe and affordable drinking water for all and improving water quality by reducing pollution and minimizing the release of hazardous chemicals and materials (SDGO, 2019). Culture also influences the satisfaction of these needs, as cultural norms largely dictate eating habits, food choices, and meal preparation methods. Recognizing the importance of clean air and environmental hygiene for disease prevention underscores the need for maintaining a clean environment, including air, water, sanitation, cleaning, and lighting (Moropeng et al., 2021), which are critical for reducing the spread of hygiene-related diseases (Thompson et al., 2003).The model of environmentally conditioned physiological needs is illustrated in Figure 3.

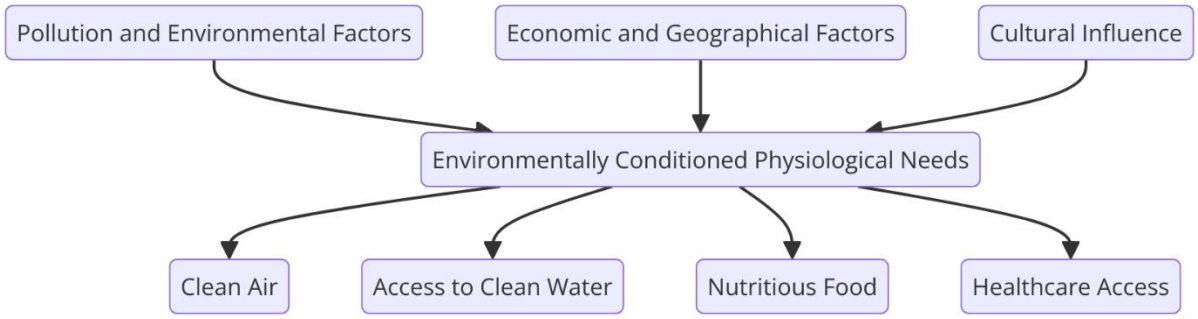


Figure 3
Hypothetical model of environmentally conditioned physiological needs

The fulfillment of environmentally conditioned safety needs is influenced by several factors, such as economic, political, social, technological, and others. Safety heavily depends on political stability, legal regulations, and economic conditions. In unstable regions, people are more exposed to dangers, increasing the need for safety. Social systems, such as social security, health insurance, and pension systems, also affect an individual's sense of safety. Technological advancements, such as security systems, surveillance, and communication technologies, can enhance or reduce the sense of safety. Environmentally conditioned safety needs are met if the living environment provides protection from natural disasters, crime, and other environmentally conditioned dangers. Stable and sustainably managed access to natural resources, such as water, food, and energy, is crucial. Urbanization that takes environmental impacts into account and environmental regulation contribute to the sense of safety. Social systems that include systematic mechanisms for protecting the environment and natural resources play a significant role in ensuring safety (Arefiev and Podchufarova 2019). Safety is also linked to economic stability, where investments in human capital and technology contribute to the innovation and competitiveness of national economies (Veselinović et al. 2014; Sugarova 2021). Social systems that include environmental protection and the sustainable use of natural resources are key to ensuring long-term safety and stability. The model of environmentally conditioned safety needs is illustrated in Figure 4.

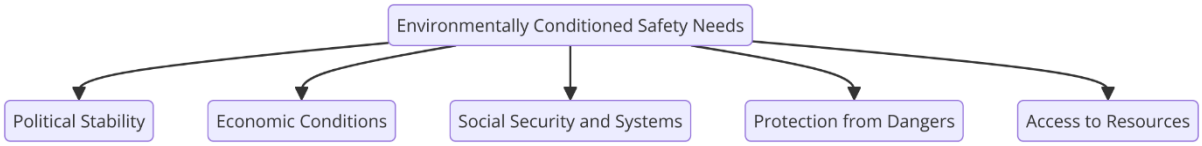


Figure 4
Hypothetical model of environmentally conditioned safety needs

Environmentally conditioned needs for belonging and love are met when there is strong community connectedness and adequate social support. Community connectedness is reflected in the sense of belonging to a particular group, which is crucial for the emotional and psychological well-being of individuals. A living environment that encourages interaction among community members creates a

sense of safety and support (Broska, 2021). This can include various activities such as organizing neighborhood gatherings, cultural events, and workshops that promote social interaction and cooperation among residents. Joint environmental initiatives and activities, such as ecological projects and volunteering, play a particularly important role in strengthening the sense of belonging. When individuals participate in projects that improve the quality of their living environment, such as cleaning parks, planting trees, or maintaining community gardens, they not only contribute to the sustainability and beauty of their environment but also strengthen their bonds with one another (Teixeira et al., 2019). Participation in these projects fosters a sense of shared purpose and solidarity, further enhancing the feeling of belonging and community. Volunteering in environmental projects not only brings benefits to the environment but also to the individuals involved. Volunteers gain a sense of usefulness and value as they see the direct results of their work and contribution to the common good. This leads to higher self-esteem, satisfaction, and stronger social connections (Shandas et al., 2008). Volunteering can also provide opportunities to learn new skills and knowledge, further contributing to personal growth and development (Cope et al., 2022). The hypothetical model of environmentally conditioned needs for belonging and love is illustrated in Figure 5.

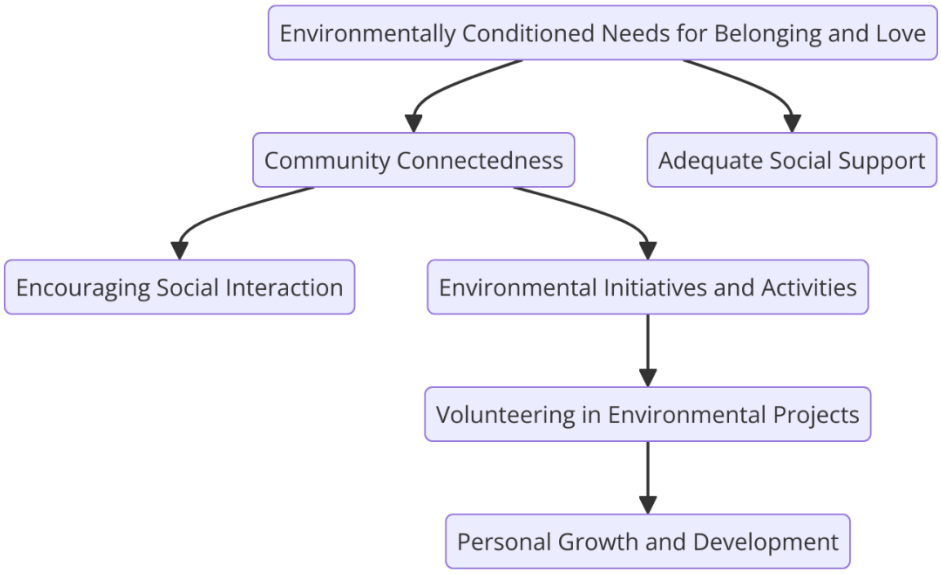


Figure 5
Hypothetical model of environmentally conditioned needs for belonging and love

Environmentally conditioned needs for esteem are met when individuals in the community develop self-respect concerning their environmental achievements and feel pride in their contribution to environmental sustainability. When individuals' efforts to preserve and improve the environment are recognized, their self-image and sense of worth are strengthened. Esteem in the community can be expressed in various ways, such as public recognition, awards, or simply social praise for achievements that contribute to the common good (Gerolemou et al., 2022; Si et al., 2022). Involvement in decision-making processes that affect the environment plays a key role in satisfying the need for esteem. When individuals have the opportunity to participate in shaping and implementing environmental policies and projects, they feel more important and valued. This participatory approach ensures that the voices of all community members are heard and considered, reinforcing the sense of shared responsibility and belonging. The feeling of importance and value that individuals gain through involvement in environmental decisions encourages their engagement and motivation to continue contributing to sustainable initiatives. This involvement enhances the outcomes of environmental projects and strengthens social cohesion and mutual respect within the community. When individuals see that their ideas and efforts are appreciated, they become more committed to preserving the environment, leading to more lasting and effective solutions (Cope et al., 2022; Laugaa and Le Campion 2015). Moreover, the sense of pride in environmental sustainability that individuals feel upon achieving significant

environmental goals, such as reducing waste, improving air quality, or protecting local ecosystems, further enhances their self-confidence and sense of worth. This pride can spread throughout the community, encouraging other members to get involved and contribute to shared goals, creating a positive feedback loop of social respect and environmental responsibility. In this way, the need for esteem is met when individuals achieve personal goals and contribute to the broader social well-being and environmental sustainability. Respect for environmental achievements and involvement in decision-making processes thus play a central role in creating a sense of importance, value, and shared responsibility for the future of our planet. The hypothetical model of environmentally conditioned needs for esteem is illustrated in Figure 5.

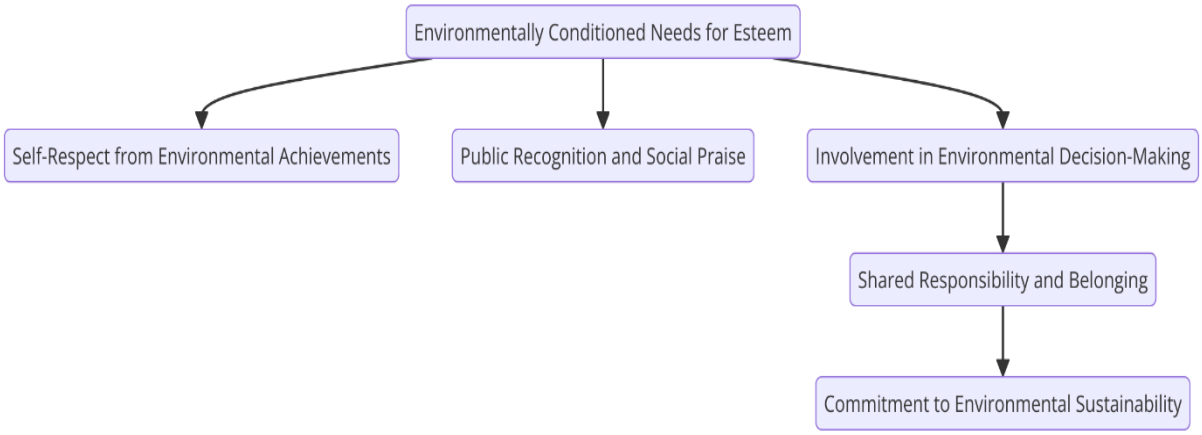


Figure 5
Hypothetical model of environmentally conditioned needs for esteem

The living environment has a strong influence on an individual's life satisfaction. A high quality of life, including safety, cleanliness, access to green spaces, and good infrastructure, contributes to higher life satisfaction. Conversely, an unfavorable living environment, marked by crime, noise, and pollution, negatively affects a person's well-being. People living in environments with highly developed infrastructure and good social services report higher life satisfaction compared to those living in less developed areas. For instance, individuals living in urban centers with good access to public transportation, educational institutions, and healthcare services are more satisfied with their lives than those living in isolated areas. In addition to the physical aspects of the environment, social interactions and a sense of belonging to a community are also important. Individuals with strong social ties and a sense of belonging to a community achieve higher life satisfaction. Social support and a sense of connection with others contribute to greater mental health stability and higher life satisfaction (Keyes, 2013). Engagement in community activities and positive social interactions help reduce stress and increase feelings of safety and support. Access to basic services such as healthcare, education, and public transportation significantly impacts an individual's life satisfaction. Research shows that people with easier access to these services report higher life satisfaction, while a lack of access can cause feelings of isolation and dissatisfaction (Diener and Tay, 2015; Hoisington et al., 2019). The research by Tay and Diener (2011) found that the fulfillment of basic needs such as food, security, and social connections is closely related to higher subjective well-being. Their study also suggests that the hierarchy of needs is not strictly linear, as Maslow proposed, but that all types of needs are important for subjective well-being, regardless of whether basic physical needs are met.

Cultural and demographic factors also play an important role in shaping life satisfaction. Cultural values and norms influence an individual's perception and expression of life satisfaction. For example, in cultures where social connections and community values are highly valued, people often report higher life satisfaction (Diener et al., 1985). Demographic variables such as age, gender, and socioeconomic status affect life satisfaction. Older individuals often report higher life satisfaction than younger ones, partly due to greater life experience and more stable social ties (Ng et al., 2021). Mental health is closely

related to life satisfaction. Individuals with good mental health report higher life satisfaction. Positive emotions, such as joy, peace, and contentment, and the absence of negative emotions, such as stress, anxiety, and depression, contribute to better mental health and higher life satisfaction (Ryff, 1989; Keyes, 2007). Research shows that interventions promoting mental health, such as physical activity, social support, and stress management techniques, can significantly improve life satisfaction. For example, physical activity is associated with higher levels of positive emotions and lower levels of stress, contributing to better mental health and higher life satisfaction (Diener, 2001). The hypothetical model of of environmentally conditioned life satisfaction and well-being is illustrated in Figure 6.

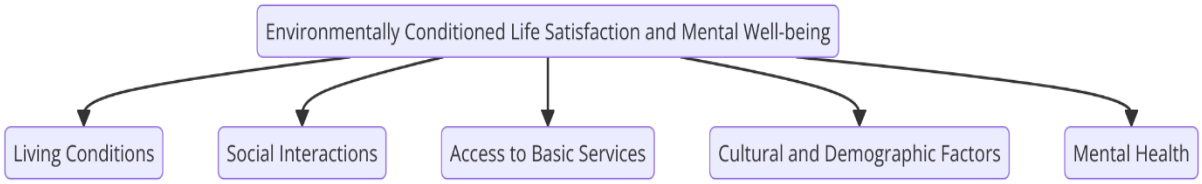


Figure 6
Hypothetical model of environmentally conditioned life satisfaction and well-being

Conclusion

To conclude, this study emphasizes the crucial role of environmentally conditioned needs in shaping human motivation and overall well-being. By adopting a dynamic and integrative model, the research challenges traditional hierarchical frameworks of needs and introduces a more flexible approach that accounts for environmental influences. The findings indicate that human motivation is not only driven by intrinsic psychological factors but is also deeply conditioned by external environmental variables, such as social, cultural, and economic conditions. These factors directly impact the fulfillment of basic needs such as safety, belonging, and esteem, and their interplay significantly contributes to life satisfaction and well-being.

The environmentally conditioned needs model proposed in this research highlights the importance of environmental adaptability in meeting these needs. The satisfaction of physiological needs is contingent on access to resources like clean air, water, and food, which are often unequally distributed due to environmental and socio-economic disparities. Safety needs, similarly, are influenced by factors like political stability and environmental security, further underscoring the complex relationship between environment and well-being. Social belonging and esteem are fostered by supportive, well-designed community environments, while participation in environmental sustainability projects enhances self-esteem and personal fulfillment.

In summary, this study contributes to a growing body of research advocating for an expanded understanding of human motivation, integrating environmental factors into psychological models of need fulfillment. The ECN model offers practical implications for urban planning, public health, and policymaking, advocating for environments that actively support well-being and sustainability. By addressing these needs in a holistic manner, society can promote more resilient, motivated, and satisfied individuals who are better equipped to thrive in dynamic and often challenging environmental contexts. Future research should continue to explore the empirical validation of this model and its application across diverse cultural and geographical settings.

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Acknowledgements: *The authors acknowledge the financial support from the Slovenian Research and InnovationAgency (ARIS) through the research projects:* Evaluation of the sustainable development of the urban environment through the parameters of social infrastructure and life satisfaction, št. J5-3112 and Health-oriented behavior as a creator of sustainable development of the built environment, št. J7-4599.

Workflow enabling various design and planning possibilities of neighborhoods via digital twins

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Introduction

Background

According to The World Bank, approximately 56% of the world's population currently resides in urban areas. The complexity of urban environments has significantly increased, and it is projected that by 2050, two-thirds of the world's population will live in cities(Dodman, 2022). This rapid urbanization presents enormous challenges for cities, including traffic congestion, pollution, the negative impacts of climate change (including rising sea levels and extreme weather events), deteriorating and insufficient infrastructure, and slow responses to emergencies (Bank, 2023). Traditional urban management tools are increasingly unable to cope with the dynamic complexity of modern cities, prompting more cities to seek new solutions (Ketzler, 2020, Shahat et al., 2021).

With the research and development of big data, the Internet of Things, and cloud computing, there is a growing integration of traditional urban planning methods with emerging data-driven technologies, which leads to more efficient and smarter urban management. In this context, the application of urban digital twins has emerged(Nochta et al., 2020), utilizing large data sets, high-performance computing, and advanced analytical tools to create virtual models of cities. The introduction of digital twin technology is envisioned to transform urban planning from relying solely on past experiences and static data to becoming more dynamic, interconnected, and intelligent. This not only enhances the efficiency and effectiveness of urban management but also opens new possibilities for long-term urban development(Hämäläinen, 2020)。

Despite recent discussions about urban digital twins, the core concept—digital twin—is not new. Its origins trace back several decades, initially developed and used in the aerospace industry. Digital twin technology was first developed by NASA in the 1960s to create high-precision virtual models of complex flight systems, which could simulate, monitor, and optimize the performance of spacecraft during missions. This technology allowed engineers to conduct various hypothetical tests on spacecraft using digital twin models on the ground, thereby predicting and resolving issues that might arise during actual flights (Grieves, 2017)。 Over time, digital twin technology has expanded into other sectors, particularly in manufacturing, healthcare, the automotive industry, and retail(Augustine, 2020)。

Thus, the digital twin is not a novel concept in other industries and sectors, but it only began to gain widespread attention in the realm of urban management in 2016(Jeddoub et al., 2023, Ketzler, 2020). Recently, as urbanization accelerates, more countries and cities are developing urban digital twin projects

of varying scales. Cities like Helsinki, Rotterdam, Zurich, and Singapore are actively exploring this technology to enhance precision in urban planning, improve traffic system management, optimize energy usage, increase public safety, and strengthen environmental monitoring and disaster response capabilities. (Wegen, 2022)

However, developing urban digital twins is significantly different from other industries due to the inherent complexity of cities in both time and space, making it unrealistic to directly replicate experiences from other industries(Jeddoub et al., 2023). Additionally, the complexity of data acquisition in urban environments involves a vast amount of urban infrastructure, such as buildings, roads, and bridges, which belong to different entities. This dispersal of ownership involves complex privacy issues, which makes the process of data collection and sharing extremely complicated. Another challenge is the lack of a clear value proposition. The key to driving digital twin projects is to clearly define the specific benefits of multi-party collaboration, but in practice, this value return is often unclear, which directly leads to slower development of urban digital twins compared to other industries(Nochta et al., 2020).

In the development of urban digital twins, despite facing multiple challenges and even a lack of broad consensus on the definition of "urban digital twin,"(Weil et al., 2023), there is unanimous agreement on one aspect: the importance of 3D city models. These models are the cornerstone of effective digital twin systems that not only provide precise visual and structural representations of the urban physical environment but also serve as key components to efficient urban planning and management(Bacher, 2022, Dembski et al., 2020, Dimitrov and Petrova-Antonova, 2021, Jeddoub et al., 2023, Ketzler, 2020, Lehner and Dorffner, 2020, Lehtola et al., 2022, Schrotter and Hürzeler, 2020).

Research scope

Urban digital twins are an exceedingly complex and extensive research topic, involving intricate data integration, advanced analytical methods, and diverse application scenarios. Given the high technical and resource demands of digital twins at the city scale, this study narrows its focus to the neighborhood level. By doing so, we can more thoroughly explore the practical applications and effects of digital twin technology in smaller-scale, more specific environments, which also facilitates easier management and operation. Additionally, neighborhood-level digital twins are more likely to gain direct participation and feedback from residents, making the project more human-centric and adaptable. This also provides valuable experience and data support for future scalability.

The primary objective of this research is to develop a workflow to guide the establishment of digital twin technology at the neighborhood scale, aiding in neighborhood construction, and supporting planning and design efforts. It also attempts to create a 3D model of a test neighborhood using available data to support the implementation of a full digital twin project in the future.

The research scope is defined as follows:

1. **3D Modeling**: This study emphasizes the use of the CityGML standard due to its rich data structure and good interoperability, which is suitable for modeling complex urban environments.
2. **Neighborhood scale**: The application of digital twin technology in this research is limited to the "neighborhood scale", and two neighborhoods are selected for testing, one in Norway and the other in China. The Norwegian neighborhood is located in the Fornebu area of Bærum, with the construction goal of creating a green and zeroemission neighborhood; the Chinese neighborhood is located in the Nanyuan area of the Xi'an University of Architecture and Technology community in Xi'an's Beilin District, which aims to design a new youth apartment and optimizing the neighborhood environment.
3. **Primary user**: Although urban digital twin technology can play a role in multiple areas, this study will focus on supporting neighborhood planning and architectural design. The target user group includes decision-makers, architects, and planners.

Literature review

What is urban digital twin

What exactly is an urban digital twin? Many people mistakenly believe that an UDT is simply a virtual model of the real world. In reality, for UDTs, "our main purpose is not to create virtual entertainment or beautiful pictures. Our aim is to enhance understanding of various phenomena and issues; to simulate, predict, and optimize" (Heiskanen, 2019), It goes beyond merely creating models. However, there is no precise definition of 'urban digital twin' because the concept itself is multifaceted and has been used in various fields of urban development, leading to different definitions based on different focal points(Weil et al., 2023). Through the reading of multiple documents and Jeddoub's 2023 summary of the evolution of the UDT concept (Jeddoub, 2022), it is evident that nearly all literature mentions three important aspects:

- First, the foundation of an UDT is the city information model, which is a 3D replica of a city. Establishing a three-dimensional city model is the first step and starting point in building an UDT. 3D models are typically created as needed for urban objects such as terrain, buildings, roads, vegetation, tunnels, bridges, waterbodies, underground spaces, and even urban furniture. It is important to note that these models usually contain not only geometric information but also semantic information.
- Second, an urban digital twin is a dynamic, living system that continually updates as the real city updates. This update is achieved through the exchange of data and information between the physical city and its virtual counterpart, a process characterized by a real-time flow of information. This is a key feature of urban digital twins.
- Third, an UDT is a comprehensive approach. Indeed, the requirement for "dynamics" dictates that an UDT is not just about establishing a 3D city model; it relies on AI (artificial intelligence), the IoT (Internet of Things), BD (big data), edge computing, RFID, and cloud services(Fabricius, 2020). These elements are essential for UDTs. UDTs provide a platform for the interaction of information from various sources, giving them significant influence. They help us analyze history, predict the future, and improve the present.

Furthermore, the development of UDTs is still in its early stages, so currently there are no clear guidelines or plans for building urban digital twins to guide people in creating them (Weil et al., 2023, VanDerHorn and Mahadevan, 2021)。This is due to the inherent complexity of cities, with each city at different stages of development and facing different challenges. To date, implemented urban digital twins have primarily been used in urban planning, infrastructure management, transportation system management, energy management, disaster management (floods/fires), and epidemic prevention, among other areas(Jang et al., 2021, Tzachor et al., 2022, Shahat et al., 2021)。

The elements of creating a UDT

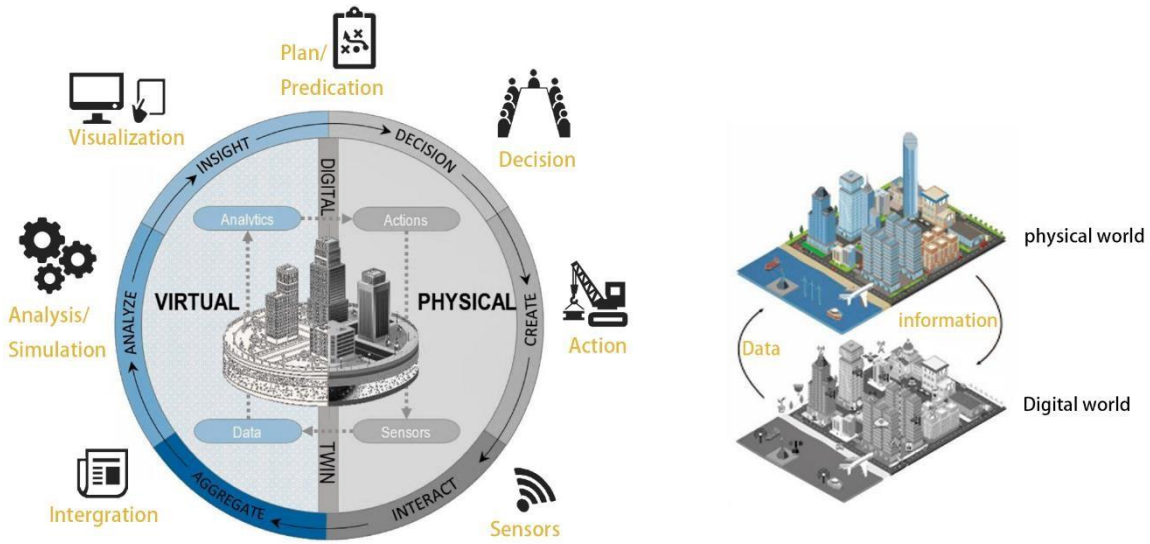

figure 1 The operation of UDTs. Image reprocessed from(Caprari et al., 2022)

The operation of urban digital twins is depicted in figure 1, which clearly illustrates the interaction between the real world and the virtual world. After creating an urban digital twin, the data transmission from the real world to the virtual world primarily relies on sensor technology. These sensors capture information from the real world, convert it into data, and transmit it to the virtual city. Once processed and analyzed, this data can be used to assess whether changes need to be implemented in the physical world, and corresponding actions are then executed to achieve the desired state(VanDerHorn and Mahadevan, 2021). As the physical environment changes, sensors capture new data, initiating another cycle of transmission, analysis, evaluation, and action. Therefore, under ideal conditions—when sensor coverage is extensive, data availability is high, and computational processing power is strong(Tzachor et al., 2022) —an UDT functions as a continuous dynamic cycle. This cycle allows urban management strategies to be constantly updated and optimized based on real-time data.

In creating an UDT, the process is generally divided into three layers: Data layer, Information layer, and Knowledge layer, as shown in figure 2:

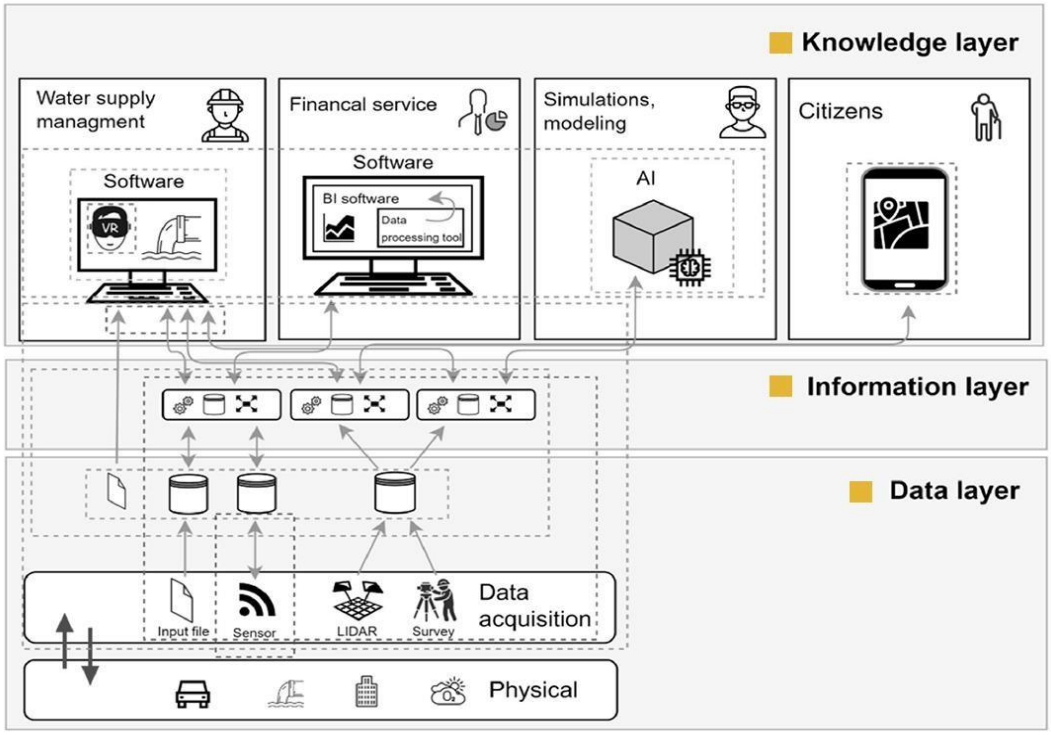

figure 2 The three essential layers when creating a UDT. Image reprocessed from(Weil et al., 2023)

Data layer: Responsible for the collection and storage of data from the physical world. It gathers raw data from the operation of the city using various data collection technologies.
Information layer: Mainly processes and analyzes data. This layer cleans, integrates, and analyzes the raw data, transforming it into useful information.

Knowledge layer: Involves the visualization and interaction of the digital twin. Urban digital twins often cater to different users, requiring selective display of model details and relevant information based on varying user needs.

Current implementation status

Now, an increasing number of cities are starting UDT projects. figure 3 displays UDT projects globally, notably those for which records or documentation are available. There are also some countries and cities planning to implement UDT projects, such as Shanghai in China(B1M, 2020). However, since only news reports are available and there is a lack of detailed project documentation about these projects, these are not included in the figure. It is evident that the implementation of UDT technology is primarily concentrated in Europe and Australia, with only Singapore in Asia actively creating urban digital twins.

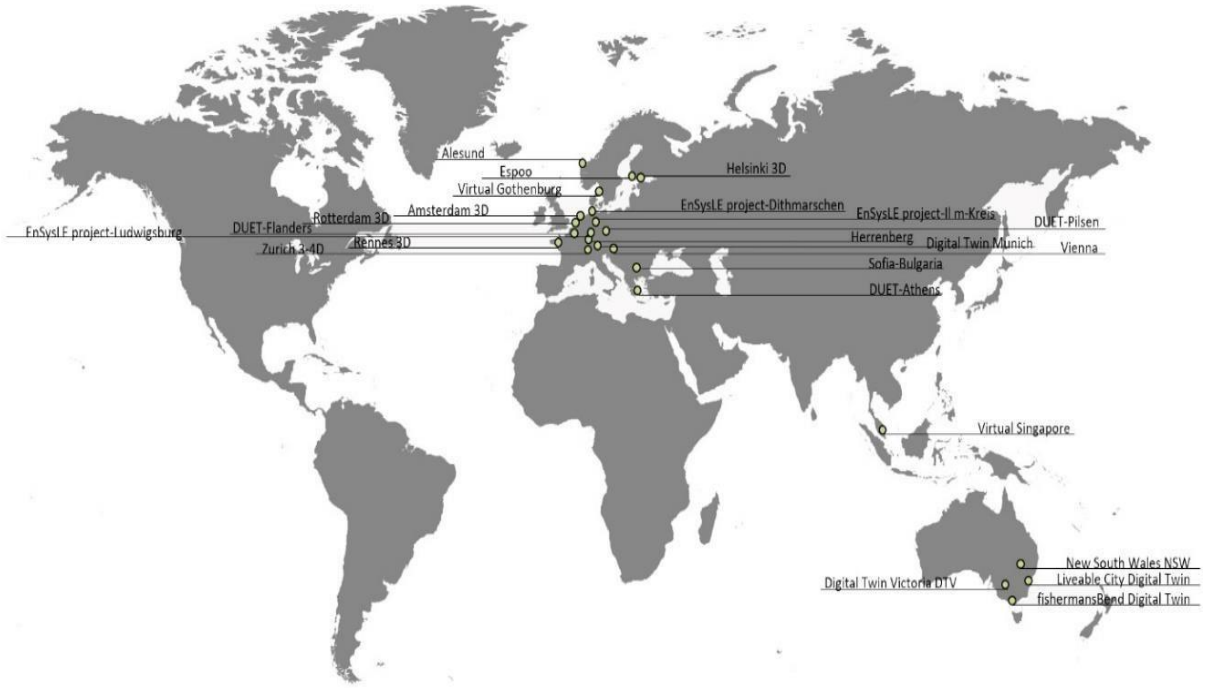

figure 3. *Locations worldwide with implemented UDTs*

To better understand and learn UDT technology, this research referenced Jeddoub's summary table in 'Digital Twins for Cities: Analyzing the Gap between Concepts and Current Implementations with a Specific Focus on Data Integration', which also included official websites and project reports of specific projects. Results are shown in Figure 4. This table compares more established UDT projects across seven aspects: the scale of the urban digital twins, integrated data types, included urban model elements, level of detail, implementation objectives, visualization platforms, and simulation experience.

From this table, it is observed that: ① Existing digital twins are primarily on the scale of cities and districts. ② Urban models usually include buildings, terrain, vegetation, and roads. Some also include bridges, tunnels, and waterbodies. Only a few UDTs include urban furniture, cables, and pipelines. The Virtual Singapore project is the most mature, including coastlines, airspace, underground assets, and land use. It is worth mentioning that almost all city models are based on a common standard—CityGML. ③ In terms of Level of Detail, LoD2 is the most commonly used in urban contexts. ④ Nearly every UDT has slightly different purposes, but most are related to urban planning, climate, and energy management. ⑤ Common visualization platforms for UDTs include VirtualCitySystems, Cesium, CityEngine, and 3DEXPERENCity, which are specifically designed for urban model visualization, as well as traditional GIS platforms like QGIS and ArcGIS. Game engines like Unity and Unreal Engine are also used for UDT visualization. ⑥ In terms of simulation, different projects perform a variety of simulations based on their specific objectives. However, it is evident that UDT simulations mainly focus on energy-related and sustainability simulations.

Figure 4 *Specific details of existing UDT projects: scale, data sources, the elements of city models, level of details, purposes, visualization platforms and simulation experiences (Jeddoub et al., 2023)*

	Scale	**Data sources**	**City models**	**LoD**	**Purposes**	**Visualization platforms**	**Simulations experiences**
Helsinki 3D+ Kalasatama (Rossknecht and Airaksinen, 2020)	City District	Oblique Orthophotos Photogrammetry Aerial LiDAR Point cloud	Buildings Bridges Tunnels Waterbodies terrain	LoD2 with textures	urban planning Energy consumption Virtual tourism Life cycle assessment	VirtualCitySystems Cesium Web and VR interfaces	Urban planning Energy and Climate Atlas utilization analysis flood assessments noise calculations Tourism
Rotterdam 3D	City	LiDAR BIM models	Buildings terrain Trees(roots) Lampposts Cables pipelines	LoD1 LoD2	Climate adaptation Viewsheds of buildings Energy performance	VirtualCitySystems IMAGEM UNITY	Energy calculations green roof potential solar potential subsurface infrastructure management urban flooding applications
Zurich 3-4D (Shahat et al., 2021)	City	LiDAR images floor plans photogrammetry	Buildings Trees Forests bridges	LoD0 LoD1 LoD2	Urban planning Climate adaptation	Web application	Visualization air pollution construction projects solar potential analyses noise simulations flood simulations shadow calculations mobile phone radiation historical models using a time slider

Virtual Singapore	City	GIS data Aerial mapping Mobile street mapping of all public roads LiDAR and imagery Data Orthophotos CityGML used for vector models and surfaces	Terrain buildings roads coastline airspace underground asset vegetation cadaster	Several LoDs	Virtual experimentation planning urban planning efficient energy consumption climate population dynamics	3DEXPERIENCity	Solar energy production Demographics Climate Traffic Installing green roofs Simulation scenarios to adapt the regional temperature Disaster prevention

			land use waterbodies pipelines cables				
Digital twin Munich	City	Aerial surveys 3D point cloud GPS measurements	3D CityGML model		Climate neutral smart cities.	Urban data platform based on the OGC standards	Traffic simulations Urban expansion simulation based on urban dynamics
Virtual Gothenburg	City		Buildings Street Lampposts Trees Plantations forests		Urban planning Urbanization growth Segregation of the city Climate change (sea level/flooding)	Unreal engine City Engine	Traffic simulations Self-driving vehicles Shadow analysis Noise simulations Air quality analysis Torrential rain simulations
Herrenberg	City	Geographic data 3D laser scanning data Data from mobile devices	3D city model		Routes planning for elderly people Potential for solar energy	COVISE	Pedestrian movement Traffic simulations air quality analysis Spatial network analysis

Sofia- Bulgaria GATE	District	Footprints of building DTM DSM	CityGML 2.0 Buildings Vegetation Terrain	LoD1	Urban planning		Urban planning Air pollution analysis 15-minutes walkable cities
DUET	City	GIS data IoT sensor data	Buildings Roads	LoD2	Urban planning	VirtualCitySystems	Traffic simulations Air pollution analysis Noise simulations
FishermansBend Digital Twin	District	Massive 3D datasets BIM model 3DTiles DEM	CityGML model Buildings Roads Pipelines Cables		Urban planning Analysis of pedestrian movement	web-GIS Cesium	Shadow analysis viewshed analysis Public health analysis Real time indoor positioning
Digital Twin Victoria	City		Buildings Roads vegetation		Urban planning	Cesium	Renewable energy capacity Flood simulations Emergency management
Liveable City Digital Twin	District		Buildings Terrain Transportation Waterbodies	LoD2		Cesium QGIS	Shadow analysis Visualization of sensor data Pedestrian flows
Amsterdam 3D	City	3D BAG	Buildings Roads Vegetation Pipelines Cables		Urban planning	Unity	
NUS-FRS	District	City Energy Analyst (CEA) Building footprints from OSM	3D campus model BIM model CityGML model	LoD1	Energy management	Cesium	post-pandemic analysis Climate change analysis

Ålesund (Pierre Major, 2021)	City	Orthophoto DEM BIM data GIS data Traffic Outdoor activity Energy/ Water usage	Building Road Terrain Transportation	LoD2	Urban planning Energy management	Unity	Shadow analysis Pedestrian flows Traffic simulations Air quality analysis

Research Gap

In existing studies of urban digital twins, the majority of focus has been on the urban level, primarily addressing technical challenges. Although this technology is intended to drive urban development and assist with complex urban issues, as previously mentioned, the specific applications of city-level digital twins in urban planning have not yet been fully validated(VanDerHorn and Mahadevan, 2021).

This research proposes narrowing the focus to the neighborhood level, using simplified information and a smaller implementation scope, to explore the specific application effects of digital twin technology. Neighborhoods form the foundation of cities, and thus, by initially experimenting on this smaller unit, we can assess and refine the strategies for implementing digital twins across a city at a lower cost. However, effective application methods for digital twin planning and management at the neighborhood level are nearly absent in the current literature. Furthermore, it is foreseeable that the practical applications of digital twins will vary significantly among different types of communities (such as urban versus rural, developed versus developing areas).

Therefore, this study aims to develop and test a digital twin workflow designed for neighborhood design and management, intending to fill this research gap and provide theoretical and practical support for the broader application of digital twin technology in urban environments.

Research Questions

The main research question is：

- How can a generalized digital twin workflow be designed to assist in neighborhood design and planning?

To delve deeper into this topic, this study further refines into the following three auxiliary research questions:

- What are the key steps involved in building a neighborhood digital twin?
- Given the specific needs of different neighborhood development stages, how should the digital twin workflow be adaptively adjusted?
- In developing the core of the digital twin (3D model in CityGML standard), which tools and methods should be employed?

These questions will guide this research in a detailed analysis of the application of digital twin technology at the neighborhood level, especially in how to customize and develop effective workflows based on the specific needs and resource conditions of different neighborhoods.

Methodology

Research method

This study focuses on the creation of urban digital twins and their impact on and enhancement of neighborhood planning and design. The aim is to understand the current implementation status of urban digital twins, the challenges faced, explore their practical significance, and propose a guiding workflow that will help future construction of digital twins at the neighborhood level. The research method includes the following four steps:

- Step One: Literature Review and Technical Survey - Research and analyze existing urban digital twins, including the types and formats of input data, software tools used for 3D modeling, Levels of Detail (LoD), project objectives, visualization platforms, and simulation experiences.
- Step Two: Workflow Development - Summarize the main processes of converting physical entities into digital twins, and clarify how this system influences and promotes neighborhood planning and design. This step aims to develop a standardized workflow, providing a foundational framework for subsequent steps.
- Step Three: Case Study Implementation - Validate the feasibility of the workflow within two neighborhoods in China and Norway, each with different construction focuses. Based on the general workflow formed in Step Two, devise specific workflows for each neighborhood to study how digital twins can significantly enhance the efficiency of neighborhood planning and design.
- Step Four: 3D Modeling - Perform 3D modeling in compliance with the CityGML standard in the two neighborhoods, laying the groundwork for potential future integration of sensor data, simulations, and the creation of visualization platforms.

Through these methods, this study not only provides a set of practical research steps but also builds a bridge from theory to practice, facilitating the future widespread adoption and implementation of digital twin technology in broader communities.

Neighborhood in Norway

Current situation

Basic Information

The selected test neighborhood is located in the Fornebu area, within the municipality of Bærum. Bærum is Norway’s fifth-largest municipality, with a population of about 130,000 people. It is situated near Oslo, the capital of Norway, in a region experiencing rapid population growth. The Fornebu area, formerly Oslo's airport area, is currently being transformed into a green, urbanized, and zero-emission zone, with completion planned for 2027. It is expected to include 11,000 buildings. Fornebu is a regionally significant business area, hosting the headquarters of numerous domestic and international technology and knowledge companies. By utilizing Fornebu as a testing ground for the municipality's climate initiatives, Bærum will collaborate with academia, the business community, and citizens to test new technologies and forward-looking solutions.

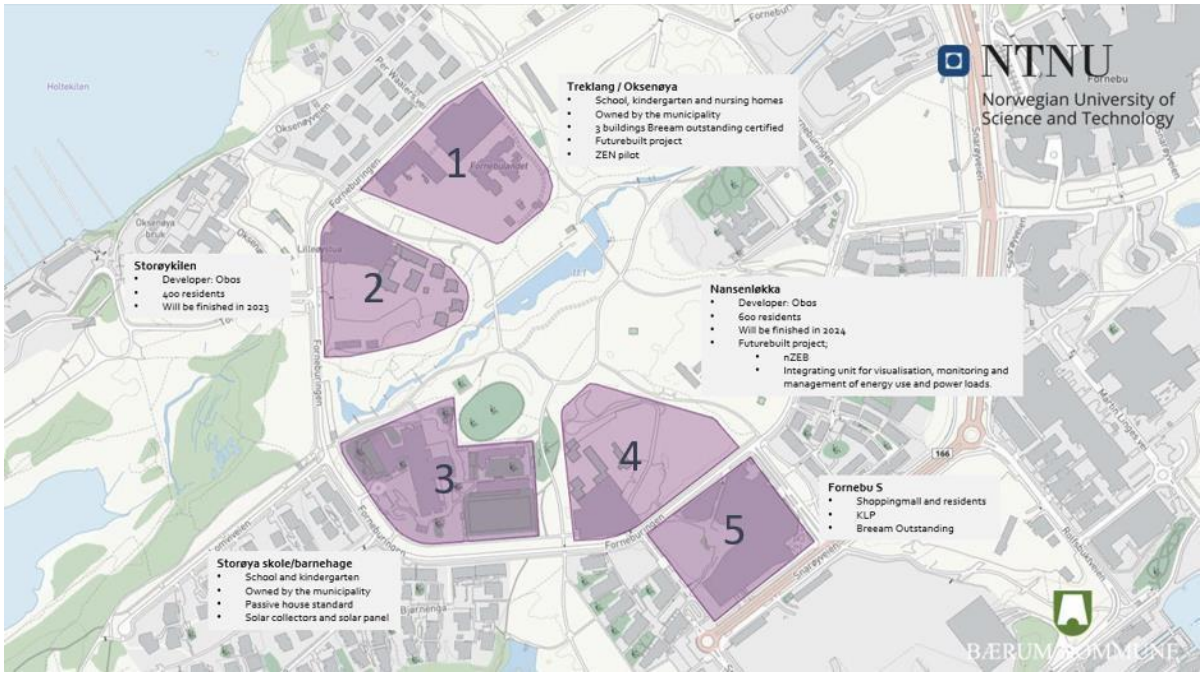

figure 5 *The pilot area in the Fornebu region selected for the case study is divided into five zones*

Current State of Community Energy Development

Bærum's urban development goal is to become an eco-friendly smart city, striving to create a suitable environment for work and living. To reduce the city's overall energy consumption, the municipality has implemented several measures. These include providing free energy advice to private residences, constructing climate-friendly buildings, promoting green bus projects, managing rainwater, and establishing warehouses for storing and reusing surplus building materials. Through these initiatives, Bærum is actively transitioning into a more sustainable and environmentally friendly community (Bærum)。

Available Data

The Fornebu area possesses a rich array of accessible data, as detailed in Figure 6.

Figure 6 Types, formats, and sources of available data for the Fornebu area

Type of data	**Format of data**	**Source**
Spatial data		
DTM DEM	GeoTIFF	Geodata Online
Orthophotos	GeoTIFF	Norgeibilder
Point cloud data (Lidar)	LAZ	Høydedata
GIS data	Geodatabase/SHP	Geonorge
Architecture drawings	PDF	OBOS
Other data		
Energy consumption for heating, cooling and lighting (municipal buildings)		Control center at Fornebu
Energy production from heat pump and solar panel		Oslofjord Varme
Mobility of bicycles, pedestrians and cars	JSON	Counters at Fornebu

Modeling method

For the Fornebu area, select “1 Treklang/Oksenøya” for modeling tests. Considering the limitations of the software and the availability of spatial data, FME is chosen as the software to generate the models. The spatial data used includes point clouds and building footprints. More details show in Figure 7.

Figure 7 Overview of the spatial data and software used in the modeling process for Fornebu area

Spatial data			Software		LoD
Type	Format	Source	Name	Use case	
Footprint	SHP	Geonorge.no	QGIS	Process spatial data	LoD2
Point clouds	LAZ	Høydedata.no	FME	Generate 3D model	
Details: The footprint includes base elevation information			KITModelViewer	View CItyGML model	

Main modeling Steps are as follows：

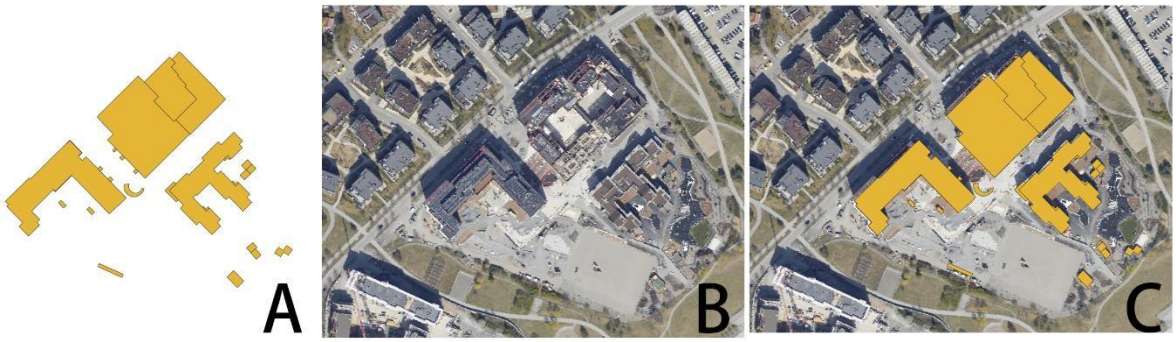

Figure 8 *Import the building footprints(A) and point clouds(B) of selected area in QGIS, and place them in the same coordinate system(C).*

1. **Data Preparing in QGIS**: Open the Geodatabase file of the Fornebu area in QGIS, select the footprints that need to be exported in SHP format, and ensure the 'base height' is retained in the attribute. Create a new QGIS file, import both the point cloud data and footprint data to ensure both of them are in the same coordinate system, and then export them (figure 8).

Figure 9 *The view of data input in FME: building footprints (left) and point clouds (right).*

2. **Point Cloud Data Processing**: Open FME and import the two files (figure 9). Use the PointCloudFilter to filter the point cloud to obtain separate point clouds for the buildings. Use the Clipper to trim the building point clouds along the building's footprint to obtain the required building point cloud.
3. **Extruding Buildings**: Extrude the building from its footprint, with the height being the 'base elevation' extracted from the footprint to the 'median height' in the point cloud.
4. **Export as CityGML**: Use the CityGMLGeometrySetter to assign CityGML semantics and LoD2 to the model. Then, Use the OCG CityGML Writer to obtain the final model output.

The entire FME workbench is shown in figure 10 below, based on a tutorial from the FME Support Center(Sanderson, 2024).

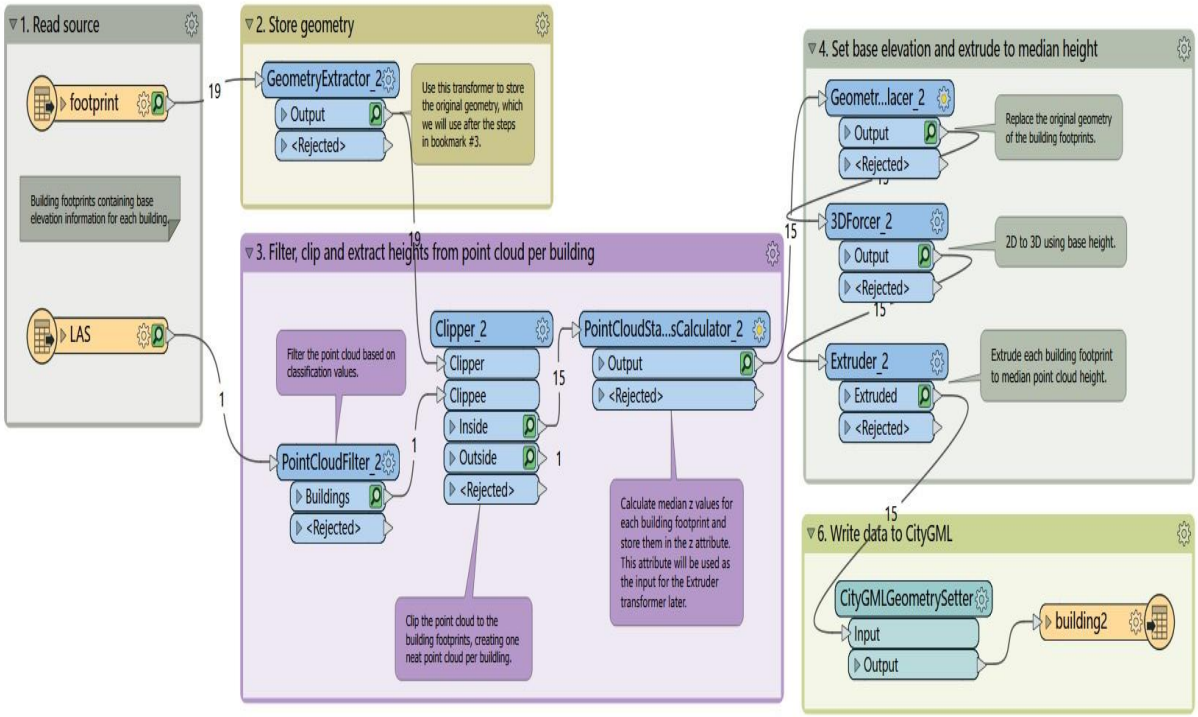

Figure 10 *The modeling workbench for the Fornebu area in FME.*

Neighborhood in China

Current situation

Societal Context

Neighborhoods in China are at different stages of development compared to those in Norway. Over the past decade, the construction of neighborhoods in China has mainly faced the challenge of providing sufficient housing for a large population, which results in numerous aging neighborhoods throughout many cities. These neighborhoods are increasingly unable to meet the current demand for high-quality living standards and urgently require overall quality improvements. Since 2019, the Chinese government has launched extensive renovation projects for these old neighborhoods, transforming approximately 220,000 neighborhoods and benefiting over 100 million residents (Xu, 2024). The renovation of these aging neighborhoods has not only received governmental attention but also reflects the expectations of the general populace.

Basic Information

The neighborhood chosen for this study is located in the Nanyuan area of Xi'an University of Architecture and Technology, situated in the Beilin District of Xi'an, Shaanxi Province, China. It was gradually constructed between 1985 and 2015, spans an area of 13.6 hectares, and houses approximately 6,000 residents, with 42% being elderly. The neighborhood is positioned between the university, commercial areas, and residential zones (figure 11). The functional zoning within the neighborhood primarily includes residential areas (including a mixed-use building and general apartment buildings), educational institutions (including a kindergarten and an elementary school), and an office area of the university. To ensure the safety and privacy of the neighborhood, it is completely enclosed by a perimeter wall and has one main entrance and exit, along with three secondary access points.

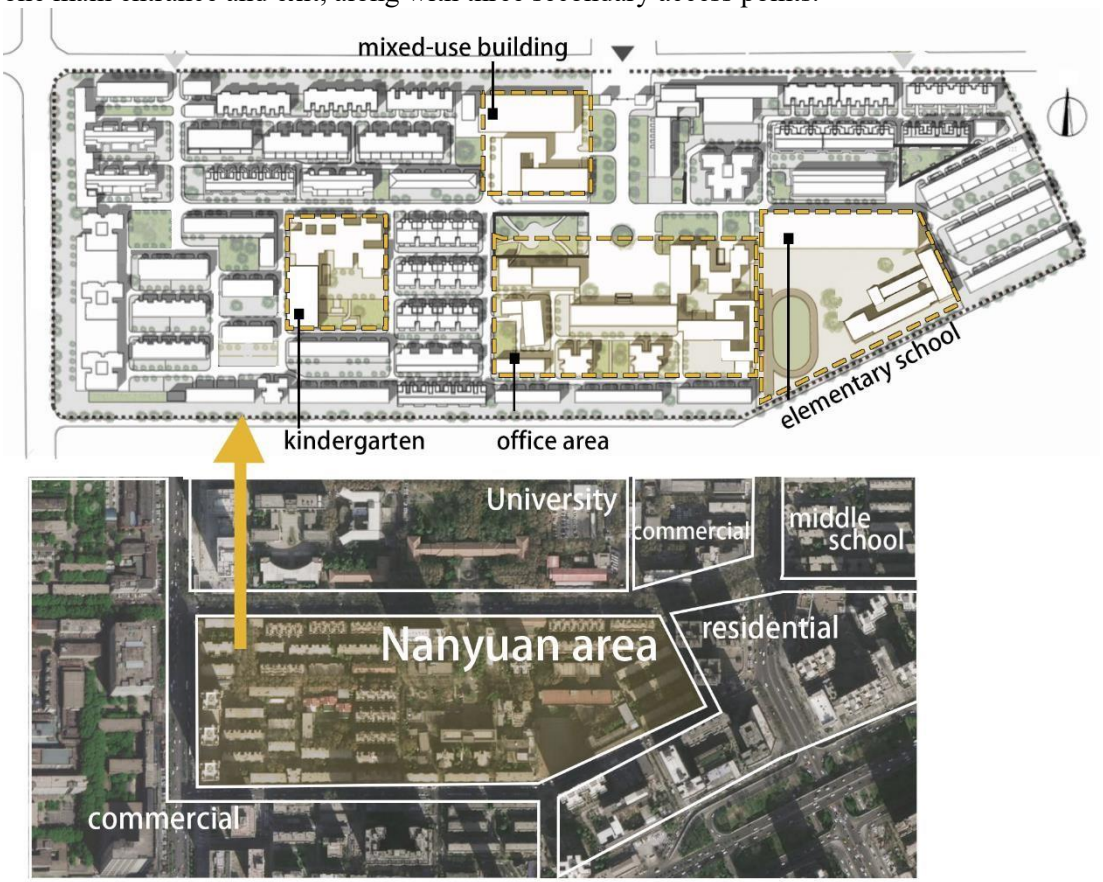

Figure 11 *The surrounding environment and internal functional zoning of the Nanyuan neighborhood.*

Renovation Plan

The renovation target is a mixed-use building located next to the main entrance of the neighborhood. It has commercial areas on the first and second floors, with residential area above which is occupied by young university teachers. The current plan for the neighborhood involves designing a new mixed-use building on the site. The new design will build on the existing functions and incorporate additional features to enhance the overall environment of the neighborhood.

Existing Issues

Volunteers from Xi'an University of Architecture and Technology have conducted multiple field surveys here, which have identified some urgent issues: ① Congestion at entrances during peak hours and highly inefficient pedestrian circulation within the community, ② Insufficient and unattractive public spaces and facilities, ③ Lack of community services for elderly care and childcare.

Available Data

Compared to the Fornebu area, this neighborhood lacks a rich source of data. Only the 3D model of the neighborhood is available, which was created by university volunteers during previous neighborhood survey projects (Figure 12Figure 12).

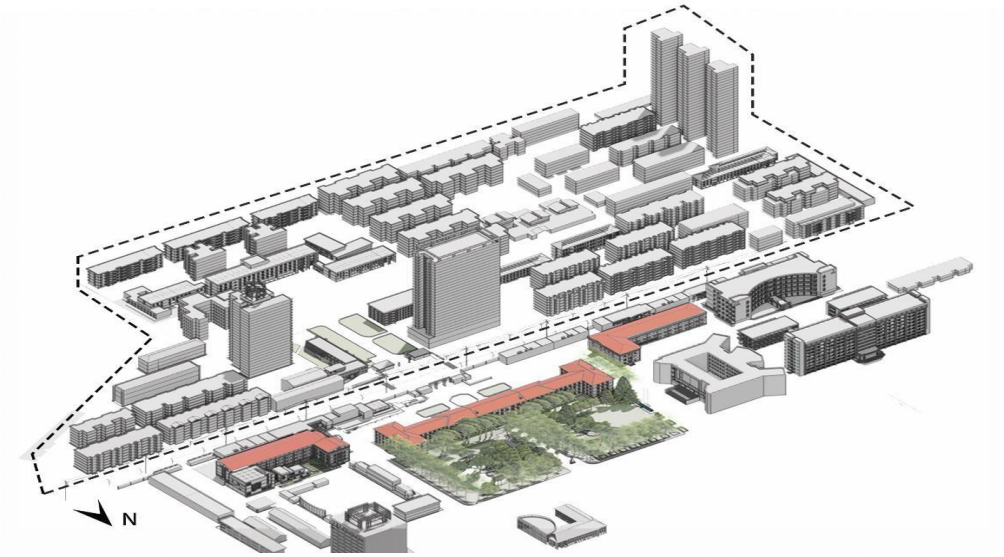

Figure 12 *The view of the 3D model in SketchUp*

Figure 13 *Types, formats, and sources of available data for the Nanyuan neighborhood*

Type of data	**Format of data**	**Source**
Detailed 3D model of the neighborhood	SKP	Xi'an University of Architecture and Technology

Modeling method

For the Nanyuan neighborhood, choose to generate CityGML models using SKP models. There is no need to switch software; models can be simplified directly in SketchUp and then converted to CityGML standard LoD2 models using the GEORES plugin.

Figure 14 *Overview of the spatial data and software used in the modeling process for Nanyuan area*

Spatial data			Software		LoD
Type	Format	Source	Name	Use case	
3D model	SKP	Xi'an University of Architecture and Technology	Sketchup (GEORES plugin)	Simplify 3D model	LoD2
				Convert to CityGML standard	
			KITModelViewer	View CItyGML model	

Modeling Steps are as follows (Voitenko et al., 2024) :

1. **Simplify the model**: the buildings in the neighborhood to the required level of detail
2. **Add attributes**: Use “CityGML Building Toolbar” in the GEORES plugin to add attributes to each building and its components. At the LoD2, add attributes for Ground surface, Roof surface, and Wall surface to each building.

Figure 15 *‘CityGML Building Toolbar’ in GEORES plugin*

3. **Export as CityGML**: After setting all the attributes, the export can be proceeded. Select the type of object to export as "Building", check “LoD2”, choose the CityGML 2.0 standard, specify the save path, and then click “Start”. This will produce a CityGML standard model of the neighborhood in XML format.

Results and outcome

General Workflow

This workflow (figure 16), derived from a study of existing literature on urban digital twins, includes four main steps: data acquisition, 3D modeling, simulation, and visualization. Through this systematic process, digital twins can be practically applied in urban planning and design in a neighborhood scale, which offers effective support to decision-makers, architects, and planners.

1. **Data Acquisition**: The first step in the workflow involves gathering data, primarily divided into spatial data and other data types (such as sensor and IoT data).

- **Spatial Data Acquisition**: For a neighborhood, the physical environment's buildings can be categorized into existing buildings and new developments, each with different spatial data acquisition needs. For existing buildings, accessible spatial data includes terrain data, satellite and aerial imagery, building and infrastructure data, point cloud data, and GIS data. For new developments, the available data typically consists of architectural drawings and models.
- **Other Data Acquisition**: This primarily involves sensor and IoT data, including air quality, meteorological data (temperature, humidity, wind speed), noise data, building energy consumption data, energy collection data from solar panels and energy generation data from geothermal systems, among others.

2. **3D Modeling**: Depending on the available spatial data, different modeling methods are used for existing and new buildings. This step essentially integrates data from various sources, formats, and structures into a standardized format, namely the CityGML standard.

- **Data-driven Modeling**: Suitable for scenarios where high-quality spatial data is available, this method uses software to automatically generate models in the CityGML standard. It allows for the rapid creation of numerous buildings but depends heavily on the accuracy and availability of spatial data. However, the models generated typically have lower levels of detail, suitable only for LoD2 and below.
- **Manual Modeling**: Typically used where architectural models or drawings are available, this method involves converting various forms of 3D models into the CityGML format. Although time-consuming, it allows for highly accurate modeling and can create higher-detail LoD3 CityGML models.

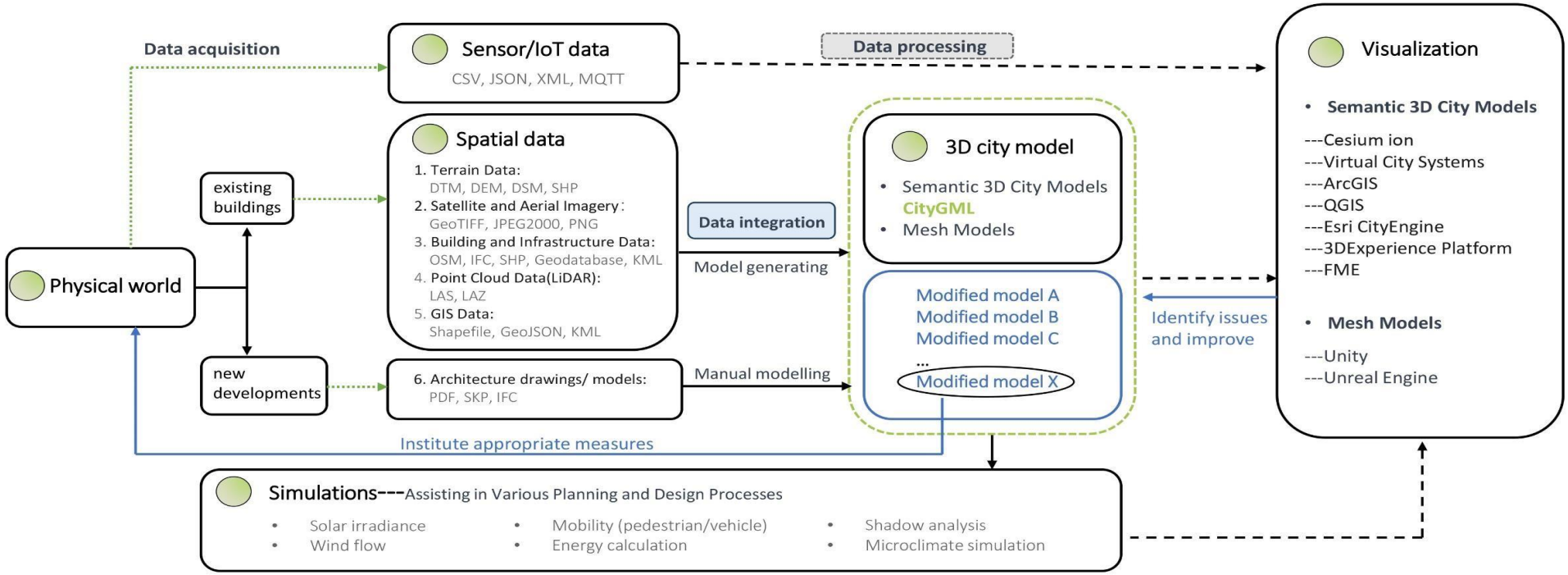

figure 16 ***The general workflow for digital twins at the neighborhood scale***

3. **Simulation**: Once the city's 3D model is obtained, simulations can be performed to aid urban planning and design. Common simulations include solar irradiance, solar radiation, mobility, wind flow, energy calculation, and shadow analysis. (See Appendix)
4. **Visualization**: After acquiring the city's 3D model, sensor and IoT data, and simulation results, these elements can be visualized. There are two main types of software for visualization: one for semantic 3D models and another for mesh models, depending on the specific project requirements. By collectively displaying the city's 3D model, sensor data, and simulation results, the operational status of the neighborhood can be understood more intuitively.

Decision Support and Improvement: Urban digital twins are not just about visually appealing models and simulation results but are intended for practical application to assist in decision-making. This section briefly describes the application of urban digital twins in decision-making and improvement:

In the visualization platform, by integrating sensor data and simulation results, issues of the neighborhood can usually be identified or predicted, allowing users to propose optimization strategies based on this information. Next, by remodeling, the optimization strategies mentioned are implemented in the 3D city model, followed by re-simulation and visualization. This step may be repeated several times.

However, under the collaboration of decision-makers, architects, and planners, an appropriate plan will eventually be formed and can then be implemented in the actual neighborhood. As the real neighborhood evolves, sensor and spatial data are updated, and the new data is used to update the 3D model. Then, a new round of simulation and visualization will commence.

The application of urban digital twins at the neighborhood level is essentially a continuous cycle of improvement and refinement.

Case study(Norway)

The Value of Applying Digital Twin

In this project, the Fornebu area primarily focuses on energy management, aiming to develop the community into a zero-emission area. By understanding the efforts made towards sustainability and environmental friendliness, it is anticipated that digital twins will play a crucial role in energy monitoring within this neighborhood. This includes monitoring the energy consumption for heating, cooling, and lighting of buildings, as well as the energy generated by solar panels and seawater heat pumps.

Additionally, since digital twins can perform various energy-related simulations, such as solar radiation simulation, energy calculations, and shadow analysis, these simulations will help to accurately evaluate the effectiveness of energy strategies and optimize energy use.

Furthermore, as digital twin technology advances, it is expected to integrate more functionalities. For instance, measures currently provided by Bærum municipality, such as energy advice for residents, development of green bus routes, and the storage and reuse of surplus building materials, all have the potential to be incorporated into the digital twin platform. Overall, this platform may evolve into a comprehensive tool closely linked with the daily lives of residents.

Workflow Application

Combining the available data with the neighborhood's development goals, the workflow is designed as shown in figure 17.

Modeling: For existing buildings, considering the limitations of the software and available spatial data, FME is chosen as the software to generate models. The spatial data used includes point clouds (LAZ format) and building outlines (Shapefile), with FME capable of directly outputting CityGML models.

For new constructions, architectural drawings provided by OBOS can be modeled in SketchUp and converted to CityGML standard using the GEORES plugin.

Other Data: The neighborhood can provide data on energy consumption and production, as well as mobility data. Integrating these data in the digital twin will help facilitate the neighborhood's transition to a zero-emission area. Specifically, by monitoring the collected data on energy consumption, buildings with high energy usage can be promptly identified, allowing for the implementation of optimization strategies. Data on energy production helps in the rational allocation of energy. Monitoring mobility sharply detects the movement patterns of residents within the neighborhood, which is

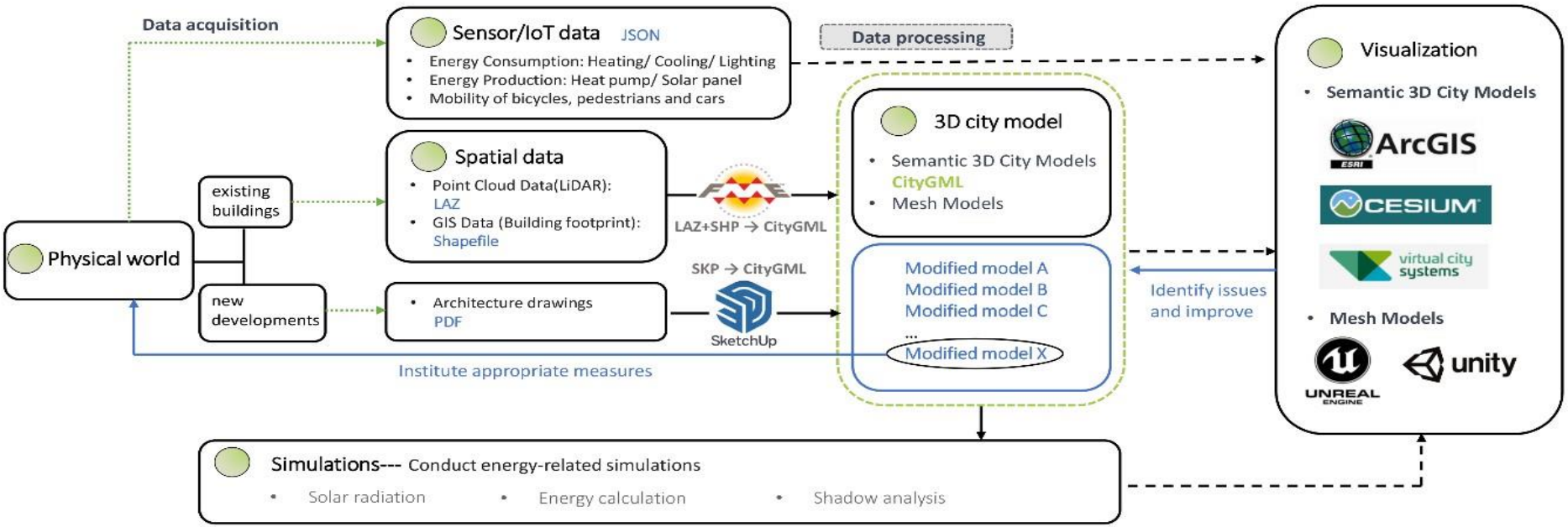

figure 17 *Workflow for Fornebu area*

very useful for the neighborhood 's emission reduction efforts, such as helping to develop new shared bus routes to reduce the use of private cars.
Simulation: Energy-related simulations, including solar radiation, energy consumption calculations, and shadow analysis, will be conducted to optimize energy management and community design.
Visualization Platform: Considering that the project is led by the municipality and focuses on the long-term sustainability of the digital twin, professional paid software is considered to support advanced data visualization needs.

3D model in CityGML standard

The modeling of '1 Treklang/Oksenøya' is completed according to the method described in section 2.2.3, and figure 18 illustrates the important outcomes of each specific step within FME. figure 19 shows the view of the CityGML model in the professional software KITModelViewer, which can separately present the roof surface, wall surface, and ground surface of buildings.

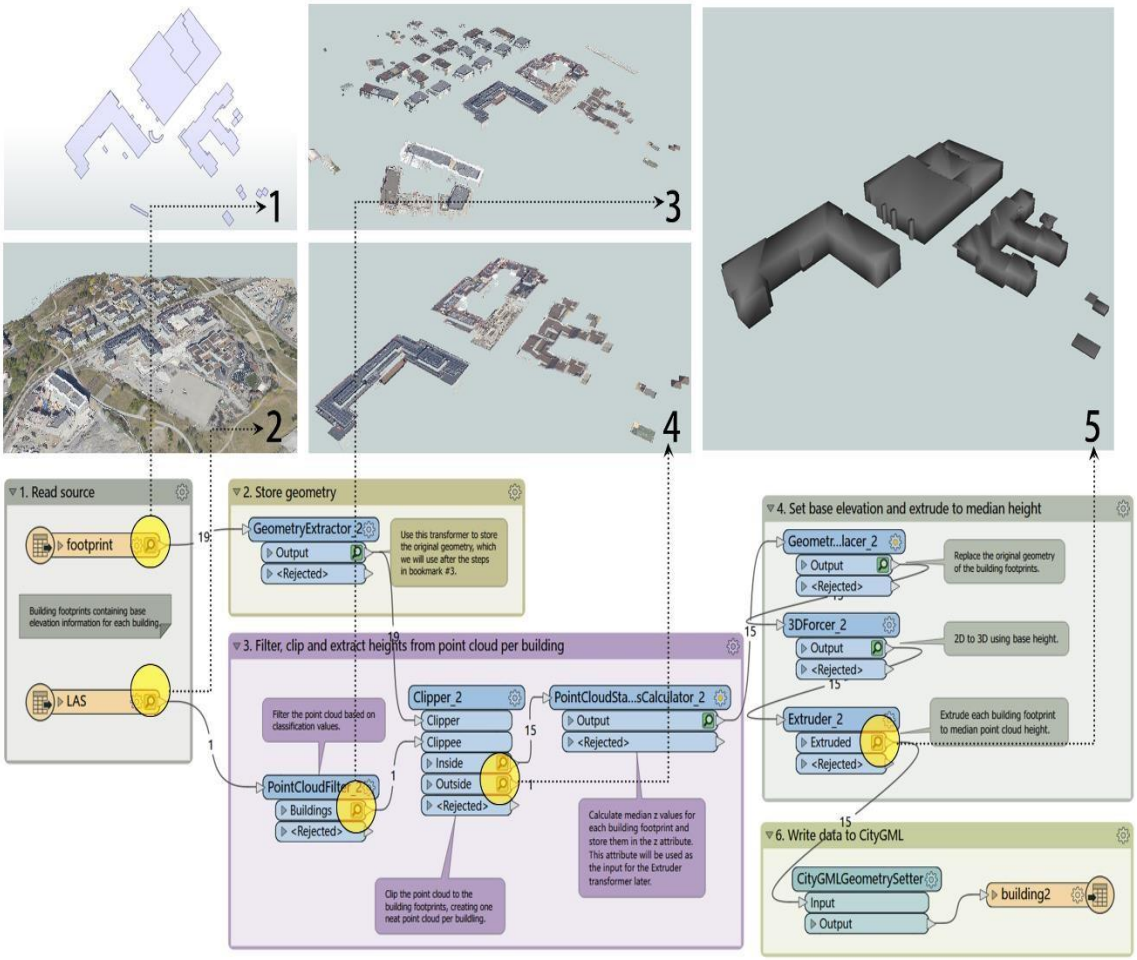

figure 18 *The important outcomes of modeling steps in FME*

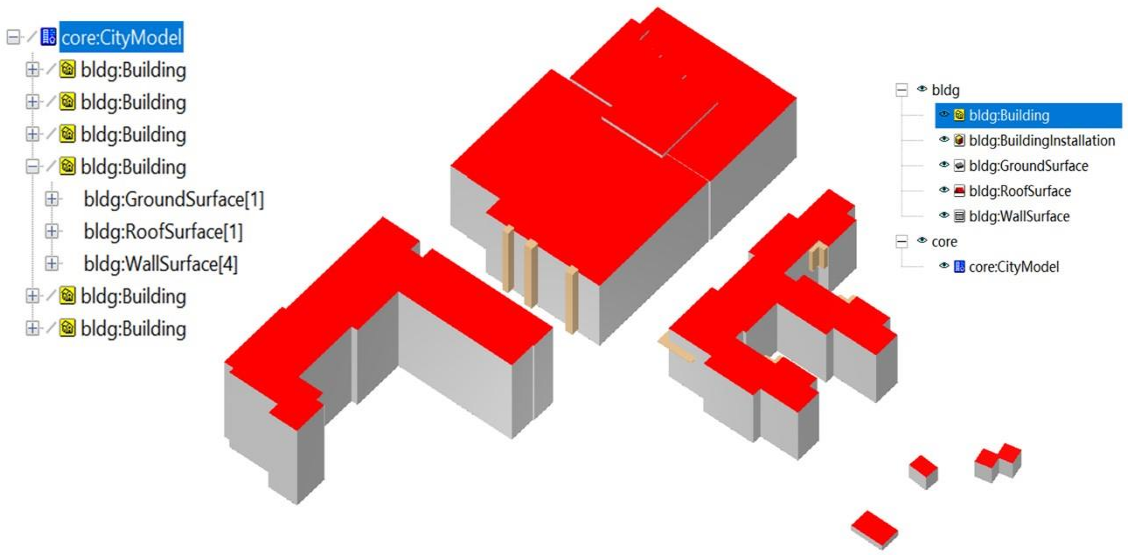

figure 19 *View the CityGML model of the Treklang/Oksenøya area in KITModelViewer*

Overall, generating a CityGML standard model using point clouds and building footprints in FME is feasible, but a comparison with buildings in reality reveals differences in the final model.

Case study(China)

The Value of Applying Digital Twin

For the renovation of aging neighborhoods, due to the complexity of the environment, conducting field research is one of the most crucial steps. Architects and planners need to invest significant time in the area, engaging with residents, observing the dynamics of pedestrian flow, and identifying deficiencies in space utilization in order to accurately understand the specific needs of residents. For example, the activities have been conducted by university volunteers in the Nanyuan neighborhood, including questionnaires, analysis of population density at different times, and pedestrian flow analysis.

However, relying solely on traditional observation methods to collect dynamic information is often time-consuming and labor-intensive, and it is challenging to achieve precise data collection. Digital twin technology can provide significant assistance in this regard by integrating sensor and Internet of Things (IoT) data.

Furthermore, old neighborhoods often lack sufficient attention to microclimate design, which significantly impacts the living environment of community residents, especially in high-density areas where these conditions directly affect the quality of life. By monitoring physical environmental variables such as temperature, humidity, and wind speed with sensors, deficiencies in the environment can be sensitively detected. It is also possible to indirectly assess the physical environment by monitoring human activities. Additionally, by simulating microclimatic conditions in a virtual model, measures can be taken very accurately to improve the community environment.

In summary, the primary goal for this neighborhood is to enhance the environment and provide a better living experience for its residents. Digital twin technology allows a more sensitive detection of deficiencies within the neighborhood, significantly accelerating its renewal and improvement.

Workflow Application

This workflow is designed based on the current state and future development goals of Nanyuan neighborhood (figure 20). Although the neighborhood currently lacks devices like sensors, it is developed based on the experience gained from the survey of this area. The workflow is intended to explore the potential of digital twins for future renovations of neighborhoods in China, serving a certain exploratory and guiding role.

Other Data:

- Infrared Sensors/Thermal Imaging Sensors: In this neighborhood, installing infrared or thermal imaging sensors at key points can monitor changes in pedestrian density at different times. This helps analyze pedestrian movement patterns, identifying and guiding improvements in the current functional layout and design flaws of the neighborhood. For example, areas of the neighborhood may experience local high temperatures and poor ventilation during summer due to high density, which can be directly reflected in pedestrian density. Sensors can accurately detect these issues, aiding in the implementation of corrective measures later on.
- Resident Feedback: Renovations in older communities heavily rely on resident feedback. Collecting feedback through smartphones or other devices is more efficient and convenient, which also allows people to provide feedback at any time.

Modeling:

- As mentioned in section, existing SketchUp models are converted into CityGML standard models using the GEORES plugin.

Simulation:

- Perform microclimate simulations and shadow analysis of the neighborhood to pretest the potential impact of new measures or new constructions on the physical environment of the community in a virtual setting. Such simulations help explore and determine optimal solutions without increasing actual costs, such as identifying the best locations and angles for summer shading facilities, or refining new building forms to enhance community ventilation and improve the summer environment for residents.

Visualization:

- Considering the cost issues associated with neighborhood development, it is recommended to use free software. For semantic models, QGIS is chosen as the visualization platform, mainly aimed at architects and planners. For mesh models that need to be presented to residents, Unity is an ideal choice because it provides a richer interactive experience and visual effects.

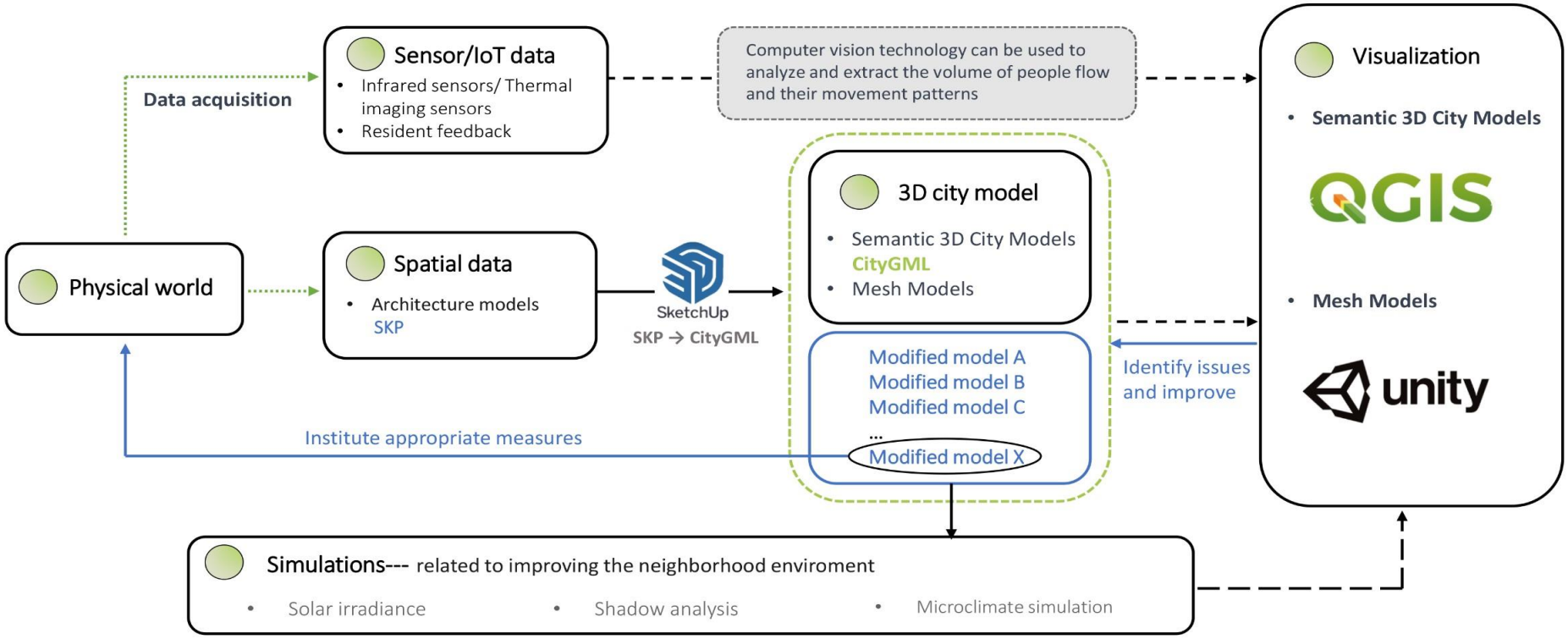

figure 20 *Workflow for Nanyuan area*

Using the modeling method described in section 2.3.3, the modeling of the Nanyuan neighborhood is successfully completed. figure 21 shows the results of manually simplifying the model in SketchUp. figure 22 displays the CityGML standard model generated by the GEORES plugin as viewed in KITModelViewer. The model of the kindergarten is particularly notable; its dataset includes not only the ground surface, roof surface, and wall surface but also the building parts and its own surfaces.

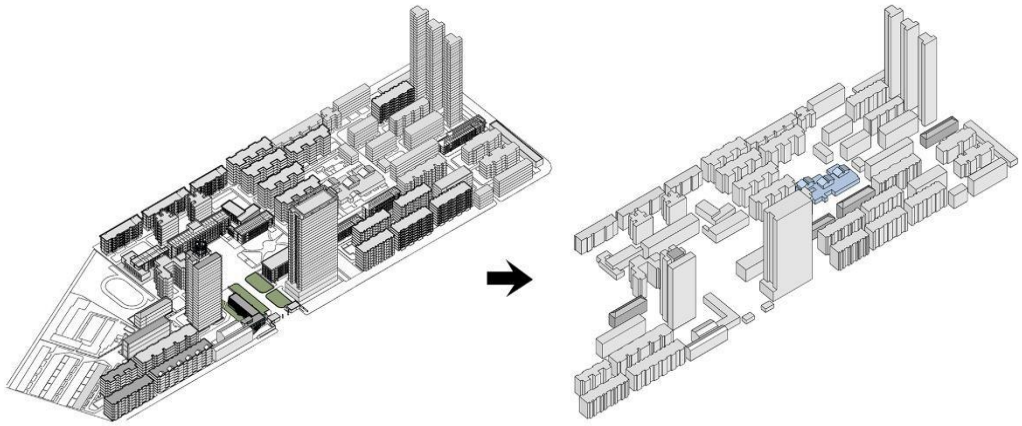

figure 21 *The result of manually simplify the Nanyuan neighborhood in SketchUp*

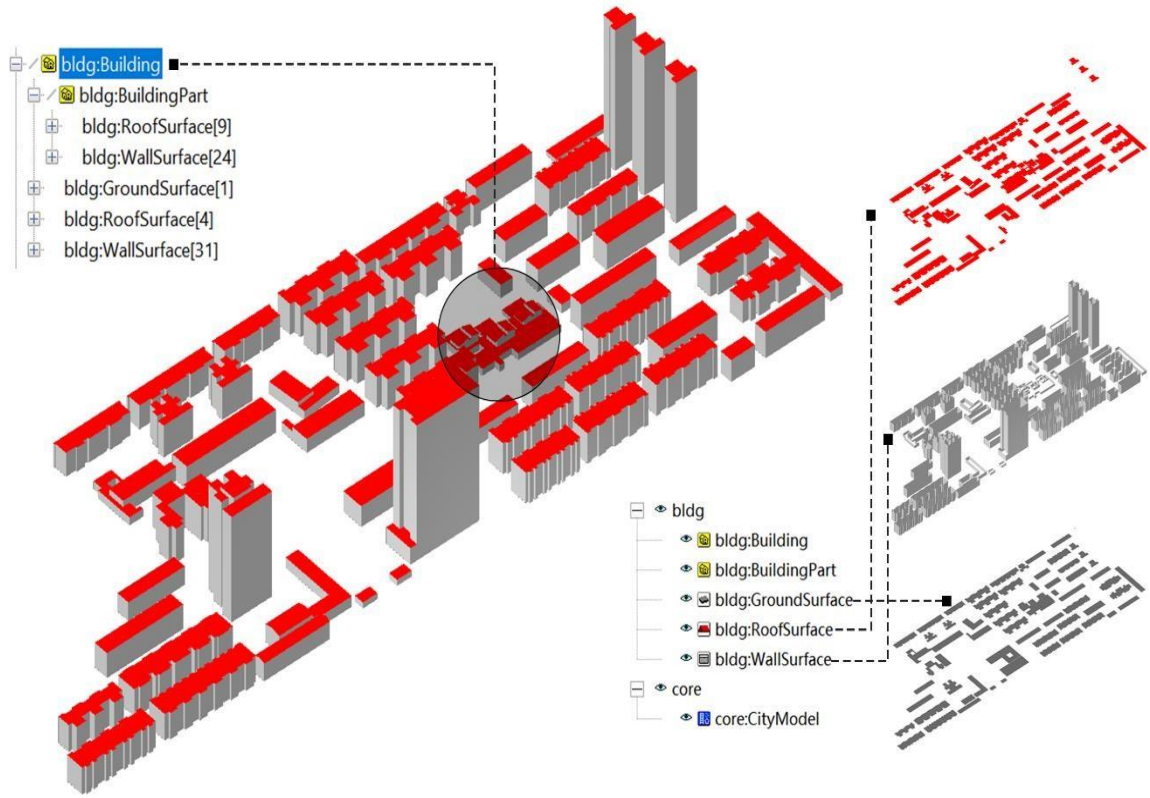

figure 22 *The view of CityGML standard Nanyuan neighborhood model in KITModelViewer*

Conclusions

Overall, the research achieved its anticipated results. It began with a literature review, which was completed by examining relevant studies. Based on the initial research goals of 'developing a workflow to aid neighborhoods in planning and designing via digital twins,' specific research questions and methodologies were proposed. A general workflow was developed based on the insights gained from the literature review, and this workflow was applied to two neighborhoods at different stages of development. It is important to note that, as the development of the workflow was based on theoretical learning, transitioning from theory to practice was crucial. However, due to the multidisciplinary nature of digital twin technology, only the '3D modeling' step was practically tested through the case study of two neighborhood. The 3D model is central to the digital twin concept, and the modeling test served to bridge theory and practice for this study.

The results of the study address the research questions outlined in Section 1.5. The findings indicate that the general workflow described in Section 3.1 can be applied across neighborhoods with different social backgrounds and stages of development, aiding in diverse planning and design efforts. The specific responses to the research questions are as follows:

- The development of a neighborhood digital twin primarily includes four modules: data acquisition, 3D modeling, simulation, and visualization.
- For different neighborhoods, the inputs and outputs of each module are adjusted according to the type of data acquired, the development goals, and the cost requirements of the project, thereby creating a workflow tailored to that neighborhood. In this study, the workflow objectives for the two test neighborhoods are: ① to assist the neighborhood in transitioning to a green, zero-emission area, and ② to help renovate older neighborhoods to improve the environment. The conclusion drawn from the two case studies is that the general workflow has played a significant guiding role in the construction of neighborhood digital twins.
- For the creation of CityGML models, the study used FME and SketchUp, testing two modeling approaches through case studies in two neighborhoods. The details are as follows below:
-

Figure 23 *Comparison of FME and SketchUp in neighborhood modeling*

	FME	SketchUp
Learning curve	powerful but requires a significant amount of time to learn, making it unfriendly to beginners	quick to master, especially for users with an architectural background
Dependency on data	High: can only generate models based on data, making it difficult to modify details	Low: SketchUp is primarily a modeling software
Best use case	Suitable for generating large numbers of buildings with simple roof shapes, such as blocks of apartment buildings.	In the absence of available models, manual modeling is less efficient and better suited for modeling a few complex buildings
Usage recommendation	Pre-process input data in QGIS or ArcGIS to ensure data accuracy and availability.	It is recommended as the next step after FME modeling to optimize individual complex models

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(Re)urbanisa,on of the city: The Case of Ljubljana 2025

Does the Beauty Have a Price?

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Introduction

The art of restructuring and rebuilding ciEes is sEll high on the agenda of the professional debate, searching for methods and concepts that could lead to beFer and more sustainable ciEes. In the last three decades of post-industrial society, due to the implementaEon of the paradigm of sustainable development, the processes of (re)urbanizaEon in European ciEes have intensified. Infill and densificaEon projects in the historical fabric of European ciEes require a sensiEve approach with detailed urban design guidelines that would preserve old and create new urban idenEEes, that is essenEal in view to global standardizaEon and uniformity of the urban space. In the planning and design of ciEes, the aestheEcs of the urban environment is gaining importance again. 'Beauty is a necessity', says Lehman (2010:776), who supports the development of 'green urbanism'.

AestheEcs and design are characterized as two parts of the same process: design as the acEvity of organizing forms and spaces, and aestheEcs as the visual assessment of the final product. However, when architecture and urban space are discussed in addiEon to visual quality, we also evaluate the quality of funcEons, which means that usability is also taken into account when evaluaEng an object or space (Scruton, 1979). AestheEc judgement, which can refer to different levels of aestheEc experience (e.g. sensory, formal and symbolic)[5], primarily depends on the idenEficaEon of phenomena according to certain reference framworks (cultural, ideological, poliEcal) (Teymur, 1981). Thus, for example, aestheEcs in modernism is completely opposed to the aestheEcs of neoclassicism. However, basic aestheEc qualiEes, that we can recognised, are defined as unity, variety, complexity, coherence, dominance, ambiguety, enclosure/ exposure, mystery and suprise. Context, permeability, variety, legibility, robustness and visual appropriateness are the most frequently used qualitaEve urbanisEc criteria in guiding and evaluaEng the quality of reurbanizaEon plans and projects.

Research results show, that good architecture and good design - both on an urban area level and on the more detailed building level – translates into a considerable willignes to pay higer market price or rent. AstheEcal aspects includes the views: from the building, to the building and inside the building. The uElity of aestheEcal aspects generate different benefits:

- Just consumpEon ('art consumpEon'),
- Increased producEvity among employees,
- Icncreased image for the company / family (a symbolic value).
  (Turner, 2002)

[5] Santayana (1955) in his scientific work 'The meaning of beauty' discusses three levels of aesthetic experience: sensory, formal and symbolic. Sensory aesthetic experience: the result of sensory reactions to the environment. Formal aesthetic experience: reaction to certain physical qualities of objects (eg size, shape, color, complexity, balance, symmetry). Symbolic aesthetic experience: conditioned by the meaning and tradition of an object or space (e.g. style and context; image of a space).

Dose the Beauty Have a Price?

Research results indicate:

- A price difference of 5 to 20 percent for good versus poor architecture / urban design.
- Although an investment in good architecture is somewhat risky, especially as it normally implies higher building costs, research results indicate that good architecture is profitable.
- Good architecture/urban design creates posiEve external effects in the urban environment. These effects are not fully taken into account in the economic calculaEon made by the developers, although they are verry important for the quality of city's urban environment.

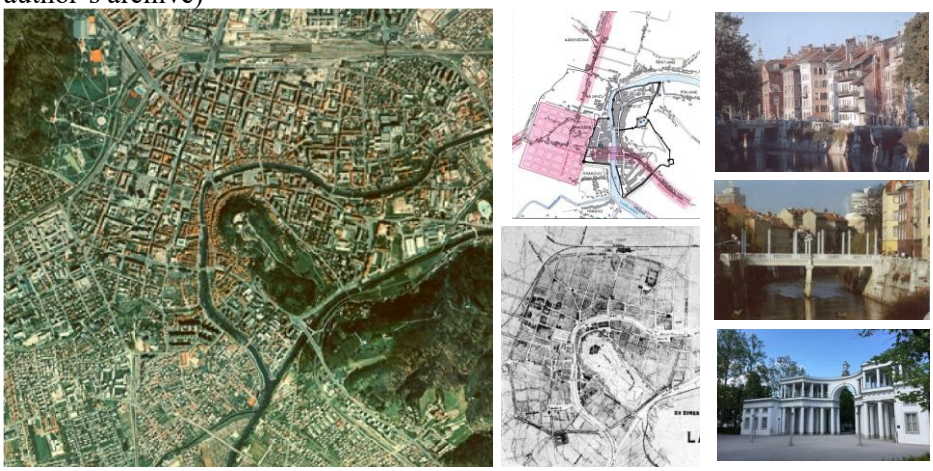
For the placement of the building in the exisEng urban fabric, in addiEon to the funcEons/programs, the arrangement of external public (semi-public) areas and harmonisaEon with the exisEng built structure are important, the same as external effects of beauty (the view to façades of a building).

In order to achieve the desired quality of the built structure and urban space, urban design guiding and evaluaEng the quality of the plans and reurbanizaEon projects is essenEal. The precondiEon for all this is successful urban planning and proacEve city governance, as well as enlightened developers and well informed general public. The case of Ljubljana confirms these theses.

Spatial and Urban Planning in Ljubljana: an overview

Ljubljana has a rich history of successful spatial and urban planning starting after the 1895 earthquake when city adopted general regulation plan prepared on the bases of Maks Fabiani's winning urban design competition project.

Figure 1. City centre of Ljubljana: Emona, Medieval town, Fabiani's plan 1985 (Source: author's archive)



Major part of the City centre of Ljubljana is built in accordance with this plan in orthogonal grid pattern in the first part of 20thcentaury. In the urban tissue of Ljubljana city centre can be recognised also well-preserved urban blocks from the medieval town 16-18 century and remains of Roman Emona town 2-4 century (e.g. archaeological sites and part of the walls).

The city growth, particularly between the two World Wars, prompted the development of several new urban regulation plans, some influenced by Jože Plečnik's "Great Ljubljana" study in 1929 and his human scale vision for the city.

The visual presence of the past in the urban scene is an important element of the aesthetics of the urban environment. In the design of the modernist facade of the building along Slovenska street (former cardo

maximum) with a round brick bulge (bay window), Edo Ravnikar symbolically illustrated the remains of the late antique building - the rotunda, which stood on this site (the area of the Roman Forum).

Figure 2. Ljubljana: The visual presence of the past (source: author's archive)

In 1966 the "General Urban Development Plan" (GUP, 1960) of Ljubljana was adopted, marking the first comprehensive urban development act in former Yugoslavia, based on the modernist-funcEonalist paradigm introducing land-use plan and large housing estates on the outskirt of the town. In the 1980s, the city formulated a new long term urban development plan Etled "The Long-Term Plan of Communes and the City of Ljubljana for the period 1986– 2000," commonly referred to as "Ljubljana 2000."

Figure 3. GUP, 1960 and "Ljubljana 2000" plan (Source: author's archive)

Following Slovenia's independence, in 2001, the city commissioned the development of an innovaEve, informal, strategic spaEal development document Etled the "Urban Development Concept". That was one eyer before the new planning low was adopted. Rooted in the sustainable planning paradigm and the European SpaEal Development PerspecEve (1999) this Concept provided guidelines for the creaEon of the "Ljubljana 2025 Vision" and subsequently the formal strategic spaEal planning document for the period unEl 2025 Etled "The Municipal SpaEal Plan of the City of Ljubljana," known as "Ljubljana 2025", adopted in 2010. "Ljubljana 2025" represented the most crucial step toward earning many awards and the Etle of European Green Capital in 2016. This Etle is given to a city that is achieving high environmental standards, has ambiEous goals for sustainable development and can inspire and promote best pracEces to all other European ciEes (Dimitrovska Andrews et al, 2024). During the preparaEon of the new generaEon of planning documents emphasis was given to sustainability,

strengthening the city's idenEty, making the reinforcement of cultural idenEty and conEnuity of the urban structure.

The aim of the "Ljubljana 2025 Vision" was to stimulate the creation the image of the city as an planned, designed, connected, equipped, self-sufficient, green and resistant city. The "Municipal Spatial Plan of the City of Ljubljana," comprises two distinct components: the strategic and the implementation parts.

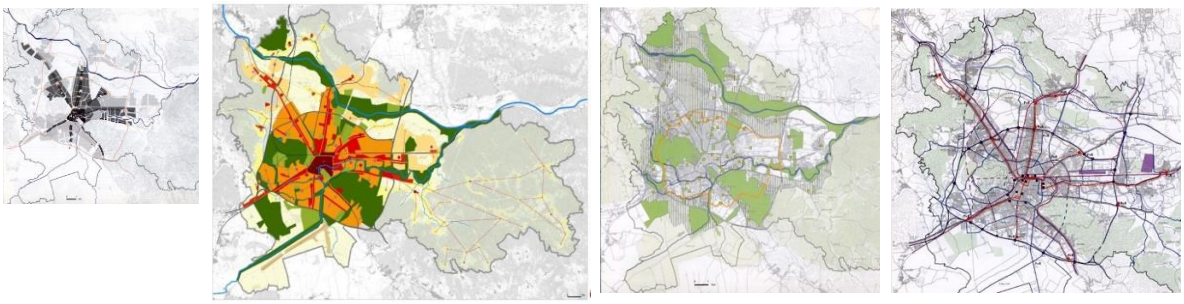
The strategic part of Ljubljana 2025 plan establishes goals, spatial concepts, and guidelines for the development of settlements, landscapes, and infrastructure systems of the city with a strong emphasis on sustainability.

In the development of settlement system, the plane is grounded in the preservation and reinforcement of the radio-centric model in the compact city and enhancement of city image, an increase in density and mixed-use, the provision of a local centres network, and ensuring 500 meters accessibility to public transport stations. Ljubljana 2025 also provides urban design guidelines for the protection, renewal, and development of cultural heritage areas and the distinctive structure of the city.

The landscape system serves as the foundation for planning nature conservation, environmental protection, and other functions related to green and open spaces. The primary goal is to establish the green system as an effective network of green and open spaces crucial for enhancing the quality of life and the city's overall image. The municipal strategic spatial plan also designates spatial protection areas, such as water resource protection areas, flood protection areas, protection of natural and cultural landscapes, protective forests, special purpose forests, and agricultural areas. According to the plan, three-quarters of the entire territory of Ljubljana are green areas.

The development of integrated transport and other infrastructure is aiming to ensure equitable access to various functions and services while facilitating the advancement of public and environmentally friendly transport. The plan places a strong emphasis on introducing sustainable forms of mobility and limiting private car use. Significantly, the plan aims to reduce car traffic in the city centre and expand pedestrian zones. It includes the implementation of a park-and-ride (P+R) system, a comprehensive bicycle network, and enhancements to high-quality public transport.

Figure 4. Ljubljana 2025: morphological concept; settlement, landscape and transportation systems (source: Šašek Divjak et al., 2010)



Territorial governance

Building on successful governance, the City of Ljubljana has developed numerous (sectoral) programs and action plans to implement the goals and spatial infrastructure concepts defined in the Ljubljana 2025 plan. A significant role was also played by the comprehensive reorganization of the city administration, spearheaded by Mayor Janković since 2007. The primary objectives of this restructuring were to enhance efficiency, reinforce specialization, promote cross-sectoral cooperation and teamwork, leading to cross-sectoral synergies.

Mayor Zoran Janković demonstrated the essential skills for a successful urban leader, combining business management, political leadership, and creativity. He assigned the profession an important role in the administration of the city, led by the Deputy Mayor Professor Janez Koželj, an architect and urban planner.

In connection with spatial planning governance practices in Ljubljana, five out of the ten guiding principles for sustainable city governance defined in the Copenhagen Agenda for Sustainable Cities (2006) have been fulfilled since 2006:

- rediscover the city – a city must become a self-sustaining organism complementary to nature,
- redefine city value – the city must encourage a sense of citizenship and individual responsibility towards sustainable values,
- break down silos – sustainable city planning is inherently multidisciplinary therefore innovative, cross-sectoral cooperation,
- redistribute urban decision-making – vertical cooperation between local, national and international public institutions is crucial to sustainable city planning. • Encourage passion in Urban Leadership

(Dimitrovska Andrews et al, 2024)

(Re)urbanisation and renewal projects

The most significant (re)urbanisaEon projects in the inner-city area of Ljubljana[6] have been on 'brownfield' sites of former industrial and military uses. Larger sites with good access from the expressway/ motorway ring road have been restructured predominately in mixed uses (business, commerce and recreaEon), while sites near the recreaEon areas have been restructured predominantly in housing.

RepresentaEve examples of (re) urbanisaEon projects in the inner-city area since 1990 are the following:

- Bežigrajski dvori, mixed uses complex (business and residenEal), built on a a site of former military barracks, along the main axis road Dunajska street,
- Housing estate Nove Poljane, built on a site of former military barracks located by Ljubljanica River,
- Housing estate Mostec, built on a former industrial site located near recreaEonal are Mostec and landscape park Rožnik,
- Sport-park Stožice (stadium and arena), located along the motorway ring road, on a former gravel pit,
- 'BTC City', a shopping, business, leisure and cultural centre established through redevelopment of warehouses zone in the north-east part of the city with a direct access from the motorway ring road. The internaEonal urban planning compeEEon was organized in 2008 by the ŠmarEnska Public-Private Partnership as a guidance for the long-term development of BTC City's wider area.

[6] The area within the expressway/ motorway ring road is defined as the inner city area of Ljubljana.

Figure 4. Ljubljana: Housing estate Mostec and Bežigrajski Dvori (re)development (Source: author's archive)

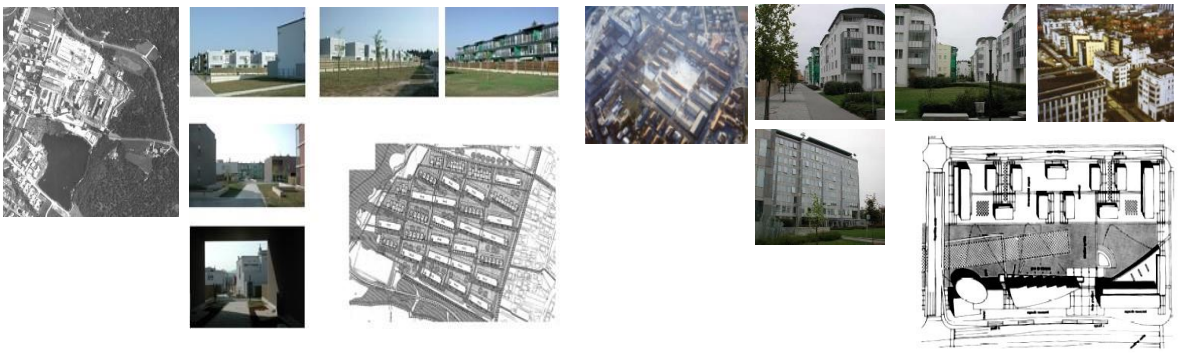


Figure 5. Ljubljana: Partnership ŠmarEnska and Sport park Stožice (Source: author's archive)

(Re) urbanizaEon projects in the inner area of the city included also two new urban parks in a former degraded natural area.

Figure 6. Ljubjana: ŠmarEnska Park and North City Park (Source: author's archive)

Current urban changes in the historic core of the city of Ljubljana have been associated predominantly with commercializaEon and gentrificaEon projects. These projects are most oxen executed as renewal /refurbishment of exisEng building or infill development.

RepresentaEve examples are following:

- Capitol Gardens, mixed uses (offices, housing, shopping mall, public underground garage), gentrificaEon project,
- Center Šumi, mixed use complex (housing, hotel, commerce) built on derelict site of former chocolade & candy factory, thar was used as temporary parking,
- Housing complex Palais & Villa Schellenburg built on a site of demolished, derelict listed building Kolizej,
- Cukrarna Gallery, cultural heritage buildg renovated to galerry,
- Center Rog, tecnical heritage building renowated to creaEve hub.

Figure 7. Ljubljana: Cukrarna Gallery and Center Rog (Source: author's archive)

In the historic core, acording to the strategic plan a large pedestrian zone was established as a reintroducEon of vital and liveable public open spaces to reinforce the public realm.

Figure 8: Kongresni trg (Congress Square) and Novi trg (New Square)

Conclusions

The case of Ljubljana confirms that precondiEon for the quality of urban environment and the image of the city as a desirable locaEon for living and working is successful urban planning and city governance. Ljubljana is achieving high environmental standards, has ambiEous goals for sustainable development and can inspire and promote best urban design pracEces. The city was awarded with many prizes and awards, the most important co-winner of 2012 European Price for Urban Public Space CompeEEon and 2016 European Green Capital Award. In 2021 Plečnik's Iconic Ljubljana architectural works have been inscribed on UNESCO's World Heritage List.

The case of Ljubljana confirms that precondition for the quality of urban environment and its aesthetics, as well as the image of the city as a desirable location for living and working is successful urban planning and city governance.

The case of Ljubljana, confirms also that successful planning and governance require:

- Formation of a selective professional basis, in-depth study of key areas (problems and development opportunities), before the preparation of a legal planning document.
- Effective planning method emphasizing implementation of a realizable long-term vision, which includes concrete development projects and foresees cross-sectoral cooperation and participation of key stakeholders, experts and citizens.
- Proactive territorial governance, which will enable endogenous growth at different levels with new connections between institutions, actors and their interests.
- Public policy on strategically key topics identified as crucial to problem-solving and desired development outcomes supported by sectoral programmes and action plans for their implementation in practice.
- Knowledge how to make 'places' out of 'spaces' with participation of general public and professionals considering issues such as Context, Social, Visual, Functional, Temporal. Creation of legible, vibrant and meaningful public places sensitively integrated into the pre-existing urban, natural and cultural context.
- Strenghthening the identity: (re)building with the respect to the local contextual motto; enhancement of local context, identity and legibility.

The "Urban Development Concept", is now two decades old, signalling the need for a new cycle of strategic reflecEon on the further development of Ljubljana. The Municipality of Ljubljana is also aware of this, and has started acEviEes to define the new vision of Ljubljana 2045 as a basis for preparaEon of new generaEon of planning documents. In April 2024, an internaEonal conference and urban planning workshops were held on the topic of Vision of Ljubljana 2045. Best urban pracEces from Paris, Barcelona, Bilbao, Aarhus and Vienna were presented on the topics of IdenEty (Image of the city and urban landscape), Resilience (Resistance to climate change) and Accessibility (City of good accessibility**)**. Hopefully, the Ljubljana 2024 Vision, with renewed synergy of strategic spaEal planning and governance, will inspire new successful development and placemaking that will raise the quality of the urban environment and even posiEon the city for more presEgious awards.

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Valuation of Sustainable Real Estate Development through Life Satisfaction Parameters

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Abstract

The assessment of sustainable development in real estate through parameters of life satisfaction focuses on evaluating how sustainability practices in property development contribute to overall well-being and quality of life. This approach considers factors such as energy efficiency, environmental impact, accessibility, and community integration. The core idea is that sustainable real estate should not only minimize its environmental footprint but also enhance the residents' quality of life. By aligning sustainable development goals with life satisfaction metrics, real estate projects can create environments that support long-term well-being and social equity, making them more valuable and desirable in the market.

Keywords: Sustainable Development, Life Satisfaction, Real Estate, Enivronment Impact, Quality of Life

1. Introduction

Sustainable real estate development, defined by environmentally friendly design and resource efficiency, has gained prominence in the real estate sector. This trend is driven by both market demand and regulatory requirements that aim to reduce the carbon footprint of buildings and enhance resource efficiency. Traditional valuation models of real estate have primarily focused on economic returns, such as rental yields, property prices, and energy savings. However, with an increased understanding of the interdependence between the built environment and quality of life, there is a need to include non-financial factors, such as life satisfaction, in the valuation process.

Life satisfaction, a core element of well-being, reflects a comprehensive evaluation of an individual's quality of life across multiple domains (Diener, 2000). Parameters such as health, security, environmental quality, social connectedness, and comfort directly contribute to life satisfaction and are influenced by the physical and social characteristics of one's living environment (OECD, 2016). This paper explores the valuation of sustainable real estate developments through the lens of life satisfaction, suggesting that sustainable developments offer benefits beyond financial gains, thus providing a fuller understanding of their long-term value.

Sustainable urban development represents one of the key challenges of modern society. With the rapid growth of urbanization, the need for effective strategies that balance economic development, environmental sustainability, and social justice is increasing. The development of social infrastructure and life satisfaction are essential parameters influencing the success of sustainable urban development. The aim of the research presented in this monograph was to examine how these parameters interrelate and contribute to the holistic sustainable development of urban spaces.

The development of social infrastructure is assessed through various parameters, such as accessibility, quality of services, equality of access, and adaptability to the needs of the population. According to an OECD (2016) study, cities with well-developed social infrastructure are more resilient to social and economic challenges and better support sustainable development.

Life satisfaction represents a subjective assessment of the quality of life of individuals and communities. This indicator is closely linked to health, social relationships, economic well-being, and a sense of security. According to a study by the European Foundation for the Improvement of Living and Working Conditions (Eurofound, 2018), life satisfaction is an important indicator of the success of sustainable urban development. Studies have shown a strong connection between the development of social infrastructure and residents' life satisfaction. For example, access to quality healthcare services and educational institutions contributes to higher levels of life satisfaction (Dolan and Metcalfe, 2012). Additionally, cultural and sports facilities promote social inclusion and strengthen the sense of community (Seaman, Jones, and Ellaway, 2010).

Several cities around the world have successfully implemented strategies for developing social infrastructure and improving life satisfaction. For example, the city of Copenhagen is known for its sustainable urban policies, which include investments in cycling infrastructure, green spaces, and social services. These strategies have contributed to the high life satisfaction of its residents (Gehl, 2010).

Despite numerous positive examples, many challenges remain in the implementation of sustainable urban development. These include financing, management, and the involvement of all stakeholders in the planning process. However, new technologies and approaches, such as smart cities and participatory planning, open new opportunities for improving social infrastructure and life satisfaction (Batty, 2018).

The evaluation of sustainable urban development through the parameters of social infrastructure development and life satisfaction allows for a comprehensive understanding of the complexity of these processes. A holistic strategy that includes investments in social infrastructure and enhancing life satisfaction is crucial for the successful sustainable development of cities. The connection between these

parameters highlights the importance of an integrated approach that considers the needs and desires of residents while promoting social justice and sustainable growth.

2. Literature Review

Many researchers have explored the effects of housing and neighborhoods on residents' satisfaction (Baum et al., 2010; Dekker, 2013; Grum and Kobal Grum, 2023; Grum, Temeljotov Salaj, 2013; Kobal Grum and Grum 2020; Parkes et al., 2002). However, far fewer studies link residential satisfaction to differences among population groups and neighborhood characteristics. Baum et al. (2010) explore differences among racial or ethnic groups and the effects of satisfaction based on neighborhood characteristics. Baum et al. (2010) and Greif (2015) examine differences between homeowners and renters regarding neighborhood characteristics. However, we have not come across a study that connects neighborhood characteristics with intergenerational harmony and residents' satisfaction. To avoid the negative consequences of dividing people into age groups or generations, the concept of the unity of human life is increasingly emphasized, leading to a higher quality of life (Kobal Grum and Grum, 2020; Ramovš, 2019). Unlike many other common approaches that partially analyze individual generations and their placement in residential environments, neighborhoods, and society through various affiliations, we will focus on intergenerational harmony and the comprehensive equal treatment of generations. Our hypothesis is that "the evaluation of sustainable urban development is based on the consensus of generations, which together form a sustainable and resilient intergenerational model of residential environment development aimed at intergenerational well-being." We will explore urban space in a multilayered way, giving central importance to interactions between users of the built environment and the built environment itself. We do not understand the built urban environment solely from its static position, but rather define it as a dynamic interweaving of physical, social, and psychological dimensions of the relationship between individuals and the built environment (Kobal Grum, 2019). We believe that this is the foundation for developing a sustainable housing policy that leads to the understanding of a sustainable city and community. Walker and Lowenstein (2009) even argue that housing policy makers do not understand the fundamental importance of intergenerational solidarity, perceiving it only as a financial-utilitarian relationship. They believe that the idea that social investments and education are primarily for the young stems from an outdated paradigm of a three-generation society. This could lead to the risk of intergenerational conflict, as public finance distributors in welfare states tend to privilege certain social groups. Both young and older generations have various needs, which, in times of slowed economic growth (or recession), especially during a pandemic (COVID-19), will be increasingly difficult to meet from the resources of the welfare state (or at the expense of the middle generation). Therefore, the research will focus on the concept of intergenerational connectedness and the parameters of social infrastructure and life satisfaction, that is, on the connection between social infrastructure and well-being, which determines the level of quality of life and the well-being of the user or their welfare. Quality of life is generally considered an important indicator of the social sustainability of a city and community, and is a multidimensional concept that has been assessed and quantified using numerous objective and subjective indicators. In the field of social sciences and urban or community planning, life satisfaction and happiness are often used as indicators of subjective quality of life (Du et al., 2017). We understand residential satisfaction as the feeling when a person, by living in their property, city, or neighborhood, achieves what they need or desire (Grum, 2017; Mohit et al., 2010). The concept of quality of life, which is today one of the dominant concepts worldwide, is hardly conceivable without the concept of the quality of the urban environment, which is increasingly characterized by its human-centered design (Grum and Temeljotov Salaj, 2016). The built residential environment and the associated satisfaction of users include a range of domains, such as the physical properties and characteristics of the housing, neighborhood, city, social environment, and attachment to the place (Grum and Kobal Grum, 2020).

Sustainable real estate involves designing, constructing, and operating buildings in a way that minimizes their environmental impact. According to the United Nations Environment Programme (UNEP), the built environment contributes to 40% of global energy use and 30% of greenhouse gas emissions (UNEP, 2020). Sustainable developments aim to reduce these impacts through energy-efficient technologies, sustainable materials, and practices that enhance resource conservation (Ding, 2008).

The concept of life satisfaction has been studied extensively in psychology and social sciences, emphasizing subjective well-being (Diener et al., 1999). Various factors contribute to life satisfaction, including personal health, safety, access to nature, and social belonging (Cummins, 2000). In real estate, these factors align closely with sustainable development features that promote healthier living environments, lower pollution, and foster community interactions (Colantonio & Dixon, 2010).

3. Methodology

To examine the relationship between sustainable real estate development and life satisfaction, this study adopted a mixed-methods approach. Quantitative data were collected from surveys measuring life satisfaction in residents living in sustainable and non-sustainable developments. Life satisfaction was assessed through parameters such as health, environmental quality, security, comfort, and social connectedness (Helliwell et al., 2012). Additionally, qualitative interviews were conducted to provide a deeper understanding of residents' experiences in sustainable environments.

The sample consisted of 150 respondents from five different sustainable housing developments in urban settings. Statistical analysis, including regression models, was applied to determine the impact of sustainability features on life satisfaction metrics.

The overall reliability of the scale (Cronbach's alpha) in the original study was .83. In our study, the overall reliability of the scale is .84, with individual factors ranging from .79 to .84. General life satisfaction was measured using a 5-point scale called the "Satisfaction with Life Scale" (Diener, Emmons, Larsen, and Griffin; 1985; SWLS), which measures overall life satisfaction. A high score indicates a high level of expressed life satisfaction. The reliability is high (alpha coefficient is .89).

The research was conducted online, with data collected via an online survey and individually, where participants filled out questionnaires. The sample of participants was randomly selected, with the requirement that they be over 18 years of age.

4. Results (brief owerview)

4.1 Impact of Health and Environmental Quality

Sustainable developments scored significantly higher on health-related satisfaction parameters. Respondents living in green-certified buildings reported lower incidences of respiratory illnesses, which they attributed to better air quality and reduced pollution. Studies have shown that sustainable housing, especially those with green roofs and proper ventilation systems, positively impacts physical health (Evans et al., 2003). These findings support the hypothesis that health is a significant mediator in the relationship between sustainable development and life satisfaction.

4.2 Safety and Security Perceptions

Residents of sustainable developments also expressed higher levels of perceived security, which was attributed to enhanced urban design, such as well-lit common areas and green spaces that promote community surveillance. This aligns with findings from previous studies that highlight the role of environmental design in reducing crime and increasing community cohesion (Newman, 1996).

4.3 Comfort and Energy Efficiency

Comfort, defined by thermal regulation, noise reduction, and overall living conditions, emerged as a critical component of life satisfaction. Sustainable buildings with passive design features that optimize natural light and reduce energy consumption were found to enhance residential comfort. Notably, residents also reported higher levels of satisfaction due to reduced utility costs, which contributed to their overall well-being.

5. Discussion

The results indicate a positive correlation between sustainable real estate developments and life satisfaction, with health, security, and comfort serving as primary drivers. These findings suggest that sustainability in real estate should be valued not only in terms of energy savings and environmental impact but also for its contribution to improving the well-being of residents. Incorporating life satisfaction parameters into real estate valuation could provide developers and investors with a more comprehensive understanding of a property's long-term value. Furthermore, these results imply that policy-makers and urban planners should prioritize sustainability in residential developments to enhance community well-being. Policies that encourage green infrastructure, energy-efficient design, and environmental quality can have a significant impact on public health and safety, which in turn fosters higher levels of life satisfaction. Creating a healthy living environment is the duty of each one of us. The time ahead must prioritize people over material goods, as our research encouragingly suggests. The results of all research methods indicate that people are highly aware of the impact nature has on our health. The findings of the survey show that people want to live closer to nature and need elements of greenery and water, as they have a calming effect on them. Even a short walk in nature can significantly improve an individual's mental and physical well-being. We found that even the greenery in a home can positively affect a person’s well-being, and a view of nature through a window has been proven to positively impact the health of a patient in a hospital. We have explored the influence of the community on the individual. We have also examined the understanding of Confucianism in society. Measures to contain the pandemic were most successful in those East Asian societies that are not autocratic but rather progressive and democratic. Humanity develops in accordance with the structural order of existence. Confucianism, after all, represents a moral interpretation of relationships as the foundation of the building blocks of human life and morality. It is the community that either takes away individual freedom or defends their relative autonomy in relation to the broader society.

6. Conclusion

Sustainable real estate development plays a crucial role in enhancing life satisfaction by providing healthier, safer, and more comfortable living environments. By integrating life satisfaction parameters into the valuation of sustainable developments, this paper highlights the broader societal benefits of sustainability in real estate. Future research should further explore how these parameters can be standardized and quantified in real estate appraisals to better capture the non-financial value that sustainable developments offer.

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Acknowledgements: *The authors acknowledge the financial support from the Slovenian Research and InnovationAgency (ARIS) through the research projects:* Evaluation of the sustainable development of the urban environment through the parameters of social infrastructure and life satisfaction, št. J5-3112 and Health-oriented behavior as a creator of sustainable development of the built environment, št. J7-4599.

Digital technologies and systems for the living of the elderly in their home environments

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Abstract

In Europe and Slovenia, the population is aging, and these demographic changes present challenges. Elderly housing care has become a pressing issue due to the lack of spatial and personnel capacities in institutional care. Additionally, most older people express a desire to live at home, as it provides them with a sense of freedom, independence, and personal control over their own lives. Digital technologies and systems in the home environment play a crucial role in supporting their independent living, allowing them to continue their lifestyle, which in turn boosts their confidence and safety. In this article, various technologies that support this have been reviewed. The purpose of these technologies is to enable the elderly to remain at home for as long as possible, improving their quality of life while also alleviating the burden on informal caregivers, institutional care, and the healthcare system.

Key words: older people, digital technologies, digitalization, smart homes

1 Introduction

The population has been aging rapidly for several years both in Europe and in Slovenia. In Slovenia, since mid-2003, the number of the older people has exceeded the number of young people (Statistical Office of the Republic of Slovenia, 2024). The proportion of the elderly has also been continuously increasing since then—from 16.1% of the population aged 65 and over in 2008, to 19.4% in 2018, and by 2023, this proportion had already reached 21.6% (Statistical Office of the Republic of Slovenia, 2023). At the European Union level, the proportion of the elderly, which was 18.3% in 2013, had risen to 21.3% by 2023 (Eurostat, 2023). The problem of an aging population is particularly pressing in the field of elderly housing care, as institutional care, which lacks sufficient spatial and personnel capacities, is under increasing pressure (Kerbler et al., 2019). Therefore, efforts should be made to ensure that older people can remain in their homes for as long as possible. As noted by Boštjan Kerbler et al. (2017), older people in Slovenia are very attached to their own homes. The home environment represents a familiar space where they can relive their memories (Dahlin-Ivanoff et al., 2007). According to several studies (see Fernandez-Carro, 2014; Stones and Gullifer, 2016; or Mulliner et al., 2020), older people wish to remain in their home environment for as long as possible. In this environment, they feel free and independent, and it also gives them a sense of control over their own lives (Dale et al., 2012). Digital technologies and systems can contribute to extending the time older people spend in their home environment by providing them with a sense of security and confidence for independent living. The term "digital technologies" refers to tools, devices, and services that store, process, and transmit data in electronic form (Pullen, 2009). As explained by Sakari Taipale and Rita Hanninen (2018), digital technologies enable the elderly to live independently, leading to a higher quality and more fulfilling life, while according to Wendy A. Rogers and Tracy L. Mitzner (2017), these technologies can also help them stay connected with others. Technological development and the digitalization of society enable digital technologies and systems. Their use in everyday life is also supported by various strategic directions in Slovenia and the European Union. In Slovenia, these include documents such as *Digital Slovenia 2030* and others (National Interoperability Framework, 2023), as well as the *Act on the Promotion of Digital Inclusion* (ZSDV, Official Gazette of the Republic of Slovenia, No. 35/22, 40/23, and 30/24; hereinafter: ZSDV). At the European Union level, these include the *European Declaration on Digital Rights and Principles for the Digital Decade*, *EU4Digital*, and others. Therefore, the purpose of this article is to present various digital technologies and systems for the elderly to live at home and their benefits in enabling the elderly to stay at home as long as possible.

2 Digital technologies and society

2.1 Advantages of digital technologies and systems for the elderly living

Digital technologies and systems available to the elderly in their homes offer several advantages. One of the main benefits is that they can contribute to successful aging in the individual's home environment. The concept of successful aging was developed by John W. Rowe and Robert L. Kahn (2015) in 2015. It is a multidimensional concept that includes the aging process with reduced risks and physical limitations while maintaining cognitive functions (Crowther et al., 2002). According to Wendy A. Rogers et al. (2020), on one hand, digital technologies can compensate for the reduced abilities of older people to live independently and contribute to living according to their preferences; on the other hand, they can also encourage engagement in various cognitive tasks. Various computer programs and applications available on phones and tablets for older people significantly improve and maintain cognitive functions such as memory and attention, thus contributing to a higher quality of daily life and independence (Shanmugasundaram and Tamilarasu, 2023). Additionally, learning apps and websites offer opportunities for learning and personal development (Aggarwal et al., 2020).

Another advantage of living with the help of digital technologies is that they assist in maintaining an individual's lifestyle and preferences despite changes that occur due to aging, which might otherwise limit physical and other activities (Widmer-Iliescu, 2022). This is facilitated by various home automation devices (such as sensors for door opening and closing, and lights switching on and off), which ensure that older people can remain safe and independent in their home environment (Ollevier et

al., 2020). These technologies also provide routine automation (such as medication reminders) and contribute to a better understanding of the needs of older people (Kerbler, 2012). Additionally, devices help the elderly maintain their lifestyle and preferences by aiding their mobility (such as robotic prosthetics and exoskeletons), thereby enabling them to perform daily activities (Bixter et al., 2019). Daily activities of the elderly are also supported by telemedicine and telecare. Telemedicine involves monitoring patients for diagnosing, preventing, and managing health issues (such as video consultations with a personal doctor), while telecare involves care based on sensor technology (such as fall sensors, emergency call pendants; Carretero, 2015a).

An advantage of digital technologies is that they connect older people with family, friends, and others, enabling them to participate in active social life (Crowther et al., 2002). They thus have an important emotional-social component, highlighted by the socio-emotional selectivity theory. This theory, developed by Laura Carstensen et al. (1999), explains that as people age, they place greater importance on relationships and activities that provide emotional fulfilment. The older they become, the more they value human relationships (Barber et al., 2016). Various studies (e.g., Cotten et al., 2013, and Yu et al., 2021) have shown that the internet and social networks contribute to maintaining social connections and reducing feelings of loneliness and social isolation among older people. Digital technologies also enable older people to stay informed and connected with the "demands of the modern world" (such as online banking, online shopping; Aggarwal et al., 2020).

2.2 Strategic guidelines of Slovenia and the European Union

At the level of the European Union and Slovenia, several strategies, programs, and other legal acts have been adopted with the aim of increasing digitalization among the elderly. At the European Union level, digitalization is a priority (European Union, 2024a), and several measures, programs, and documents have been introduced in this area, including *Council Conclusions on Human Rights, Participation, and Well-being of Older Persons in the Era of Digitalisation*, *Green Paper on Ageing*, *Active and Assisted Living Programme*, *Declaration on Digital Rights and Principles*, *EU Digital Strategy*, *EU4Digital*, and others. In 2020, the Council of the European Union (2020) issued the document *Council Conclusions on Human Rights, Participation, and Well-being of Older Persons in the Era of Digitalisation*, which highlights, in point 5, the political commitment to focusing on the necessary digital skills for older people, in points 8, 20, and 33, the importance of digital literacy for the elderly and the integration of robotics for older people, and in point 34, the need for digital technology to be tailored to the needs of the elderly so that it is accessible, user-friendly, and secure. In 2021, the European Commission (2021b) published the *Green Paper on Ageing*, a document that initiated a consultative process on ageing and intergenerational solidarity. It highlights the need for digital solutions in the home environment of older people, especially those living in rural areas, and the need for digital literacy for the elderly (European Commission, 2021b). *Active and Assisted Living Programme* is a European Union program that funds projects exploring technologies for healthy ageing and innovations, resulting in technological products or services (Active and Assisted Living Programme, 2024). *The European Declaration on Digital Rights and Principles* outlines in point 2b that countries must include older people, especially those living in rural areas, in the process of digital transformation, and in points 4a and 4b, it states that they must provide necessary education and training (European Commission, 2022). *EU4Digital* is an initiative of the European Union aimed at improving digital infrastructure and accessibility, while also enhancing digital literacy and inclusion for older people in European Union member states and Eastern partner countries (European Union, 2024b). The *EU Digital Strategy* is a broader document focused on creating a single and connected digital market and establishing digitalization standards within the European Union (European Union, 2024a). It follows the Digital Compass, which includes four development goals for digitalization to be achieved by 2030. The Digital Compass aims at digital literacy for all citizens, secure and efficient digital infrastructure, digital transformation of businesses, and the digitalization of public services (European Commission, 2021a).

Documents adopted for the area of digitalization in Slovenia that also include older people are, for example, *Digital Slovenia 2020*, *Digital Slovenia 2030* (National Interoperability Framework, 2023), and the ZSDV. The goal of the *Digital Slovenia 2020* strategy was to improve access to digital

technologies and promote digital literacy through education and lifelong learning. The aim was to ensure that services like eHealth and eTaxes were accessible to everyone, including the elderly (Ministry of Digital Transformation, 2016). *Digital Slovenia 2030* extends the goals of the previous strategy, with its main objective being to promote the digital transformation of Slovenia in four areas: society, the state, local communities, and the economy (National Interoperability Framework, 2023). The goal of the ZSDV is to achieve digital inclusion for all residents, including older people, by ensuring access to digital resources and services. For older people, the law addresses this by providing computer equipment (Article 14) and digital vouchers, which allow individuals over the age of 55 who have participated in an educational program to receive a digital voucher worth 150 euros for purchasing basic computer equipment, according to point 2 of Article 27.

2.3 The significance of digital technologies and systems for society

Digital technologies and systems contribute to alleviating the burden on the state and society in several ways. According to Sara Czaja (2016), they enable older people to live independently and fully in their own homes for longer, which reduces the strain on the national budget and the healthcare system (Senbekov et al., 2020). Digital technologies and systems in the home environment help monitor and manage chronic diseases, thus reducing the number of doctor visits and hospitalizations. They also alleviate the pressure on institutional care, which often causes stress for older people (Van der Pers et al., 2015), potentially accelerating their health decline (González-Colaço Harmand et al., 2014) and consequently increasing the need for more intensive institutional care. Moreover, technologies have various impacts on different areas of society. For example, they may lead the government to reallocate financial resources for care (Hatcher et al., 2019), such as shifting funds from institutional care to co-funding digital technologies and systems in the home environment for older people. By allowing older people to remain in their own homes longer, they also reduce the pressure on public funds and formal care (Hatcher et al., 2019). In Slovenia, this is facilitated by the ZSDV.

In addition, the use of digital technologies for elderly care reduces the pressure on informal caregivers, particularly family members who play a primary caregiving role (Kerbler, 2021). As noted by Simona Hvalič Touzery (2006), informal caregivers often struggle to balance work responsibilities with caregiving and face challenges in reconciling caregiving with family life (Jones and Peters, 1992; Salin et al., 2009). Digital technologies relieve informal caregivers (Smole-Orehek et al., 2018) by allowing them to stay in touch with older people when they wish and to monitor their health status without needing to be physically present with the care recipient (Monteiro et al., 2019). Digital technologies also help reduce the number of hours informal caregivers need to spend on caregiving, thereby partially relieving them from caregiving duties (Penteridis et al., 2017).

3 Methods

For the purpose of writing the article and describing selected digital technologies for older people, a literature review was conducted, and documents and other materials available online on the topic of digital technologies and systems for the elderly living at home were examined. The method involves collecting, analysing, and synthesizing previous research that researches various types of such digital technologies and systems that enable independent living for older people.

As part of the project "*Digitalization of Home Living Environments for Older People in Slovenia*," the types of digital technologies and systems available for elderly living were researched. In reviewing the literature on digital technologies and systems, it was found that different classifications are used by authors. Two classifications have been presented and defined:
1. Digital technologies and systems for monitoring and safeguarding the individual and their living environment.
2. Digital technologies and systems for independent living of older people in the home environment.

The first classification was defined by Boštjan Kerbler (2021), and the second by Stephanie Carretero (2015a, 2015b). Emerging digital technologies for the care and support of older people in their living

environments, as defined by Sarah Abdi et al. (2020), were also presented. All digital technologies and systems were categorized into groups and subgroups based on their characteristics.

4 Types of digital technologies for elderly living

4.1 Digital technologies and systems for monitoring and safeguarding the individual and their living environment

Boštjan Kerbler (2021) refers to the living environment of an older person, where various digital technologies and systems are installed, as a smart home. In such an environment, digital technologies and systems enable health and social care services to be provided remotely—known as telecare. The author classifies these into simpler and more advanced versions.

The simplest version of digital technologies is a safety alarm system, a technically simple device based on a telephone connection. A special telephone or a dedicated app installed on a smartphone is provided to the user of the service. The phone is connected to a wireless remote trigger, which the person carries on them (such as a wristband or a pendant around the neck). This monitoring/communication platform allows the user to call for help from a caregiver (such as a relative, neighbour, or acquaintance) or a coordination-information centre by simply pressing the wireless trigger, whenever and from anywhere in the apartment/house in case of an emergency (for example, if they fall and cannot get up), and speak to an operator about their need for assistance. The service may also include reminders. In this case, the user receives messages through various telecommunications media at a chosen time, reminding them to perform a specific task. The reminder can be sent to one or multiple addresses simultaneously, and the user's caregiver may also receive it. The user must confirm the receipt of the reminder. If they do not, the reminder is sent again, and the caregiver is notified.

A more advanced digital system allows the home living environment of an older person to be connected to a remote monitoring network and, through it, to interact with care providers and other service providers. It is used for collecting, storing, managing, processing, transmitting, and disseminating data through a telecommunications system. The author divides more advanced digital technologies and systems into two categories:
1. Digital technologies for monitoring the individual's condition,
2. Digital technologies for monitoring the condition of the living environment.

1. Digital technologies for monitoring the individual's condition
These are sensors installed in the older person's living environment that are part of a remote monitoring network and enable contact with care and assistance providers. The sensors are seamlessly integrated into the individual's home environment, and their role is to monitor the user's life cycle by:
– Measuring physiological functions (e.g., heart rate, blood pressure, skin moisture, blood sugar levels, body weight, body temperature, carbon dioxide levels in exhaled air, bodily sounds, urine and bowel movements, etc.);
– Detecting user activity (e.g., monitoring slow and persistent changes in lifestyle, assessing the behavioural patterns of the observed person based on the number of door passages, frequency of opening the refrigerator door, frequency of stepping on the rug in front of the bed, meal timing and number of meals, etc.);
– Providing alerts to users with cognitive and/or sensory impairments (e.g., reminders for when it is time to take medication, auditory instructions for navigating the space, etc.);
– Enabling and recording social interactions (e.g., video calls to maintain contact with relatives, friends, and acquaintances, and for virtual participation in shared activities).

2. Digital technologies for monitoring the condition of the living environment
These are devices and sensors integrated into a smart home that detect unusual conditions or situations in the living environment, ensuring safety and monitoring. They include motion detectors (for fall detection, automatic lighting control, and door opening), fire, smoke, or gas detectors, water leak detectors, and similar devices. If they detect any changes deviating from the normal parameters of the

user or the conditions in their living environment, an alarm is automatically triggered and transmitted to a call (alarm) centre (to a remote caregiver). The centre then responds appropriately to the situation in the user's home environment. Depending on the type and severity of the issue, the responsible person provides the user with appropriate instructions (recommendations), such as taking medication, visiting a doctor, etc., or notifies public services or service providers (such as home care services, emergency medical assistance, firefighters, etc.) about the user's needs.

4.2 Digital technologies and systems for independent living of older people in the home environment

Stephanie Carretero (2015a, 2015b) categorizes digital technologies and systems for independent living of older people in their home environments into six groups: 1. Information and communication technologies (hereinafter: ICT), 2. Assistive technologies, 3. Smart home technologies, 4. Health care technologies, 5. Home care technologies, and 6. Technologies based on well-being services.

1. Information and Communication Technologies
These are technologies that consist of communication devices such as mobile phones, tablets, and internet applications. They provide older people with access to information, advice, and educational content, as well as opportunities to engage in social, cultural, and political activities. They can also access services such as banking or shopping. For individuals with limited mobility, these technologies facilitate contact with "distant" family members, relatives, and friends (Carretero, 2015b). These technologies can be divided into three subgroups.

a) Social networking technologies
Social networking technologies are designed to create and maintain social networks for older people and to combat loneliness. This includes real-time communication between individuals (Carretero, 2015a) and platforms for organizing meetings, events, and leisure activities (Carretero, 2015b). Technologies enabling real-time communication include services like *Zoom*, *Teams*, and *Skype*. Platforms for organizing events and meetings encompass various forums, exchange platforms, dating sites, and online communities (Carretero, 2015b). Examples of such platforms are *Amintro* and *Mi smo face*.

b) Information platforms and training platforms
These are platforms that offer content for education and training in various fields and on different topics (Carretero, 2015b). They enable learning from the comfort of one's home, regardless of whether the older person has health issues or not. Examples of such platforms include *Simbioza Magda*, *Digitalno vključeni*, *Senior Planet*, and *Academic Earth*.

c) Online services
Services that enable online shopping and online banking (Carretero, 2015b). In Slovenia, more and more stores are offering online shopping for groceries and other necessities. All banks provide online banking services. Such services are helpful for older people who have physical limitations, as well as for those who live far from these services (for example, those living in rural areas).

2. Assistive technologies
Devices and equipment that assist people with physical and cognitive impairments in moving and performing daily tasks (Hansen, 2011). The purpose of these devices is to support older people who would otherwise need to enter institutional or residential care, enabling them to remain in their own home environment (Courtney et al., 2008). Assistive technologies are divided into several subcategories.

a) Cleaning and logistics robots
Technological devices designed to assist in maintaining cleanliness and order in the home environment of older people. Examples include robotic vacuum cleaners, robotic window cleaners, and robotic lawn mowers. An example is the *iRobot* robotic vacuum cleaner, which uses sensors to navigate around the room and both vacuums and mops the floors. These devices help the elderly with mobility impairments

and also assist caregivers by allowing them to allocate their time to other caregiving tasks (Hansen, 2011).

b) Personal care robots
Devices that assist older people with their personal hygiene. These devices are important as they allow older people to maintain a dignified quality of life (Hansen, 2011). An example of a personal care robot is a smart toilet, which cleans the user after use (Washloo, 2024).

c) Robotic prosthetics
Prosthetics that replace lost or damaged body parts (Carretero, 2015b). These are artificial limbs or organs that mechanically and electronically mimic the function of the body parts they replace (Hansen, 2011). An example of such assistive technologies is the *I-limb*. This is a mechanical hand that looks and functions like a human hand and is controlled using signals from the user's muscles and joints (Össur, 2024).

d) Assistive mobility technologies
Technologies that are not prosthetics but substitute or enhance the functionality of arms or legs (Carretero, 2015a). They are designed to replace lost limb control functionality (Hansen, 2011). An example of such assistive technologies is the *iBot* wheelchair, which differs from other electric wheelchairs in its ability to lift the user, navigate stairs, and operate on challenging terrain (Mobius Mobility, 2024).

e) Exercise and rehabilitation robots
Robots used for rehabilitation and exercise to improve mobility compromised by injuries or neurological issues (Carretero, 2015b). The advantage of these technologies is that they can be programmed to be tailored to individual needs (Hansen, 2011), with the goal of improving and recovering sensorimotor functions by leveraging the brain's neuroplasticity and activating limb muscles. This is achieved through functional exercises for the arms and legs, monitored by devices with sensors that adapt according to the person's actual condition (Gassert and Dietz, 2018). An example of such a device for rehabilitation is the *ANYexo 2.0*, used for upper limb rehabilitation (ETH Zürich, 2024).

Matjaž Gams (2019) also includes other digital technologies among assistive technologies, namely exoskeletons, therapeutic robots, and virtual assistants.

f) Exoskeletons
A type of robot that functions as a human skeleton, assisting with activities like walking, standing up, and sitting down (Carretero, 2015a). The purpose of these technologies is to enhance the body's strength in areas where its function is diminished. It works by reading the body's electrical signals for movement, which the device's sensors then translate into movement via the exoskeleton's motors, attached to the body's joints (Hansen, 2011). An example of such an exoskeleton is *HAL-5*, which represents the integration of humans and robots and is used for rehabilitation and improving the quality of life for people with mobility impairments (Cyberdyne, 2024).

g) Therapeutic robots
Robots designed to resemble humans or animals, intended for communication and care of the user (Carretero, 2015a). They are particularly helpful for the elderly who are lonely or have cognitive difficulties. An example is the *PARO* robot (see PARO, 2024), which is shaped like a plush seal and encourages the user to engage in communication and provides care.

h) Virtual assistant
A web-based interface that provides clear and prompt answers to questions, facilitating access to online information, especially for users who are not familiar with digital technologies or those who cannot use them due to physical limitations. Some of these devices also allow for managing functionalities of various applications, such as setting reminders, ordering food delivery, playing music, and more (Carretero, 2015a). Examples include *Siri*, *Alexa*, and *Google Home*.

3. Smart Home Technologies

In a smart home, various digital technologies are integrated to assist the elderly with daily activities. These technologies are programmed to respond and communicate with each other through a local network. They enable monitoring of the user, sending alerts, and performing functions based on specific criteria. Their goal is to contribute to the quality of life for older people by automating tasks and household chores and enhancing physical accessibility (Le et al., 2012). Stephanie Carretero (2015a, 2015b) divides smart home technologies into two subcategories.

a) Home Automation Technologies

Systems that are monitored and managed remotely. Their purpose is to make it easier for the elderly to manage their homes. These include systems for remotely opening/closing doors, turning lights on/off, controlling microwave ovens, stoves, and other household appliances, wireless doorbells with cameras for front doors, keyless entry systems, as well as remote heating or cooling systems, etc. (Carretero, 2015b).

b) Applications of ICT in the household

Devices located on household appliances through which an older person can order food delivery, call for assistance, etc. An example of such a device is the *Samsung* smart refrigerator, which has a display on the door. Through this display, the user can see what food is in the refrigerator, order new food, create a weekly meal plan, or select a recipe (Samsung, 2024).

4. Healthcare technologies

Devices intended for the prevention, detection of diseases, treatment, and maintenance of the health of an older person (Carretero, 2015b). This form of healthcare is also known as *mCare* and *mHealth*. The digital technologies in this group are divided into three subgroups.

a) Telemedicine

Telemedicine includes the secure transmission of medical data and information, such as biological and physiological measurements, alerts, images, audio, video, or any other type of data necessary for the prevention, diagnosis, and treatment of medical conditions, as well as patient monitoring (Carretero, 2015a). Examples include consultations with a doctor or specialist via email or video call.

b) Telehealth

Telemedicine and telehealth are similar terms, but the former refers specifically to services provided by physicians, while the latter encompasses services provided by a range of healthcare professionals, including nurses, pharmacists, social workers, and others (Carretero, 2015a). Its purpose is to offer social and healthcare support, as well as education, health counselling, and answering individuals' questions (Federal Communications Commission, 2024). Examples of such devices include smartphones or tablets, which allow the elderly to have conversations with healthcare professionals.

c) Telemonitoring

Devices for monitoring patients' health and providing remote care (Carretero, 2015b). These devices remotely manage and monitor various health conditions and collect/send information about vital signs to a (monitoring) centre for user oversight (Carretero, 2015a). Examples include smart scales, pulse oximeters, glucometers, and blood pressure monitors. An example of a smart pulse oximeter is the *Wellue Bluetooth Pulse Oximeter* (Amazon, 2024), which stores measurements on an app on a smartphone or computer, and these measurements can be shared with healthcare professionals.

5. Home care technologies

Care that involves the use of digital technologies to maintain the well-being of the elderly and others who need assistance, and to ensure a safe home environment (Carretero, 2015b). These are categorized into three subgroups.

a) Telecare
Telecare or remote care is provided through telecommunications devices that have evolved through three generations. The first generation includes social alarms, such as pendants and wristbands with emergency call buttons. The second generation involves the use of sensors that support social alarms and activate without user intervention (passive dimension of devices), such as sensors for smoke, falls, water leaks, etc. The third generation of devices uses sensors for the automatic collection of daily data and its transmission to caregiving staff or family members, so they can assess older person's need for assistance (Kubitschke et al., 2010). An example of such a device is the *Just Checking* system (Just Checking, 2024), which includes sensors to monitor an individual's movement and activity.

b) Devices for medication optimization
Devices for medication optimization are designed for managing information about medications, their dispensing, usage, and tracking. This includes both integrated devices used to notify and remind stakeholders at multiple decision-making and action points throughout the patient care process, as well as simpler, standalone devices with more limited functionality (such as medication reminders and dispensers; Carretero, 2015a). An example of such a device is the *Hero smart dispenser* (Hero Health, 2023), which automatically dispenses medications and allows monitoring of medication intake and scheduling through a smartphone.

Naprave za optimizacijo zdravil so namenjene upravljanju z informacijami o zdravilih, njihovem izdajanju, uporabi in sledenju. To obsega tako integrirane naprave, ki se uporabljajo za obveščanje in opominjanje zainteresiranih strani na več točkah odločanja in ukrepanja v celotnem procesu oskrbe pacienta, kot tudi preprostejše, samostojne naprave z bolj omejeno funkcionalnostjo (na primer opomniki in dozerji za zdravila; Carretero, 2015a). An example of such a device is the *Hero smart dispenser* (Hero Health, 2023), which automatically dispenses medications and allows users to monitor medication intake and set dosing schedules through a smartphone.

c) AI chatbots
Sarah Abdi et al. (2020) include AI chatbots among smart home technologies. These chatbots allow an older person to converse with them and receive advice on potential disease diagnoses before visiting their doctor. They can be wearable devices, such as smartwatches, connected to an AI-based system that can recognize early signs of illness and provide advice on preventive measures. An example of such technology is *SeniorTalk* (SeniorTalk, 2024), which is a voice-activated smart technology that learns and adapts to conversations, designed for chatting with older people.

6. Technologies based on well-being services
Technologies based on well-being services include devices designed to maintain a healthy lifestyle for older people in their home environment (Carretero, 2015b). They are classified into two subcategories.

a) Technologies for maintaining physical fitness and cognitive functions
This subcategory includes devices designed to maintain cognitive functions and/or physical skills (Carretero, 2015b). Examples include interactive games for cognitive health enhancement and tablet applications that improve reflexes.

b) Lifestyle monitoring technologies
These are sensors in the home environment of an older person, designed to monitor their lifestyle (Kerbler, 2021). An example of such devices is smartwatches, which record and analyse lifestyle patterns.

4.3 Emerging digital technologies for the care and support of the elderly living independently

Sarah Abdi et al. (2020) identified eight emerging digital technologies and systems that could be used in the future for the care and support of older people living independently, namely: a) assistive autonomous robots, b) self-driving vehicles, c) health smart apps and AI-powered wearable devices, d)

new medication dosing mechanisms, e) portable diagnostics, f) voice-activated devices, g) virtual reality, augmented reality, and mixed reality, and h) advanced smart homes.

a) Assistive autonomous robots
Advancements in artificial intelligence, sensors, and human-computer interfaces, along with improvements in robotic skills such as the ability to grasp objects, could enable robots to perform household and self-care tasks. As a result, assistive autonomous robots will be able to help older people overcome physical obstacles etc. Wearable robots, such as suits and exoskeletons, are expected to become more common over time due to reduced costs and sizes. Brain-computer interfaces enable new ways to control prosthetics and exoskeletons, which can assist in the rehabilitation of patients with severe paralysis and visual impairment.

b) Self-driving vehicles
Self-driving vehicles are a new technology that could create new forms of transportation, improve road safety, and reduce traffic congestion. This type of digital technology could contribute to meeting the transportation needs of older people. However, the potential benefits of self-driving vehicles will largely depend on the level of automation that can be achieved. So far, significant progress has been made in creating semi-autonomous vehicles, where the vehicle performs some automated functions, but driver involvement is still required to some extent.

c) Health smart apps and AI-powered wearable devices
These are applications and wearable devices that can potentially support older people in meeting their needs for psychological support, self-care, and access to healthcare. An example of such technologies includes the previously mentioned AI-powered chatbots, designed to provide advice for supporting the treatment of chronic conditions, such as cognitive-behavioural therapy for mental health. Some of these chatbots also offer health advice and suggestions on possible diagnoses before visiting doctors.

d) New medication dosing mechanisms
Advances in sensors, artificial intelligence, and other technologies are enabling innovative methods of drug delivery. Examples include digital pills and DNA origami for targeted therapy, though these advancements are still in the early stages of development.

e) Portable diagnostics
The development of point-of-care diagnostics using smartphones could improve access to healthcare, particularly for older people. Advances in sensor technology for better detection of metabolites are already underway, with the goal of bringing disease diagnosis closer to patients. There is a need to enhance diagnostic processes and integrate them with care services, and advancements in artificial intelligence have shown potential in this area.

f) Voice-activated devices
Voice-controlled interfaces, enabled by artificial intelligence and natural language processing, are becoming important tools for supporting daily living. These interfaces, including virtual assistants like *Google Assistant* and *Amazon Alexa*, can assist older people with healthcare, social life, and home environments by providing information, reminders, and control over home automation. Ongoing research is also focusing on more complex tasks, such as medical triage and management of chronic conditions.

g) Virtual Reality, augmented reality and mixed reality
These technologies create immersive digital experiences by merging virtual and real worlds. They have the potential to enhance social interactions, psychological well-being, and daily activities for older people. Advances in internet connectivity are expected to improve the performance of these technologies, particularly in supporting mental health.

h) Advanced smart homes
These homes use digital technologies to create adaptable environments that respond to users' needs and preferences. They enable automated management of home devices and provide remote health monitoring. Improvements in network connectivity and artificial intelligence could further enhance these systems, making homes more responsive to both verbal and nonverbal signals, and improving health monitoring and activity patterns.

5 Conclusion

In this article, the types of digital technologies and systems in the home environment of older people that contribute to independent and higher-quality living during their extended stay at home have been presented. However, it is important to highlight that the benefits brought by digital technologies and systems to the living environment of older people were the focus. It is also crucial to mention their drawbacks. From a technological perspective, the complexity of using digital technologies can be intimidating to older people, and these technologies may not be well-suited to their needs. Older people may also perceive digital technologies as unreliable and useless if they do not meet their needs (Mitzner et al., 2010). Older people often lack confidence and doubt their ability to learn how to use digital technologies in their later years (Kerbler, 2021). These obstacles can discourage them from adopting and using digital technologies and systems in their home environment. Additionally, the cost of technologies and the high expenses associated with their maintenance can also be deterrents. From the perspective of people's attitudes towards digital technologies and systems, it is important to mention the stigmatization of older people who use these digital technologies and systems. For instance, when they use devices like a help button pendant, others in their environment may perceive them as less independent, which can deter older adults from accepting these technologies or discourage their peers from using them as well (Yusif et al., 2016). Legal and ethical concerns associated with the digitization of older peoples' home environments should also be noted. These primarily involve issues related to privacy and data protection, specifically how and what data digital technologies and systems collect and how it is safeguarded. There is also a dilemma regarding the intrusiveness of digital technologies and the potential reduction in the independence of older people who use these technologies (Zwijsen et al., 2011).

To address the mentioned drawbacks of using digital technologies in the home environment and to emphasize their benefits, it would be necessary to implement legislation specifically for digital technologies. This law should protect users' privacy and ensure that the data collected is appropriately secured. It should also require manufacturers to safeguard users against cybersecurity threats and clearly specify what data is stored by digital technologies and systems and how it is managed. In the future, it would be valuable to researches what factors influence older peoples' acceptance of digital technologies and systems in their home environment, what types of digital technologies and systems they actually need, and how to introduce them appropriately into Slovenian society.

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Acknowledgments
The findings presented in this article are the result of a three-year project, "Digitization of older peoples' home environments in Slovenia," which runs from 2023 to 2026 and is financially supported by the Slovenian Research and Innovation Agency (project code J5-50175). *The authors acknowledge the financial support from the Slovenian Research and InnovationAgency (ARIS) through the research project:* Health-oriented behavior as a creator of sustainable development of the built environment (Project code J7-4599).

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Implementation of digital technologies and systems for the elderly in society

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Abstract

In Slovenia and Europe, the accelerated aging of the population has been observed for many years. This brings challenges for healthcare, institutional care, and social services. Extended home residency for older people and the use of digital technologies and systems can help alleviate these pressures, as they can support older people in remaining independent in their home environment, which can improve their quality of life. It is important, however, that digital technologies are adapted to the changing abilities of aging people, rather than the other way around. Although the European Union and Slovenia have adopted various programs and documents for the digital inclusion of the elderly, digital technologies are still not widely accepted among older people due to various factors. To better understand how different factors influence the acceptance of digital technologies and systems among the elderly, the article presents methods for implementing digital technologies and systems for older people living abroad and in Slovenia.

Key words: housing, older people, digitalization, digital technologies, implementation

1 Introduction

In Slovenia and Europe, the accelerated aging of the population has been observed for many years. For example, the average age of Slovenia's population, which was 41.1 years in 2008, is projected to be 44.2 years in 2024, indicating an increase of 3.1 years. The aging index, which was 116.3 in 2008, is expected to rise to 147.8 by 2024 (Statistical Office of the Republic of Slovenia, 2024; hereinafter: SURS), reflecting an increase of 31.5 index points over 16 years. The proportion of the population aged 65 or older is also rising. According to SURS (2024), this proportion increased by 5.7 percentage points over 16 years—from 16.1% in 2008 to 21.8% in 2024. Population aging is not unique to Slovenia; it is a trend observed across the entire European Union. Data from Eurostat (2024) show that the proportion of the European population aged 65 or older, which was 18.3% in 2013, grew by 3 percentage points by 2023, reaching 21.3%. The accelerated growth of the older population has numerous implications for society and the state, such as the rapidly increasing number of older people who require healthcare and institutional care. The latter is under particularly great pressure due to insufficient staffing and space capacities (Kerbler et al., 2017). Older people can help alleviate the system's burden, as they wish to remain in their home environment for as long as possible (Golant, 2020). Home represents a place they are attached to, where they feel comfortable and can fulfil their desires and needs (Dale et al., 2012), and where they have established social networks (Molina-Mula et al., 2020). The state also supports extended home residency for older people. For example, in 2021, the Long-Term Care Act (ZDOsk, Official Gazette of the RS, No. 196/21, 163/22, 18/23, and 84/23) was adopted and later updated. This law includes various measures, such as family caregivers, to encourage older people to remain at home for as long as possible. In the era of digitalization, digital technologies and systems also enable older people to remain in their homes. With their help, older people can maintain independence in their home environment (Piau et al., 2014), as these technologies provide remote care, monitor their health status, assist with mobility, and more (Maresova et al., 2020). Both the European Union and Slovenia have therefore adopted various programs and documents for the integration of digital technologies and systems into an aging society. At the European level, examples include the *European declaration on digital rights and principles for the digital decade*, the *Green paper on ageing*, and others. In Slovenia, documents that promote digitalization include *Digital Slovenia 2030* and the *Act on Promoting Digital Inclusion* (ZSDV, Official Gazette of the RS, No. 35/22, 40/23, and 30/24). Despite these incentives, digital technologies are not yet well accepted among the elderly, as they are perceived as inaccessible, uninteresting, and not designed for their needs, among other reasons. They also view these technologies as forms of surveillance that invade their privacy (Heart and Kalderon, 2013). Additionally, many feel that digital technologies are stigmatizing and that they are too old for them (Wu et al., 2015). To better understand how various factors influence the acceptance of digital technologies and systems among the elderly, the article presents methods for introducing digital technologies for older people into society.

2 Theoretical framework

2.1 Digital technologies and systems for the elderly

Digital technologies designed for older people are referred to as gerontechnology. The term is a combination of "gerontology," the study of aging and old age, and "technology." It brings together an aging society, which consists of a growing number of the elderly, with the digital age, characterized by technological innovations in products and services. The purpose of gerontechnology is to integrate technological innovations with the needs, desires, and ambitions of aging people, thereby improving their lives and facilitating their participation in society (Bouma et al., 2007). Older people have long used simplified technical aids, such as walking sticks and prosthetic devices. The origins of gerontechnology can be traced back to the late 1980s (Taipale, 2014) as a response to the growing older population and the rapidly changing technological environment in communication (internet, email, digital cameras, etc.) (van Bronswijk et al., 2009). Gerontechnology was introduced by engineers who decided to combine knowledge from the social sciences and humanities with the aim of designing new products and services for aging individuals (van Bronswijk et al., 2011). The main commitment of gerontechnology is that technologies must adapt to the changing abilities of aging individuals, not the other way around. This approach is what enables successful aging (van Bronswijk et al., 2009) or the

extension of functional years in the later stages of life (Urtamo et al., 2019). Gerontechnology is also an interdisciplinary and research field that studies the development and use of technologies that contribute to quality aging (Lipar, 2010).

The digital technologies encompassed by gerontechnology include technological systems related to health, housing, mobility, communication, leisure, and work for older people (Fernández-Caballero et al., 2016), enabling them to live independently in their home environment. These technologies help alleviate cognitive and physical barriers, reduce loneliness, and prevent loss of independence, among other benefits (Piau et al., 2014). This category includes all devices and tools that can enhance the functioning of an older person's limbs, organs, and senses, or even fully replace them, as well as those that simply contribute to a higher quality of life.

Digital technologies and systems found in the home environments of the elderly are classified, according to Stephanie Carretero (2015a, 2015b), into the following groups: information and communication technologies (hereinafter: ICT), assistive technologies, smart home technologies, healthcare technologies, home care technologies, and technologies based on well-being services. The development of these technologies combines multiple disciplines, such as neurobiology, artificial intelligence, cognitive psychology, and engineering, to make digital technology reliable enough to support the independence of older people (Fernández-Caballero et al., 2016).

This can be achieved with digital technologies and systems through telemedicine, which enables the monitoring of the health of the elderly in their homes and remote consultations with doctors, leading to fewer hospitalizations (Bashshur et al., 2020) and improved overall well-being for older people in their home environment (De Luca et al., 2021). With the help of digital technologies, older people can maintain their routines and habits without needing assistance from others (LaMonica et al., 2021). Digital technologies and systems also have a social component, as they help older people stay connected with family, friends, and the outside world, thereby reducing loneliness (e.g., through video conferencing apps, etc.) (Barbosa Neves et al., 2017).

2.2 Factors influencing the acceptance of digital technologies among older people

To understand how and why older people choose to accept digital technologies and systems, it is essential to examine the factors that influence these decisions. The first factor affecting whether older people will accept digital technologies and systems are sociodemographic factors, which include age, gender, education, living conditions, and marital status (Guzman-Parra et al., 2020). Younger seniors, i.e., those aged between 65 and 75, are more likely to accept digital technologies because their cognitive decline is less pronounced compared to older seniors, making it easier for them to learn how to use these digital technologies and reducing their fear of them (Czaja et al., 2006; Kim et al., 2016). Wiktoria Wilkowska et al. (2022) found that older people are more likely to accept digital technologies if they are in poor health. This means that the likelihood of acceptance increases when there is a need for it. Another factor influencing the acceptance of digital technologies and systems among older people is psychological factors. Several studies (see Heinz et al., 2013, or Martín-García et al., 2021) have shown that older people are more likely to accept digital technologies if they perceive them as useful. A significant psychological factor is also the desire for independence. Older people accept digital technologies because these technologies provide them with a sense of control over their own lives and self-sufficiency (Mitzner et al., 2010). An example of such digital technologies is telemedicine devices. The third factor in the acceptance of digital technologies and systems is social factors. Family and friends can significantly influence older adults' acceptance of digital technologies by introducing them in an understandable way and encouraging their use (Heart and Kalderon, 2013). Intergenerational support also plays an important role, where younger people introduce digital technologies to older people and teach them how to use them. By doing so, younger people also establish social connections with older people and help bridge the digital divide between generations, which encourages older people to accept digital technologies (McMurtrey et al., 2008). The last, fourth factor is the technical factors that affect acceptance. Older people are more likely to accept digital technologies if these are technically adapted to their needs (Czaja et al., 2006) and are sufficiently simple to use (Martín-García et al., 2021).

Such technical adaptations include, for example, larger fonts and text, touchscreens, and voice commands.

The acceptance of digital technologies and systems among older people is influenced by several factors, including sociodemographic, psychological, social, and technical factors. However, these are not exhaustive, as factors such as the cost of digital technologies, ease of use, and societal influence can change over time (Peek et al., 2014). Antonios Tsertsidis et al. (2019) identified additional factors through a literature review, such as older peoples' inability to adapt to digital technologies, fear of dependency on them, knowledge and previous experiences with these technologies, etc. Understanding the factors affecting the acceptance of digital technologies among older people is crucial for implementing them effectively into society in a way that will be accepted by older people.

3 Methods

For the purpose of writing the article and describing the implementation of digital technologies and systems for the elderly living in society, a review of literature, documents, and other materials available online regarding the implementation of digital technologies and systems for the elderly living in society in both foreign countries and Slovenia was conducted. This process involves gathering, analysing, and synthesizing previous research that examines various implementations of digital technologies and systems for the elderly living in society both abroad and in Slovenia.

4 Implementation of digital technologies and systems for the elderly living

For the purpose of analysing digital technologies and systems abroad and in Slovenia, the categorization of digital technologies and systems for the independent living of older people, as designed by Stephanie Carretero (2015a, 2015b), was used. This includes: 1. Information and communication technologies, 2. Assistive technologies, 3. Smart home technologies, 4. Healthcare technologies, 5. Home care technologies, and technologies based on well-being services.

4.1 Implementation of digital technologies and systems abroad

1. Information and communication technologies
Ruth Finkelstein et al. (2023) explored the experiences of older people with ICT and its services to better understand how to improve existing technologies for older people and future technologies. They provided the elderly with ICT devices, unlimited access to the internet, and educational resources about how to use these technologies, thanks to sponsors. The devices were installed in their home environments, they were given user manuals, and experts were always available for support. The research indicated that older people would accept and use ICT if the technologies were adapted to their needs and if they received prior knowledge on how to use them. For the acceptance of digital technologies within ICT, older people would require personal, tailored support and training. They emphasized technical factors in the acceptance process, noting that ICT and training on how to use these technologies must be tailored to their needs.

As reported by Birgit Jæger (2004), the Danish government launched a combined research and development program titled *Use of ICT with Older People* in 1999. Under this program, six local development projects conducted social experiments with various applications of ICT for older people and studied their effects. One such project, *Active Senior*, took place at a senior centre called Rosengårdcentret. All activities at the centre were organized by the users themselves. The main goal of the project was to introduce ICT to the centre's users, thereby improving their quality of life and increasing the independence of older people. The centre was equipped with six workstations that formed an ICT café. The café hosted courses for beginners and ICT users, which were led by volunteers. These volunteers were older people with computer knowledge. They best understand the needs and thought processes of their peers. They developed special learning materials and training programs based on the participants' needs (e.g., writing memoirs, setting up a website, etc.). Participants in the project were integrated into this socio-technical network with other older people, receiving instructions at a pace that

was adapted to them, and, if necessary, instructions were also repeated multiple times. The same applied to other local development projects that were part of the aforementioned program. The results at the individual level showed increased confidence and motivation among older people to learn how to use ICT. They expressed satisfaction that ICT allowed them to write and read, which they had previously been unable to do (due to hand tremors, poor vision, etc.). Thus, the highlighted factors were technical, as the digital technologies were technically adapted to users, and social, as the digital technologies were introduced to them by peers in a way they could understand.

2. Assistive technologies

Matthew Spenko et al. (2006) conducted research on the effectiveness and acceptance of assistive technologies for the elderly. They developed two robotic devices, the *SmartCane* and the *SmartWalker*, aimed at enabling older people to remain independent in their home environment for as long as possible. The *SmartWalker* is an assistive technology designed for older people who require a walker for mobility. The *SmartCane* is a robotic "cane" designed to assist with walking that adjusts according to the needs of each user. It features wheels, a camera for environmental recognition, and sensors that detect hand pressure. The hand pressure translates into forward movement of the "cane," which simultaneously pushes the user forward. By rotating the upper part of the "cane," it moves in different directions. In addition to these features, the *SmartCane* offers greater stability for the elderly, more movement adjustments, and the ability to perform various health measurements. The researchers tested both robotic devices in nursing homes. Before allowing the elderly to try them, they distributed questionnaires to determine which device would be more suitable for each person. After testing the devices, users were asked how they would compare the devices with their usual walking aids, how they found the learning process, how easy they were to use, how helpful they found them for mobility, and whether they would use the devices in their daily lives. It turned out that the elderly were satisfied with the devices and would accept them. They appreciated that the devices could be adapted to their needs, but they were not pleased that they initially had to exert quite a bit of effort to start the devices. Additionally, they were bothered by the fact that the devices fully controlled the path and decided on their own where the elderly should go (following a pre-determined "safe" route). It was therefore found that technical factors play an important role in the acceptance of assistive technologies, as the elderly expressed satisfaction with the devices being tailored to the individual, as well as psychological factors, as they placed great importance on having control over their own lives and where they would move.

3. Smart home technologies

George Demiris et al. (2006) explored the attitudes of older people toward digital smart home technologies, specifically a system called *TigerPlace*. *TigerPlace* is an independent living community designed for older people, based on the ageing in place model. The smart home featured an in-home monitoring system that included sensors to monitor and assess mobility issues, detect falls, and track changes in daily routines. These included a stove temperature sensor, a sensor to detect a person's presence in a room and their movements in bed, a breathing and heart rate sensor, and cameras. Older people were involved throughout the design and implementation process of the system. In general, they expressed a positive attitude towards digital technologies, appreciating that these technologies enable independent living in a non-intrusive manner, with the fall detection sensor being the most well-received. However, they had concerns regarding privacy and data protection, particularly wanting control over how the collected data would be used. Thus, psychological factors in the acceptance of digital technologies were highlighted, as the elderly expressed concerns about privacy intrusion by devices in the home environment, while at the same time valuing these devices as a means to live independently at home.

Blaine Reeder, Jane Chung, et al. (2013) studied how older people accept sensors that monitor changes in their movement within their home environment. The researchers first explained the purpose of the study and the digital technologies they intended to use to the elderly. Older people who wished to participate signed a consent form. Members of the research team visited their homes, installed the devices, and tested them, continuing this throughout the study. The devices collected measurements, and the older people also recorded any falls and completed a questionnaire before and after the study to self-assess their mobility. The researchers found that older people are willing to accept digital technologies

if they perceive them as useful. They also found that as long as people are in good health, they are less likely to accept digital technologies (Reeder, Meyer, et al., 2013). This suggests that psychological and sociodemographic factors play an important role in the acceptance of digital technologies.

Gregory P. Sarkisian et al. (2003) investigated the general opinion of older people regarding smart homes and whether they would accept them. A selected group of older people was taken to the *Aware Home*, a smart home set up for the study on the campus of the Georgia Institute of Technology. The goal was to immerse the elderly (potential users) in a technology-rich environment, introduce them to smart home technologies, and allow them to test these technologies. During the tour of the smart home, the older people were given brochures containing information and descriptions of the various smart home technologies. At the end of the tour, interviews were conducted with them. The elderly expressed concerns about the intrusion of the devices into their privacy and their invasive presence in the home environment, leading them to refer to the technologies as "Big Brother." Some were also concerned about the privacy of other family members and visitors who would come to their homes if their residences were converted into smart homes. They saw a positive aspect of smart home technologies in the security they provided, recognizing that the devices installed in smart homes could inform their relatives that they were okay, and in the possibility that these technologies could support their independence in their home environment. The factors influencing the acceptance of digital technologies among the elderly in this case were psychological, as the older people viewed smart home digital technologies both as a means of control and intrusion into privacy, and as devices that enable them to live independently in their own homes.

4. Healthcare technologies

Rakibul Hoque et al. (2017) conducted a study on the acceptance of digital healthcare technologies known as *mHealth* and found that expectations regarding performance and ease of use, fear of usage, social influence, and resistance to change are factors that affect whether older people will accept digital technologies. They determined this by first distributing brochures to older people with information about what *mHealth* is and the purpose of the study, and then distributing questionnaires. These questionnaires were designed based on a model called the unified theory of acceptance and use of technology (UTAUT). The model examines expectations regarding the performance of digital technologies, the difficulty of their use, and the social and facilitating conditions for their acceptance. The model was used to study the intention of older people to accept *mHealth*. Important factors for acceptance were found to be technical, psychological, and social, as older people indicated that for them to accept *mHealth* digital healthcare technologies, it is crucial that these technologies are tailored to their needs, that they are encouraged to use them by others, and that acceptance also depends on the individual's resistance to accepting digital technologies.

George Demiris et al. (2013) studied how older people accepted a telehealth kiosk, a multi-user system for measuring various parameters such as blood pressure, weight, heart rate, and blood glucose. The researchers provided older people with cards that granted access to the kiosk, and a nurse was available to answer any questions and ensure that the cards were not lost. Older people found the kiosk useful but considered it complex for independent use. They emphasized that digital technologies should be designed to be more user-friendly for older people. They appreciated that the kiosk could be used by everyone in the community, as they felt these reduced potential distractions while using it compared to using the technology in their own homes. They also liked the opportunity to interact with other people due to the shared use of the kiosk. Privacy and data security were not a concern for them, as the kiosk was placed in a discreet location. The study highlighted technical factors, as older people felt the device was not well-suited for independent use, and also emphasized the importance of social interactions.

Trisha Lin et al. (2020) investigated how older people accept digital healthcare technologies known as mHealth, which are installed on mobile devices in the form of applications for monitoring chronic conditions. The use of these technologies was actively promoted by the Singapore Ministry of Health. The researchers first showed older people two short videos about the use of the application. Depending on the individual's health condition, they demonstrated the functionality of two or three devices for monitoring chronic diseases (such as a diabetes monitoring app or a blood pressure measurement app).

They found that older people accepted the mobile device as a tool for communicating with healthcare professionals via phone calls and messages, which they appreciated. However, the application caused fear, leading them to be unwilling to accept it. It was thus evident that psychological factors, specifically fear of new technologies, often play a central role in the acceptance of digital technologies. The researchers suggested that older people should be encouraged to accept digital technologies through training exercises to reduce their fear.

Robert Steele et al. (2009) investigated the perception and acceptance of wireless sensor networks among older people. They conducted focus groups in which they introduced healthcare technologies and their functionality to the participants. The participants were then asked about their opinions on the described technologies. Older poeple indicated that independence was very important to them, and they would accept technologies that could enable this. Privacy of health data did not seem as crucial to them, with the primary factor influencing their acceptance of such digital technologies being their cost. Therefore, the factors identified for the acceptance of healthcare digital technologies among older people were price and the desire for independent living in their home environment—the latter being a psychological factor in acceptance.

5. Home care technologies and well-being-based service technologies
Blaine Reeder et al. (2020) investigated how older people accept wearable digital technologies (such as wristbands and smartwatches) and smart home technologies (such as bed motion sensors, room motion sensors, and video sensors). Before conducting the study, the researchers demonstrated the operation of the sensors to the users, explained where they would be placed, and how they would perform measurements. The study revealed that older people preferred wearable digital devices, as they reported spending most of their time outdoors. They found smart home technologies useful for people who spend most of their time indoors. Users did not express significant concerns about privacy and data protection, but they did worry that their data could be accessible to everyone and that this might lead to break-ins into their residences. Therefore, privacy emerged as an important factor in the acceptance of these technologies, as older people were not entirely convinced that their data would be securely stored.

4.2 Implementation of digital technologies and systems in Slovenia

1. Information and communication technologies
Helena Blažun et al. (2014) investigated whether older people are familiar with ICT and whether they use them or would like to use them. They did this by first orally presenting the project and its purpose to the older people and then conducting interviews with them. They found that general familiarity with ICT among the elderly is satisfactory, but it varies by region. The reasons older people gave for not using ICT included fear of the them, lack of knowledge, age—believing they were too old to learn how to use them—and lack of interest. Among these reasons, the majority of older people cited age and lack of knowledge as the main barriers to ICT use. They also mentioned distrust of ICT and high associated costs. Older people thus highlighted sociodemographic factors, specifically age, which they believed was the main barrier preventing them from learning to use ICT, and knowledge, as they felt they lacked the necessary skills to use ICT effectively.

The Ministry of Digital Transformation (2022), in collaboration with the social enterprise Simbioza, implemented the *Mobile Heroes* project, which used a traveling classroom and trained experts to provide digital literacy training for older people living in rural areas. The goal was to bridge the development gap between urban centres and rural areas and to enable older people to use digital technologies independently and autonomously. As part of the project, workshops were held to teach older people how to use ICT, and individual consultations were also provided. Older people who did not have their own equipment could borrow it at the workshops. According to Simbioza (2023), older people are interested in learning how to use ICT, as evidenced by the increasing number of participants each year. They emphasize that the adaptability of the environment and teaching methods tailored to the needs of older people significantly influence this interest. They find that technical factors have a major impact on the acceptance of ICT, as successful learning of digital technologies depends on the spatial and methodological adaptation to older people.

The INRISK Institute for Risk Exposure System Research, as part of the *Smart Villages for Tomorrow* project (Bogataj et al., 2020), developed the concept of the *smart silver village*. Smart Villages for Tomorrow are local communities that focus on training the older people living in rural areas to use digital technologies. This is done through workshops. However, loneliness, lack of knowledge about using digital technologies, and poor access to information have not generated significant interest or desire among older people to acquire knowledge about digital technologies. Researchers observed that older people believe they can manage well without these technologies. Another issue is the inadequate or non-existent infrastructure, as many older people in their home environments do not use telecommunication packages that would provide them with internet access.

2. Assistive technologies

An example of the introduction of assistive technologies for elderly living in society in Slovenia, which includes cleaning and logistics robots, personal care robots, virtual assistants, therapeutic robots, mobility aids, robotic prosthetics, exercise and rehabilitation robots, and exoskeletons, can be found at the University Rehabilitation Institute of the Republic of Slovenia Soča. There, they are developing a robot named *BART* (Stepančič, 2019), which is used for rehabilitation after a stroke and relearning how to walk. The robot supports the person at the pelvis and helps them walk on a treadmill. The elderly of the Šiška Senior Home were asked about their opinion on a robotic assistant. Some odler people expressed that they would miss human warmth. Others, however, would accept robots if it meant they could remain independent in their home environment for a longer time.

3. Smart home technologies

Boštjan Kerbler et al. (2020) conducted a research project to study the acceptability of certain technological solutions integrated into smart homes among older people. This was done through a survey. Before the survey, they briefly introduced the older people to smart home technologies. They found that most older people were favourable towards smart home digital technologies, particularly safety devices, devices for measuring physiological functions, reminders, and mobile phones. They also discovered that older people are more interested in the usefulness and proper information about the operation of these devices than in the technological aspects of how the devices work.

4. Healthcare technologies

Mojca Pušnik (2013) researched remote monitoring, which is conducted using the so-called red button. This is a special device that an older person uses in combination with a telephone in their home environment. The device, in the form of a red button, worn as a bracelet or necklace, allows the user to call an operator by pressing the button. During the conversation, the user can be several meters away from the phone, even in a neighbouring room. The operator provides assistance (advice, information, comfort, conversation) and, if necessary, notifies caregivers or the appropriate public service and coordinates the provision of help (Primožič, 2011). As part of the research, the researcher conducted interviews with older people, asking them about their reasons for accepting remote monitoring, how digital healthcare technologies have changed their lives, how they understand remote monitoring, how using the red button has changed their lives, and what social dimensions it had. She found that older people decide to accept remote monitoring if they need it due to deteriorating health. The elderly perceive these digital technologies as tools for independent living in their home environment and feel safe and satisfied using them. They did not view the devices as a form of surveillance but rather as a means to establish and maintain contact with their social network, particularly with family. The factors influencing acceptance are cited as health, since they would accept the technology if necessary, and social factors, as the devices help them maintain connections with their social network.

Boštjan Kerbler (2013) investigated the attitudes of older people towards remote home care, also known as telecare. As part of a broader study on the living habits, preferences, and needs of older people in Slovenia, he conducted interviews with the elderly. Before starting the interviews, he introduced them to the concept of home care system, explained how it works, and answered any questions they had. He found that older people generally had a positive attitude towards telecare, but half of the interviewees did not believe that the telecare system could enable extended living in their home environment. Some

also expressed concerns about privacy and security. Therefore, privacy was identified as a significant factor in the acceptance of digital technologies, as older people worry that these technologies might intrude too much into their private lives. Additionally, appropriate information about digital technologies is also an important factor.

Simona Hvalič-Touzery et al. (2022) conducted a four-month study to investigate the perceived benefits of wearable activity monitors and telecare systems among older people. They started by distributing a questionnaire to older people and their relatives. Then, they organized workshops on using the *GoLiveClip* device with smartphones, which the older people used for four months. The *GoLiveClip* (Gociety Solutions, 2024) is a clip-on device that functions as an activity monitor, an emergency call button, and a fall sensor. During the period when older people used the device, a customer support service was available three times. While using the device and at the end of the monitoring period, the participants filled out a questionnaire again, and follow-up interviews were conducted. The results showed that the safety features provided by the device were important to older people and that the device encouraged increased physical activity. However, the study also revealed that these devices should not be connected to smartphones, as older people are not accustomed to carrying their phones with them at all times. Therefore, technical factors are highlighted, as it is important that devices are tailored to the needs of older people.

According to Milena Zupanič (2023), Telekom Slovenia launched a pilot project called E–Home Care in 2022. The goal of the project is to provide older people with independent and high-quality living in their home environment and to relieve their families. Older people were provided with an E–Home Care package, which included a phone and a wristband with an emergency call button, a mobile motion detector on a pendant also equipped with an emergency call function, a fall sensor, a SIM card with direct connection to an assistance centre, and maintenance and servicing of the equipment. Test participants noted that the digital devices gave them a sense of security and ensured that they received help in the shortest possible time. They also believed that the devices enable them to stay in their home environment for an extended period of time. Thus, psychological factors were highlighted, as the digital devices provided a sense of security and control over their own lives.

5. Home care technologies, and technologies based on well-being services

Mojca Šetinc (2015) investigated the usability and opinions of older people regarding the *GoLivePhone* application for smartphones, which includes various emergency assistance features: 1. emergency function—in emergency situations, pressing the emergency icon displays the number 112, after which you only need to press the call icon, 2. help function—pressing the help button sends the caregiver the older person's location data within ten seconds, 3. ICE function—contains an identification card with information about the older person's date of birth, blood type, medical condition, medication details, including the medications being taken, allergies that they have, and caregiver contact details, 4. "How are you?" function—allows the older person to inform the caregiver about how they are feeling using icons, 5. "Guide me" function—provides navigation to a specific address, locating interesting or important points to which the navigation can guide the user, and sets up a safe zone around the home, alerting the caregiver when the older person leaves this area, 6. medication reminder function—allows the input of medication details, dosage, and schedule, 7. activity level function—records the user's activity level and calorie consumption, and 8. fall risk function—displays the probability of a fall at a given moment and the history of fall risks. During the usability testing and collection of opinions from older people about the *GoLivePhone* app, participants first received documents with basic information about the app and the testing process, followed by a questionnaire. The first part of the questionnaire contained socio-demographic questions, while the second part focused on mobile phone usage. This was followed by a five-minute overview of the *GoLivePhone* app, after which the elderly assessed their initial impressions of it. Testing consisted of eight tasks with instructions provided on a card. Their opinions about the app were recorded on video and audio during the testing. Additionally, a longer test was conducted to determine how someone unfamiliar with smartphones would use the app. For this, a smartphone was provided, and contacts of relatives were pre-loaded into the directory. After the testing, an in-depth interview was conducted. In the initial test, older people found the app useful and clear but complicated to use. A technical factor was highlighted, as the apps design did not meet the expectations

of the older people. In the second test with an individual who was not a smartphone user, the person quickly learned to use the app and emphasized that proper learning, which includes repeated practice and assistance, is crucial for easier use of digital technologies.

5 Advantages and disadvantages of implementing digital technologies and systems for older adults

5.1 Advantages and disadvantages of methods of implementation abroad

Abroad, manuals or video content were used to introduce digital technologies and systems for the living of older people in their home environments. Professional support and practical device testing were also offered as part of the introduction of digital technologies for older people. These approaches have been employed in several studies, demonstrating numerous advantages in implementing digital technologies. ICT was introduced in the home environments of the elderly by having experts, with the help of sponsors, supply ICT devices, install them, and provide personal training while being constantly available for support. Older people appreciated it when training for using digital technologies was conducted through personalized instruction tailored to their needs and when technical support was always available. This increased older people's motivation to learn about ICT and their confidence in using it. In the implementation of assistive technologies, older people first received a questionnaire to assess their needs, and appropriate devices were assigned for testing based on the results. Older people were satisfied that the devices were tailored to their needs. In the case of smart home technologies, older people were involved throughout the entire process of implementing digital technologies. They were informed about the functioning of the technologies and therefore accepted the devices positively. They believed that these technologies unobtrusively ensured independent living, as the devices informed family members if everything was okay. Healthcare technologies were introduced by experts through first distributing brochures with information about digital devices to older people, and then providing them with questionnaires to assess their intention to accept the technologies. Researchers introduced the operation of sensors to users, explained where they would be installed, and how measurements would be taken. Older individuals were satisfied with the devices' functionality, which allowed communication with healthcare staff, and they were not concerned about the safety of the collected data due to the clear explanation provided. Home care technologies and technologies based on well-being services were also implemented by explaining the operation of sensors to older people, including where they would be placed and how measurements would be conducted. Older people appreciated wearable digital technologies as they allowed them to spend more time outside their residence.

In addition to the advantages, our analysis of the implementation of digital technologies also identified several drawbacks. Experts introduced ICT devices into the living environments of the elderly by providing the ICT devices, installing them, supplying user manuals, and offering ongoing support. However, older people found the manuals and support inadequate, stating that they would not accept ICT devices unless these were tailored to their needs and they received prior knowledge on how to use them in a way that was adapted to them. In the field of assistive technologies, older people highlighted the issue of devices not being adapted to their needs, as obstacles for them also include various technical requirements of digital technologies, which demand more knowledge for usage or even greater physical strength. Smart home technologies were introduced by first presenting the purpose of the research and the digital technologies to the elderly, followed by visits to their homes where the devices were installed. A significant drawback identified by the elderly regarding the implementation of digital technologies for living was concern about privacy and the protection of personal data. They were also worried about the intrusiveness of the devices in their home environment and their use as a means of surveillance. Moreover, they would not accept smart home digital technologies if they were still in good health, if they perceived the devices as useless, or if the devices were too expensive. Healthcare technologies were introduced by having researchers conduct focus groups with the elderly, where they were presented with healthcare technologies and how they function, or by installing an application on their smartphones and showing them two videos on how to use it. In the implementation of healthcare technologies, the technical support provided by staff proved to be inadequate, as older people mentioned that they would not use the devices if they were not technically adapted to their needs—specifically if they were too complicated to use, as this would cause them fear. Home care technologies and technologies based on

well-being services were introduced by researchers explaining the functioning of the sensors to the elderly and clarifying where the sensors would be installed and how they would perform measurements. However, the explanation of how the devices work was not sufficiently detailed, as the elderly did not receive information on how the data would be collected and stored. The elderly were concerned about privacy and data protection, as they were not entirely sure whether their data would be securely stored.

5.2 Advantages and disadvantages of implementation methods in Slovenia

In Slovenia, attempts to introduce digital technologies and systems for older people to live in their home environments involved presentations and workshops on the use of digital technologies, as well as surveys or questionnaires about the needs of the elderly. In this process, several advantages were identified. ICT was implemented into the homes of the elderly by presenting digital technologies to them and conducting workshops where they were taught how to use these technologies. A key factor in the acceptance of digital technologies by the elderly proved to be the appropriate learning method, tailored to the abilities and needs of older people. Workshops were available to the elderly, where they could borrow various devices, and individual support was also provided for their learning. In the field of assistive technologies, data on the methods of device implementation are not available; however, elderly people mentioned that they would accept assistive robots only if it meant they could stay in their home environment for a longer period. Smart home technologies were implemented with a brief presentation, and the elderly appreciated being appropriately informed about the devices, as they would accept them if they understood how they worked and recognized them as useful. In attempts to implement healthcare technologies, digital technologies and systems were presented to the elderly, followed by workshops and interviews. They reported being satisfied with these digital technologies, as they feel safe. They are aware that these digital technologies enable them to live independently in their home environment and simultaneously encourage them to be more physically active, as some devices are also portable. The elderly would also only accept these digital technologies if they needed them due to health issues. Home care technologies and technologies based on well-being services were introduced by first providing the elderly with documents containing basic information about the digital technologies, followed by demonstrations of these technologies' applications. The elderly found these digital technologies useful and easy to use.

During the review of attempts to implement digital technologies and systems for older people to live in their home environment, several drawbacks were identified. When introducing ICT, these technologies were first presented to the elderly. The elderly mentioned that their lack of knowledge about digital technologies causes them to fear them; on the other hand, they are also not interested in them and claim that they are too old to learn how to use them. It was also found that learning and using technologies are significantly influenced by technical factors (such as whether the elderly even have access to the internet and online devices), as well as spatial (whether the space is adequately lit, the material is presented at an appropriate volume, etc.) and methodological adaptation of teaching methods (repeating the material multiple times, explaining it slowly, using simple terms, and providing visual illustrations) to the needs of the elderly. In attempts to implement assistive technologies, it was found that older people would not accept assistive robots unless it was necessary for them to remain in their home environment, as they would miss human warmth. Smart home technologies were introduced to the elderly, but they were not interested in the technological aspects of the devices. They only wanted to know about the practical value of the devices and information about their functionality. Healthcare technologies and their operation were presented to the elderly through workshops. The elderly had a sceptical attitude towards these digital devices, with their greatest concern being the loss of privacy and security. They were also troubled by the fact that some devices were not adapted to their needs and were too complex to use. Home care technologies and technologies based on well-being services were implemented by providing the elderly with documents containing basic information about the application. The elderly were also frustrated with these digital technologies and systems because they were too complicated to use and not tailored to their needs. They emphasized that learning to use these technologies should be done in an adapted manner, involving repeated practice, exercises, and individualized forms of assistance.

6 Conclusion

Digital technologies and systems play a significant role in extending the active life of older people by simplifying daily routines and helping to maintain their active, independent, and social lives (Klimova and Poulova, 2018). This article therefore presents various methods for implementing digital technologies and systems for the living of older people in society. Understanding these methods could provide insight into how different factors influence the acceptance of digital technologies and systems among older people.

Tsipi Heart and Efrat Kalderon (2013) noted that the main reasons for the non-use of digital technologies are the lack of interest among older people and their assessment that they do not need these technologies. Therefore, based on these findings, it is believed that the introduction of appropriate manuals, video content, and expert support tailored to the elderly could facilitate the easier acceptance of digital technologies and systems, as has been successfully demonstrated in their implementation abroad. Additionally, practical trials of devices help older people approach the use of digital technologies with more confidence and overcome any initial fears. Education on digital technologies is crucial for older people, but it must be delivered with content and methods that present digital technologies in an engaging manner for them. In Slovenia, workshops tailored to older people have proven successful in this regard. All of this can contribute to increasing older people's trust in digital technologies and systems and to their acceptance. However, it is crucial that older people are involved in the process of implementing digital technologies from the very beginning and that the operation of digital technologies is explained to them in detail, as it has been found that this significantly impacts their understanding of how digital technologies and systems work and their acceptance of them. Additionally, it is very important to assess the needs of older people and adapt to their needs.

Based on the presented methods of implementing digital technologies and systems and the assessed advantages and disadvantages of these implementations, it has been confirmed that sociodemographic, psychological, social, and technical factors are important for the acceptance of digital technologies and systems. Additionally, other factors must be considered, such as the inability of older people to adapt to digital technologies and systems, fear of dependency on them, their knowledge, and previous experiences with such technologies, among others.

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Acknowledgments

The findings presented in this article are the result of a three-year project, "Digitization of older peoples' home environments in Slovenia," which runs from 2023 to 2026 and is financially supported by the Slovenian Research and Innovation Agency (project code J5-50175). The authors acknowledge the financial support from the Slovenian Research and InnovationAgency (ARIS) through the research project: Health-oriented behavior as a creator of sustainable development of the built environment (Project code J7-4599).

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The Management of Healthcare Facilities in Macedonia and their Spatial Transformations

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ABSTRACT

Problem Statement: The healthcare system in Macedonia has undergone significant reforms since the breakup of Yugoslavia, particularly concerning the privatization of primary healthcare and the adoption of various models to enhance resource effectiveness and efficiency. These reforms, largely completed by 2007, have impacted healthcare facilities' architectural and spatial characteristics. The shift from public to private sector operations has often resulted in providing healthcare services at minimal rather than optimal costs, potentially compromising the quality and efficiency of health protection. Additionally, the segregation of the building's spatial characteristics complicates facility management.

Purpose of Study: The study aims to understand the spatial transformation and management processes in Macedonian healthcare facilities driven by privatization and market-oriented reforms. It focuses on the transition from compact public healthcare architectures to more segregated forms under private management. The specific case of the Bucharest Polyclinic in Skopje, part of the public Health Center "Zdravstven dom Skopje," is analyzed to illustrate these changes.

Methods: This research utilizes a combination of theoretical research, documentation review, and comparative analysis. Analytical tools and statistical data are employed to investigate the SYSTEM architectural and spatial transformations. The case study method is applied to the Bucharest Polyclinic in Skopje, RN Macedonia, providing insights into the practical implications of healthcare reforms.

Findings and Results: The findings reveal that healthcare reforms in Macedonia have significantly altered healthcare facilities' spatial and architectural characteristics. The transition from public to private management has led to facilities spatial segregation, as in the case of the Bucharest Polyclinic. This shift is driven by the need to adapt existing public facilities for private use, often leading to cost-cutting measures affecting healthcare services' quality.

Conclusions and Recommendations: The study concludes that the privatization of healthcare facilities in Macedonia, while intended to improve efficiency and resource utilization, has also introduced challenges related to the quality and management of healthcare services. The architectural segregation resulting from these reforms complicates facility management and may undermine healthcare quality.

Keywords: healthcare facility management, healthcare reforms, healthcare effectiveness, healthcare facilities, spatial transformation.

1. Introduction

The paper deals with the healthcare system reforms in Macedonia and the architectural transformation of its facilities. It emphasizes the issue of Health Centers (Zdravstven Dom) transformations as a result of the need for application of adapted models from Western economies, and opening of the healthcare to private initiatives. The need for improvement of the healthcare system and its financial models leads to transferring of the public primary care services to private practices. Moreover, it deals with the transformation of health facilities through the case of the Bucharest Policlinic in Skopje. The research shows that the reforms significantly altered healthcare facilities' spatial and architectural characteristics, and affected their performances. It concludes that the privatization of healthcare services is not always fit for purpose, especially when a market-oriented environment promotes providing services at minimal, rather than optimal costs.

Through a methodological approach, the paper exemplifies the issue of systematic and spatial transformation which creates difficulties for health services implementation and affects the quality and the efficiency of health care. The demonstration of healthcare management and spatial transformation employs two primary methods: theoretical research with statistical data and analytical tools. These approaches aim to give a comprehensive insight into the practical implications of healthcare reforms in health facilities, causing their spatial transformation, and addressing the need for future improvements toward a community-oriented and multidisciplinary model of care.

The paper is structured into two chapters, each addressing critical aspects of healthcare reforms and spatial transformations. The first chapter discusses the healthcare system and its financial models, and it elaborates on their characteristics. The subsections of this chapter provide an overview of the Macedonian healthcare system with a great focus on the development of the social health insurance system. Furthermore, it elaborates on the two distinct reform periods, and the significant changes in the healthcare system, financial management, and healthcare facilities. The second chapter delves into the architectural transformation caused by the previously elaborated healthcare reforms. It offers an overview of the case study Bucharest Policlinics and presents the results of its spatial analyses. The final chapter is the conclusion, in which the final observations are given.

2. Healthcare system and healthcare financial models

Through a country's healthcare system, the primary goal is to improve the population's health, involving all people, institutions, and activities in the process. The healthcare system aims to achieve three fundamental objectives: better health, better response to the population's expectations, and financial equity and protection from financial risks (Health Care Law, 2016).
The functions of the healthcare system (management, resource provision, financing, and service delivery) and how they are organized impact the system's performance. The World Health Organization identifies three key pillars in the organization of healthcare systems: the financing pillar, the redistribution of collected funds, and the service delivery pillar. The financing models of healthcare systems characterize the type of healthcare system in a country. According to the OECD (Organization for Economic Cooperation and Development) (Donev et al., 2013) the most well-known and widely used models are:

- National Health Service System – Beveridge Model: Created in 1948 by Sir William Beveridge in the United Kingdom, the Beveridge model is often implemented through a national health service. In this model, the government acts as the sole payer, eliminating market competition to keep costs low and standardize benefits. The funding comes from taxes, ensuring that every tax-paying citizen has equal access to healthcare. Financing healthcare through the budget plays a crucial role in ensuring equal healthcare among all citizens, regardless of their social status, economic power, place of residence, or work.

One concern with the Beveridge model is the risk of overuse, as free access may lead to patients seeking unnecessary healthcare services, driving up costs and taxes. Another concern is the ability to fund

healthcare during national emergencies, such as wars or health crises when government spending increases, or public revenue decreases. The Beveridge model is used in countries like the United Kingdom, Spain, New Zealand, Cuba, Hong Kong, and by the Veterans Health Administration in the U.S.

- Social Insurance System – Bismarck Model: The Bismarck model, introduced by Otto von Bismarck in the late 19th century, is a more decentralized approach to healthcare. Unlike the Beveridge model, the Bismarck model does not offer universal health coverage. Health insurance is tied to employment, so coverage is provided to those who financially contribute, such as employees, and employers, as well as private and public ownership of health facilities and equipment.

A key aspect is the concept of health security, which means protecting or reducing the impact of trauma, illness, or accidents by incorporating certain financial and service elements. Health insurance is achieved through an insurance contract, whose main function is to reduce the risk of financial costs in the event of illness. Social health insurance revenues are generally allocated to health and collected in the Health Insurance Fund.

This model is used in countries like Germany, Belgium, Japan, Switzerland, the Netherlands, France, some employer-based healthcare plans in the U.S., and Central and Eastern European countries.

*A Hybrid Model: combines elements of both the Beveridge and Bismarck models. In this case, the government serves as the single-payer for medical procedures, like in the Beveridge model. Similar to the Bismarck model, health insurance is mandatory for all, and the main healthcare providers are either public or private. In this model, payments come from a government-operated insurance program or fund that all citizens contribute to.

- Private Insurance System: In this model, private health insurance dominates, which can be provided by the employer or individually. The main concern is that a significant portion of the population remains uninsured, depending on their financial status. The primary healthcare providers in this model are private. This model is mainly used in the U.S., where the user selects a program or plan from private insurance options to secure health insurance.
- Out-of-Pocket System: The out-of-pocket model is most common in less-developed regions and countries lacking the financial resources to establish healthcare systems like the other three models. In this model, patients must cover the cost of their medical procedures themselves. This includes direct payments, formal cost-sharing, and informal payments. This model faces numerous challenges, particularly in ensuring equitable access to healthcare and making healthcare services available to certain population groups that cannot afford to pay.

Privatization and de-privatization of healthcare financing methods are processes aimed at achieving a balance between healthcare costs and actual financial capabilities (Donev et al., 2013).

2.2. Overview of the healthcare system in Macedonia

The health system in Yugoslavia was operated by the National Health Service in Yugoslavia, which covered the costs of healthcare, through local and regional taxation. The financing part was managed by the federal Social Insurance Fund, which collected revenues and made provider payments based on a number of beds or clinic visits inputs. Access to medical care services was free for all citizens, regardless of their ability to pay. Healthcare was provided through three levels. Moreover, on a municipal level primary and basic secondary care was provided in Health Centers (Zdravstven Dom), the Clinical Center was associated with the Medical Faculty where tertiary care was offered, and there are highly specialized services available in federally organized clinics (Kostova et al., 2017).

Macedonia, after the collapse of the former Yugoslavia, has developed a social health insurance system. Retaining the positive features of the previous Yugoslav health system and under the Law on Health Care at the time the healthcare system became highly centralized. Almost all decisions are made by the government and the Ministry of Health, without any input from the municipalities. The Ministry of Finance determines the Health Insurance Fund (HIF) budget. HIF operates the health insurance scheme and acts as the main purchaser of publicly funded health services. Moreover, the Macedonian healthcare system contains both, the Beverage and the Bismarck model of health insurance, with a purchaser-provider split and a mix of public and private providers. Going through several reforms the market for

health care service provision was liberalized, enabling private providers to enter the market (Donev et al., 2013).

The Health Insurance Fund is tasked with procuring services from both public and private providers on behalf of users. It establishes a relationship with providers at the primary, secondary, and tertiary levels by performance-based contracts, which are negotiated and signed for a specified period (Kostova et al., 2017). The Health Insurance Fund offers a comprehensive basic benefit package of services, that includes emergency care, primary and secondary outpatient care, inpatient care, and preventive and rehabilitation services. Moreover, HIF covers as well some dental and mental health services, prescribed medications, compensation for sick and maternity leave, and medical devices. Other health services require user co-payments, capped at 20% of the cost (50% for medical products). This includes outpatient specialist visits, prescribed outpatient medications, and inpatient care (WHO, 2022).
In 2023, health insurance contributions for salaries have the largest share in the HIF income with 88.6%. In addition to the salary contribution, for some of the categories of insured persons, the contribution is paid by a part of the institutions of the state, that is: for the unemployed who receive monetary compensation – the Employment Agency; for insured persons with social rights – the Ministry of Labor and Social Policy; for pensioners – the Pension and Disability Insurance Fund; for the "uninsured" - the Ministry of Health (HIF report, 2023).

The legal foundation of the health system is embodied in the two main laws: The Law on Health Care (2016) and the Law on Health Insurance (2023) as well as number of other laws and by-laws that regulate other specific issues within the health care system (Kostova et al., 2017).

2.3. Healthcare reforms in Macedonia

Since its independence, Macedonia has noted two distinct reform periods, with significant changes in the healthcare system, financial management, and healthcare facilities. The first period is the post-Yugoslav transition period 1991-1999 and is characterized by the inclusion of the right to health in the Constitution and the liberalization of health service provision through the Law on Health Care. This is a period where the financial resources have decreased as a result of disintegration from the larger health system of Yugoslavia. There were great attempts to preserve the existing system, but the lack of strategy for health system development has led to further deterioration of the quality of services (Kostova et al., 2017).

The second reform period since 2000 and still ongoing is characterized by the separation of the Health Insurance Fund from the Ministry of Health. Previous challenges justified the need for improvement, through the application of adapted models from Western economies and the opening of the health system to private initiatives. The reforms were mainly initiated and guided by the World Bank's Health Sector Transition Project and the Health Sector Management Project.

The reforms consisted of several parts, and one of them is the privatization of primary healthcare from 2004 – 2007. The privatization was toward primary care providers establishing private practices and did not imply a transfer of ownership of the premises. This meant long legislative preparations where primary care provider is obliged to sign a performance-based contract with HIF. Moreover, the previous salary-based payment system for doctors was replaced by a capitation-based payment with the income linked to the number of citizens enrolled on primary care providers' lists. Capitation-based payment is based on a blendedcapitation model, which includes 70% fixed amount and 30% variable amount. This means fulfillment of obligatory preventive health activities, referring to rational prescribing and referral, preventive check-ups, and health promotion and education activities. The primary health providers refer to the general practitioners, pediatricians, primary gynecologists, primary dental services, pharmacies, occupational medicine specialists, and school medicine specialists. They are obliged to register their practice, hire medical nurses, and take under concession premises that are publicly owned. The Health Centers are the main public health facilities that have accommodated private practices at favorable conditions and low prices. Many private health providers remained on the same premises in Health Centers as they were before, which contributed to preserving the accessibility of primary care. However,

in time, the Health Center premises were given under concession to other private providers of primary and secondary care, depending on the free space and medical equipment, which contributed to the transformation of the health facilities. The transformed Health Centers retained the provision of preventive services, including teams for immunization and preventive checkups of pupils and students, home visiting and emergency services, as well as specialist-consultative outpatient care. The Health Centers are a heritage from the previous Health System, and their locations are strategically determent, which at the time contributed toward coverage of all population needs.

Health Centers in Yugoslavia offered a wide variety of services, including preventive, primary, and secondary care, as well as emergency services and post-secondary care, such as follow-up home visits. Currently, there are 34 Health Centers across the country, and they continue to provide preventive services, secondary specialist-consultative care, and home visits following hospital discharge, alongside public and private practices (Kostova et al., 2017).

In 2007, only three years after the reforms, 95% of the licensed primary health care physicians (medical doctors, dentists, pharmacists, and nurses) had moved to the private sector, and over 35% of all licensed practicing physicians in the country at the time (Kostova, 2010).

Private investment in secondary and tertiary healthcare levels occurred well ahead of any government reforms intended for these areas. As a result, private general and specialized hospitals began operating alongside public hospitals, providing services outside the health insurance system that users had to pay for directly. With the implementation of the new Health Care Law in 2012 and the creation of the Health Network, the regulation of private health providers at these levels was introduced. This regulation is now based on declared demand, addressing the Ministry of Health's limited public services, and requires government approval for contracting (Kostova et al., 2017).

In 2012 with the new regulations in the Law on Health Care (2012), was launched the Health Network. The Network marks a new period of centralization and control by the government and the Ministry of Health. The Ministry of Health certifies public and private healthcare providers to become part of the Health Network, and HIF only signs contracts and purchases services with them. Moreover, it only reimburses the practices that are certified by the Ministry of Health. If otherwise, these services will have to be paid out-of-pocket by patients. Since 2013, e-services for GPs have been enabled via My Appointment (Moj termin) to reduce administrative workload with a great need for further improvements in this area (Kostova et al., 2017).

Patient's surveys about their experiences are not systematically collected. The surveys that the Ministry of Health conducted after the primary care reform showed that patient satisfaction with health services was between 79% and 90%. Patient satisfaction in recent years has been significantly declining and was estimated at 45%, but progress is noted because of reduced waiting times for referrals through Moj Termin (WHO, 2019). However, the marketoriented environment promotes providing services at minimal, rather than optimal costs, which may affect the quality and even the efficiency of health care (Kostova, 2010).

3. Architectural transformation

While the inventible transition of Healthcare affects the System and its management, the capital interest of both, the fund and care providers, it’s what drives the transformation in the public health facilities and its premises, thereby transforming its physical form.

The funds for preventive services delivered primarily from HIF are what challenges the provisions of care practices and by that the physician workplaces. Providing “affordable” premises within the 34 Health Centers is what makes these facilities attractive to medical doctors and nurses. With the regulations of the “Law for the necessary space, equipment, and professional staff for establishing, starting work, and performing health activities in health institutions” (2013) the private healthcare providers need to follow strictly defined area rules of the ordinations, waiting rooms, working space,

etc. Therefore, the premises in the Health Centers need to adapt to these regulations, unless they are already suitable for the specific care services. To show the facility's inner space transformations, in following is analyzed and elaborated on the case of Bucharest Polyclinic in Skopje.

3.1. The case of Bucharest Policlinic Skopje

According to the Law on Health Care (2016), the Health Center performs healthcare activities at the primary level and specialist consultative activities that are part of the network at the secondary level. The Health Center functions by applying the dispensary and team methods of work. To contribute to the more efficient and rational use of space, equipment, and staff of public health institutions, the Government together with the Ministry of Health may decide on two or several public institutions of different types to merge or to be separated into public health institutions (Law on Health Care, 2016).
The Public Health Institution - Health Center Skopje was established by integrating several health centers in the city of Skopje, based on the experiences and initiatives of WHO, to provide an integrated approach to population health care. PHI Health Center Skopje provides health care in the following polyclinics: "Bit Pazar", "Bucharest", "Jane Sandanski", "Cento", "Chair", "Idadija", "Gjorce Petrov", "Dracevo", "Shutoorizari" and "MIA". Furthermore, in the Center for Emergency Medical Assistance and Home Treatment; Institute for Sports Medicine; Institute for Mental Health of Children and Youth "Mladost" and Institute for Mothers and Children (ZDS, 2024).

Bucharest Polyclinic architecture is a symbol of the solidarity of post-earthquake Skopje. In the entrance hall of the facility there is an inscription with the following content:
"This Polyclinic was built as an aid from the people and the Government of the People's Republic of Romania and is a symbol of fraternal friendship and international human solidarity in the reconstruction of Skopje after the catastrophic earthquake of July 26, 1963" (Figure 1).
The Bucharest Polyclinic was designed by Romanian architect Eudzhenju Kosmatu, known for his contributions to early 20th-century modern architecture. The Polyclinic was built in 1970, its special feature is functionalism, which is also a reflection of the architecture of Kosmatu (Konstantinovski, 2007). Shaped like an "H" to signify its hospital function, the Polyclinic is strategically situated in the western part of Skopje, within the municipality of Karposh, to serve the local population.

Figure 2: *Photographs of Bucharest Policlinic Skopje.*
source: authors, 2024

South of the Polyclinic is the "Partizanski Odredi" boulevard, the main artery that connects the western and eastern parts of Skopje. The building is being developed on three floors: the ground floor, the first, and the second floor. This organization allows a clear program distribution in the facility, with the distinction of the circulation paths of visitors and the medical staff (Figure 2). The Polyclinic's typology is characterized by single central corridors and medical rooms on both sides. Natural light is provided in each of the rooms. The corridors are lit by the stairwell windows and extra openings at the ends of each corridor. There are two main vertical communications, positioned in the middle of the south and north wings, connected by a transverse corridor. The grid of the openings shapes the facade, which is covered with blue tiles, reflecting the building's function.

Prior to 2007, the Polyclinic exclusively performed public health services such as emergency medical care and home treatment, emergency dental care, preventive health care for preschool and school children, polyvalent patronage, dental care for children up to 14 years of age and health statistics, as well as specialist-consultative activities from neurology, ophthalmology, dermatology, radiodiagnostics and physical therapy and rehabilitation. Before the health reforms and privatization of primary care, the facility's program was evenly distributed across floors, with separate entrances for patients and staff. The main patient entrance is located on the south side, granting access to all health practices, while a separate entrance for the vaccination department is on the west side. The facility also had four additional entrances designated for employees, medical staff and distribution.

Following healthcare reforms in 2007, significant changes began in healthcare centers, with a substantial part of their space being allocated to private practices. Polyclinic "Bucharest" covers an area of 3,600 m², with approximately 30% of its space dedicated to private primary care practices. These include general and family medicine, pediatrics, gynecology, dentistry, and pharmacy. Additionally, in the northwest wing of the building, on the ground floor, there is the Medical Committee sector under the HIF regional unit. In the Policlinic, private premises for pediatrics and pharmacy are located on the ground floor, gynecology on the first floor, and dental care, family medicine, and pediatrics on the second floor (Figure 2).

Currently, the Bucharest Polyclinic has three public entrances. The main patient entrance is on the south side, while the three remaining entrances serve employee circulation and distribution. Two entrances are now entirely privatized: one on the northwest side for the medical committee sector and another on the west side for the vaccination department. The transformation diagram (Figure 2) illustrates the circulation pattern within the facility, highlighting that the corridors are partially enclosed and require passage through different healthcare premises.

Concerning the architectural features of the Polyclinic, the design originally featured a central corridor with medical rooms on both sides. However, this layout has been adapted to meet specific capacity requirements and facilitate particular activities. With further modifications and the shift from public to private premises, there has been an increased emphasis on ownership and privacy, leading to a greater separation within the interior spaces.

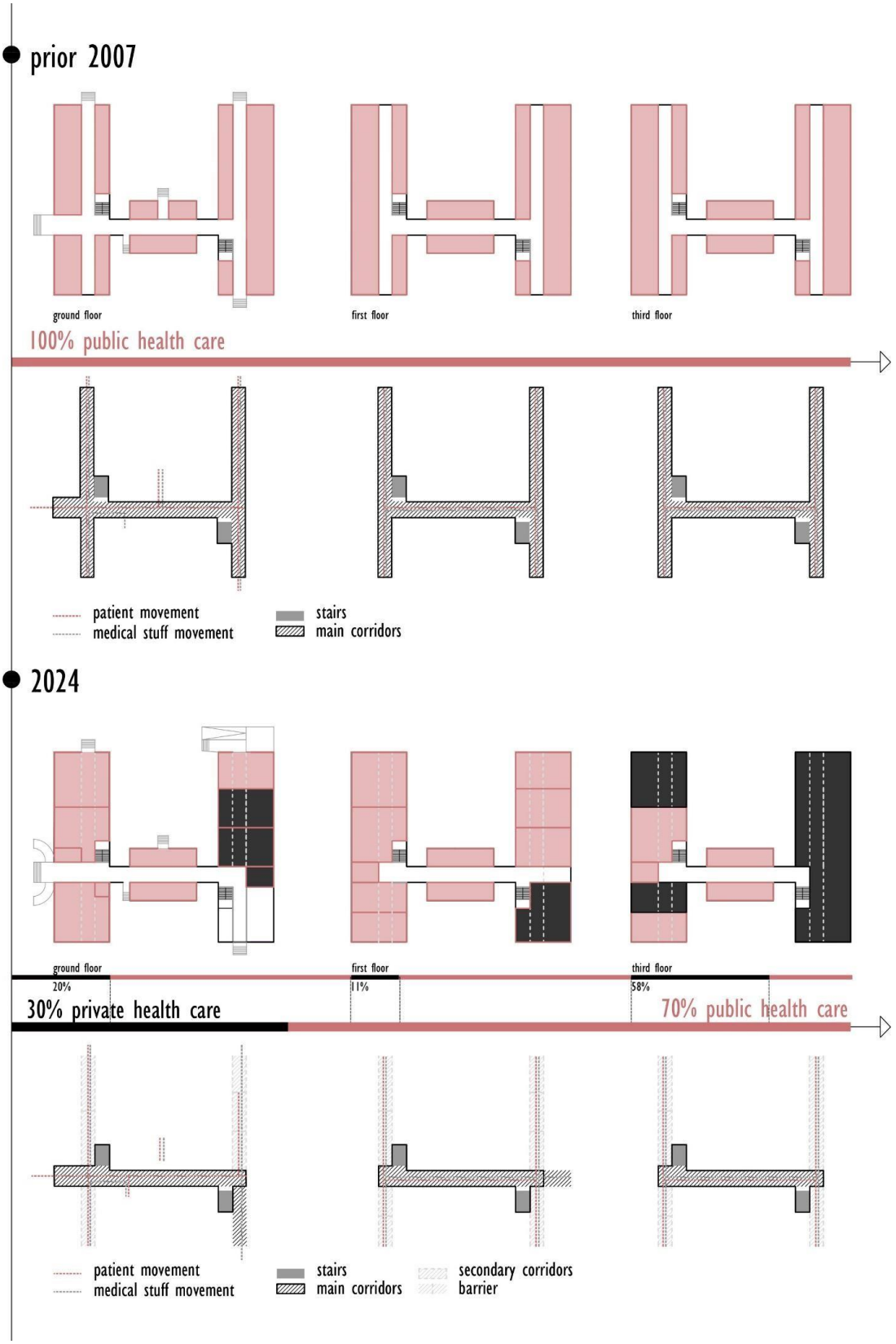

Figure 2: *Transformation diagram* – illustration of the building's spatial and circulation transformations. source: authors, 2024

These changes in the physical structure of healthcare facilities significantly alter the spatial organization and affect the circulation processes.

The movement patterns within a building are influenced by its formal properties and typomorphological characteristics. Circulation is determined by the internal spatial volumes and the flow of movement. The way movement is conceptualized relies on the architectural layout and the program it supports, which shapes the relational configurations experienced by users. Consequently, altering or distorting certain properties can modify the formal system, leading to disruptions in other architectural aspects of the building (Eisenman, 2006).

Furthermore, the distribution of private and public health premises is followed by unclear signage systems in terms of wayfinding[7], which increases the time of health care service, and thus particularly affects the overall functionality of the facility.

Wayfinding is a critical design aspect in complex environments such as hospitals, airports, large office buildings, and urban areas. The complexity of hospital infrastructure initially makes communication difficult and often makes spatial orientation more complicated to navigate. It burdens the user and increases his cognitive activity, which contributes to increased stress and anxiety. Only the spatial plan and repetitive architectural elements are not enough for a good and quick orientation, which also increases the time of a certain healthcare services (Wagenaar et al., 2018).

4. Conclusion

The current model of primary care, predominantly based on individual private practices leads to fragmentation in the health management processes as well as in the physical structures of the public healthcare facilities. It has shown several faults in its functioning and certain areas have shown as not fit for purpose. The distribution of private practices of primary care is not equal in the country, and of that, the funds are not distributed evenly. This refers to the great number of private practices in the urbanized areas and cities and the low interest in the rural environments. Moreover, the premises in the Health Centers in the cities are more requested, and their formal aspects are in continuous change leading to poor performances. This generates a dysfunctional and inefficient health system that overloads specialized and hospital care. A community-oriented and multidisciplinary model of care, that addresses health needs, requires developing a centrally managed investment program for new and renovated Health Centers designed and equipped for modern multi-profiled primary care work.

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[7] Wayfinding refers to the process of navigating and orienting oneself in a physical environment, particularly an unfamiliar one. It encompasses a variety of methods and strategies to help individuals determine their location, plot a course to their destination, and recognize when they have arrived.

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Influence of design elements on response to window views

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Abstract

In order to protect natural environment and farmland, the sustainability goals support inward city growth. The distance between the buildings is getting smaller, and the window view is restricted by the surrounding buildings. However, this approach increases urban density, which is especially challenging in residential areas, where access of daylight and the quality of window views is becoming increasingly difficult to achieve. The window view in connection with the social infrastructure can be considered above all in relation to public space (squares, parks) but also art & culture (architecture and heritage), long-term resilience (maintenance, adaptation to climate changes), information (view of activities, weather) and other. Very importantly, several studies imply that it affects health and wellbeing. The recent research implies that the quality of the visual information obtained with the help of window view depends on the features in the motive and variety of elements. Many researchers point to the impact of window view on peoples' well-being and define the responses triggered by certain motives. For instance, urban environment has a smaller restorative effect than the natural environment, and the view of the urban environment, such as pedestrian streets, a bus station and a busy road, cause increased heart rate. Not all motives are equally attractive when viewed through windows. For instance, as shown by the results of our previous study, respondents reacted more positively to views that contained greenery than to views without it. When studying the features of motives, their characteristics or information should be taken into account. In this study, we continue the work and focus on architectural elements of window views. For the purposes of this study only multistorey buildings in residential neighbourhoods were observed. A representative sample of façades in close-up view was selected for the analysis of window views. These façades were chosen to encompass a selection of variously designed and maintained façades, with varying composition features. The typical variables in the urban views are building facades of various degree of maintenance, compositional quality, surface quality, activity dynamics and complexity.

Keywords: social infrastructure, daylight, window view, descriptive statistics

Introduction

Windows in buildings serve several essential functions, most notably allowing the transmission of daylight, which significantly affects the health and well-being of occupants. Beyond this, windows also provide a crucial connection to the outside world, offering personal space for reflection while enabling interaction with the surroundings. Given the trend of increasing urbanization of the population, sustainable goals, the growth of cities and the densification of urbanized space, providing access to daylight and maintaining high-quality views through windows is increasingly challenging. This article examines the role of windows in facilitating visual interaction with the exterior environment, with A particular focus on urban settings, where the quality of window views can be compromised by building density.

Today's cities are integral part of a post-industrial society, where the majority of the population lives in urban areas, and both population and spatial urbanization continue to grow (Eurostat, 2024). The densification of urban spaces can be considered as a key principle of a sustainable urban development, as it conserves space and energy, increases the variety and intensity of social, business and cultural contacts and facilitates the efficient organization of services, social infrastructure and public transport (Drobne et al., 2022b). According to these authors, the density and quality of urban space largely depend on the user's perception of the space and its dimensions. They further note that the normative dimensions of the built environment and the definition of density based on principles of densification and compaction are often abstract and difficult to define, and the perceived density strongly depends on the individual's psychological state, which is inherently personal and subjective, rather than by physical variables alone. For example, recent studies on residential real estate values have shown that features like proximity to water bodies and attractive window views, have a positive effect on rental values (Potrawa & Tetereva, 2022). This indicates an important influence of hedonic values on real estate valuation (Grum & Kobal Grum, 2015; Zavadskas et al., 2021).

A review of previous studies reveals that the researchers have primarily focused on the features of outward views and the influence of window views in work environments. Littlefair (1996) notes that an attractive window view should include both the foreground and the horizon, providing essential information about time, human activities, weather and other elements. The appeal of such views can be further enhanced by the compositional quality of urban spaces and sonic information (Deng et al., 2020). Some studies suggest that the features observed through a window can evoke psychological reactions that match the characteristics of the observed motive itself (Van Esch et al., 2019). Moreover, the motives that comprise a variety of interesting features are rich in terms of content. Giraldo Vasquez et al. (2019) highlight that a positive perception of urban views is also influenced by the number of visual layers in the view: the more layers there are, the more attractive and informative the window view is.

The standard "Daylight in buildings" (SIST EN 17037:2019) defines three main visual layers that are essential for a high-quality window view: the top layer allows a distant view and comprises the sky and horizon, the middle layer includes natural or built elements, and the lower layer comprises the ground in the vicinity and also provides information about the distance and size of objects in the middle layer. Additionally, many studies mention greenery as an aesthetic element that can enhance the observer's response to a window view. Several researchers find that views of nature have a similar effect to being in nature (Ko et al., 2020) and evoke more positive reactions than urban environment (Drobne et al., 2022a). Also, in the working environment, many studies find that visual contact with nature improves user responses (Ko et al., 2020; Chang et al., 2020; Kaplan, 1993, 2001; Kang & Kim, 2019). Kaplan (2001) suggests that brief, repetitive breaks that occur when a person looks out the window decrease mental fatigue caused by sustained focused attention. Views of nature, on the other hand, do not demand focused attention but instead engage involuntary attention, which aids in mental regeneration (Tyrväinen et al., 2014).

An important indicator of the quality of a window view into the urban environment is also the visual aesthetics of the motive (Szybinska et al., 2016). According to these authors the aesthetic appeal is created through a harmonious combination of architectural elements that enhance visual richness – such

as geometry, plasticity, variation of colours and textures, decoration or ornamentation, articulation and accents. Kent and Sciavon (2020) observe that a diverse and dynamic scene is more engaging than a monotonous one, and attentiveness being heightened by the complexity and legibility of the motive (Herzog & Shier, 2000; Van den Berg, 2016). The perception of the urban environment is also significantly influenced by the age and maintenance of buildings (Drobne et al., 2022a).

Quality of outdoor window views are considered also in various building sustainability assessment methods and certification schemes (Abd-Alhamid et al., 2023, Lazar & Chitra, 2020, Ko et al. 2022). Widely used certification systems such as LEED, BREEAM and DGNB as well as others address the issue of view quality in their evaluation. All three mentioned evaluation and certification schemes dedicate the importance of views with around 1% of total score.

In LEED v.4.1 the Criteria Quality Views in the Indoor Environmental Quality Category evaluates if 75 % of the regularly occupied floor area has a view to the outdoor natural or urban environment. Views must include at least at least nature, urban landmarks, art or other objects at least 7,5 m from the exterior of the glazing. The views must be through glass with a visible light transmittance above 40 %.

In BREEAM v.6 the Criteria View out in the Visual Comfort Assessment issue in the Health & Wellbeing Category evaluates if 95% of the floor area space provide the adequate view out. Adequate view out is defined as a unobstructed view of a landscape or buildings (rather than just the sky) at seated eye level (1.2–1.3m) within the relevant building areas and should ideally be through an external window. A certain window size as a % of surrounding wall area is demanded depending on the distance from the window to workspace (like 7 m or less with a window size of 20 % of surrounding wall area).

In DGNB v.2023 the Indicator Visual contact with the outside in the Visual Comfort Criteria in the Sociocultural and Functional Quality Category evaluates this topic according to EN 17037 Daylight in Buildings Standard. The standard establishes three levels of View outside Quality: Minimum, Medium and High with each demanding reaching a certain level of: 1. Width of view (horizontal sight angle), 2. Outside distance of the view and 3. Number of layers to be seen.

European Commission developed a common EU framework of core indicators for assessing the sustainability of buildings – Level(s) (Dodd et al. 2021). In the Criteria Lighting and Visual Comfort, the quality of view is also considered for evaluation in the External views indicator and is based as well on the EN 17037 Daylight in Buildings Standard, similarly to the DGNB.

Recently published New European Bauhaus Investment Guidelines (EC, 2024), which is one of the results of the interdisciplinary project New European Bauhaus, mention visual connection with the outside as part of the Category 2. Connect to Nature within one of Core Values – Beautiful (besides Sustainability and Together). Bringing the outdoors environments to the inside by allowing visual connections to nature is to be followed when designing new buildings.

The current concept of urban densification is driven by the need for efficient land use. As the distance between the building decreases, window views become increasingly restricted by surrounding structures. Pallasmaa (2005) points out the role of planimetry and plasticity of architecture, as well as the importance of peripheral vision in perceiving the quality of space. A façade, with its tectonics, geometric proportions, decoration, colour etc. provides a space with its unique artistic identity. The farther a building is from the observer, the easier it is to understand its relationship with the surrounding environment, as it only comes to life in the wider context. Conversely, the closer it is to the observer, the lesser is the legibility of the tectonic structure of the building, and the more important become details such as surface and maintenance (Joedicke et al., 1975). As a result, it is the design of individual façade elements, rather than the building as a whole, that shapes an observer's response to a window view.

In densely built urban environments and tall buildings, achieving distant window views that encompass all three visual layers is challenging. Therefore, this study the primary focus on observers' responses to window views, which only contain a frontally visible view of the opposite building's façade (i.e. the

middle visual layer). The research questions explore residents' reactions to various window views and the reasons for their reactions. Data was acquired using a web-based questionnaire and analysed through descriptive statistical methods.

Methodology

For the purposes of this study only multistorey buildings in residential neighbourhoods were observed, as they allowed a wide range of buildings built in different periods and with different materials. A representative sample of 10 façades was selected for the analysis of window views. These façades were chosen to encompass a selection of variously designed and maintained façades, with varying composition features, visual attractiveness and plasticity. The examples were not selected on the basis of the quality of architecture but rather as views of the façades that encompassed elements suitable for this study. The photos were taken in residential neighbourhoods in Ljubljana, Slovenia. All the façades are realistic and were photographed frontally, from the same distance and in sunny weather, in order to eliminate influence of weather. The pictures were framed to resemble frontal window view of the 3rd and 4th floors of the adjacent building. The selection deliberately excluded elements that might disturb or distract the questionees, like people, greenery, animals etc.

A web questionnaire, based on online survey tool 1KA (www.1ka.si), was designed to collect the quantitative data. It was sent to available contacts with Slovenian email addresses in the repository of the New University. Predominantly working population was targeted, with sedentary/office work. The questionnaire consists of two parts. The first part includes demographic questions and questions related to how the respondents assess their personality, where and how they spend their day and which is their preferred window view. The second part consists of visual assessment of ten window views. The process is designed in two steps. First, the respondents were asked to select a reaction to an individual window view, depending on the selected reaction, a sub question about the evaluation and the causes for such evaluation followed. The questions were of the closed type. To assess the respondents' reactions to window views and the influence of various architectural features, descriptive statistics was used. The differences between the reactions and the reasons were analysed based on the frequency of answers and the selected responses.

Results and discussion

The survey was conducted in May 2023, resulting in a total of 112 fully completed questionnaires. Among the respondents, 38% were men and 62% were women. The participants belong into four age groups, which can be paired with the main life periods: up to 20 years - students (15%), 21 to 40 years – young working population (27%), 41 to 60 years – mature working population (38%), and above 60 years - seniors (20%). Most of the participants are employed (71%), 23% are students, and 6% are retired. Due to space restrictions, only the part of the results that deals with reactions to individual window views is presented.

An overall review of the results shows that none of the selected window views reached a high value (i.e., value 4 = I agree) and evoked predominantly positive responses. This was expected, since the survey only included cases with unfavourable window views of the nearby façades that contained one visible layer, without greenery, distant view and similar features, which proved to have a positive effect in previous studies (Drobne *et al.*, 2022a) (Table 1). In addition, the survey results showed that the respondents evaluated some window views quite negatively, and the reactions were in many cases similar.

The consistency of reactions with the help of window views 1, 6 and 8. These cases are similar in terms of simple design and small variety of architectural features, but nevertheless differ in some details. A comparison of the responses shows that all three window views were evaluated unfavourably by the respondents. All cases were predominantly defined as boring, depressing, incoherent, but with different shares of answers in this category. Nevertheless, the results indicate that the respondents reacted consistently to façades with similar characteristics. However, it has to be noted, that when a visually

appealing feature was included in the window view (such as interesting surface texture in window view 6), part of the respondents' reactions changed to neutral response. It can also be seen that if another negative feature appeared in the window view (for example poorly maintained façade surface in window view 8), the share of negative reactions increased. The results shows that the respondents' reactions are consistent with the visual appeal of the window views used in the survey.

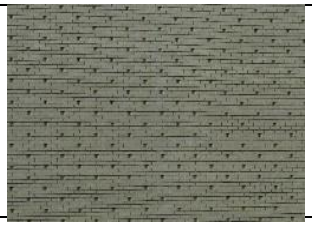
To further explore the consistency of the respondents' answers the window views 1, 2 and 3 were compared. These examples are similar in terms of design properties i.e. comprise planimetric composition with the same number of evenly spaced windows. The compositional key is simple and easily readable. These examples differ in specific details. In two cases the windows are offset, which adds dynamism and an element of surprise to the composition. In addition, they differ in minor details, such as the colour of the surface treatment, the texture of the surface and the number of architectural details. The comparison shows that in these three cases, the respondents again responded quite consistently. For example, the degree of negative and positive response changes depending on the richness of the surface treatment. The same applies to the choice of causes for such reactions, where the rate increases according to visual appeal e.g. richness of details and interesting surface treatment. The result suggests that certain type of façade designs can evoke predictable reactions in respondents. However, it should be noted that the reactions are also linked to the specifics of the surveyed population and the general cultural environment (expectations, preferences, construction culture, etc.) and should be understood in such context.

The New European Bauhaus Investment Guidelines (EC, 2024) stress the importance of beautiful built environments, highlighting how good aesthetics improve physical and mental well-being. High-quality environments enhance life satisfaction and the relationship between people and their surroundings. Studies show that aesthetically pleasing environments, such as access to nature and green spaces, positively impact health and life expectancy. Aesthetically appealing spaces also foster community pride, belonging, and social cohesion, while unattractive areas can worsen social marginalization and disempowerment. Overall, enriching environments improve quality of life, while unappealing ones have negative effects.

Although observing human activities in urban space is a very important part of information coming through windows from external environment (Littlefair, 1996), the participants were very disinclined to observing activities on the opposite building. This could be related to the cultural characteristics of the population in general which cherishes privacy and does not appreciate visual invasion of the home. Partly the answers could also be the result of misunderstanding the question in terms of social control (e.g. “spying” on neighbours or “nosiness”), which, in such a context, would not be perceived as desirable behaviour.

The influence of the maintenance of building elements on the reaction of the respondents was tested with the help of window views 5, 7 and 8. These are the cases in which the wear of the façade surfaces is visible due to exposure to atmospheric conditions and general usage. Representatives of older façades with visible wear (window views 5 and 8) were rated negatively by the respondents in a similar share of reactions. Window view 7, however, received the largest share of negative responses although it does not show substantial visible wear. Review of the results suggests that similarly low ratings relate to poor appeal of surface treatment, while the majority of respondents rated the compositional quality slightly higher. This result is consistent with our previous study (Drobne *et al.,* 2022a) which has indicated that the maintenance of the built environment is an important aspect of visual appeal and can have a significantly impact on the general impression of space and thus can affect the responses of observers.

Table 1: Overview of the individual window views, Predominant reactions and causes for reactions

Case 1	**Predominant reactions to window views**		
	Predominant reaction		Causes for reaction
	Negative: 58%	**Of negative reactions:**	**76% : boring, depressing, incoherent**
			24% : unpleasant, annoying, discordant
	Positive: 30%	Of positive reactions:	11% : interesting, stimulating, coherent
			89% : pleasant, calming, harmonious
	Neutral: 12%	Of neutral reactions:	20% : acceptable, undisturbing
			80% : does not evoke specific emotions
Case 2			
	Predominant reaction		Causes for reaction
	Positive: 52%	**Of positive reaction:**	**37% : interesting, stimulating, coherent**
			63% : pleasant, calming, harmonious
	Negative: 15%	Of negative reaction:	39% : boring, depressing, incoherent
			61% : unpleasant, annoying, discordant
	Neutral: 33%	Of neutral reaction:	35% : aacceptable, undisturbing
			65% : does not evoke specific emotions
Case 3			
	Predominant reaction		Causes for reaction
	Negative: 40%	**Of negative reaction:**	**23% : boring, depressing, incoherent**
			77% : unpleasant, annoying, discordant
	Positive: 36%	Of positive reaction:	30% : iinteresting, stimulating, coherent
			70% : pleasant, calming, harmonious
	Neutral:24%	Of neutral reaction:	39% : aacceptable, undisturbing
			61% : does not evoke specific emotions
Case 4			
	Predominant reaction		Causes for reaction
	Negative: 53%	**Of negative reaction:**	**27% : boring, depressing, incoherent**
			73% : unpleasant, annoying, discordant
	Positive:6%	Of positive reaction:	57% : iinteresting, stimulating, coherent
			43% : pleasant, calming, harmonious
	Neutral:41%	Of neutral reaction:	43% : aacceptable, undisturbing
			57% : does not evoke specific emotion
Case 5			
	Predominant reaction		Causes for reaction
	Negative: 88%	**Of negative reaction:**	**36% : boring, depressing, incoherent**
			64% : unpleasant, annoying, discordant
	Positive: 1 %	Of positive reaction:	100% : iinteresting, stimulating, coherent
			0% : pleasant, calming, harmonious
	Neutral: 11%	Of neutral reaction:	15% : aacceptable, undisturbing
			85% : does not evoke specific emotions
Case 6			
	Predominant reaction		Causes for reaction
	Negative: 44%	**Of negative reaction:**	**73% : boring, depressing, incoherent**
			27% : unpleasant, annoying, discordant
	Positive: 13%	Of positive reaction:	38% : iinteresting, stimulating, coherent
			62% : pleasant, calming, harmonious

	Neutral: 43%	Of neutral reaction:	10% : aacceptable, undisturbing
			90% : does not evoke specific emotions
Case 7			
	Predominant reaction		Causes for reaction
	Negative: 75%	**Of negative reaction:**	**25% : boring, depressing, incoherent**
			75% : unpleasant, annoying, discordant
	Positive: 3%	Of positive reaction:	100% : iinteresting, stimulating, coherent
			0% : pleasant, calming, harmonious
	Neutral: 22%	Of neutral reaction:	19% : aacceptable, undisturbing
			81% : does not evoke specific emotions
Case 8			
	Predominant reaction		Causes for reaction
	Negative: 84%	**Of negative reaction:**	**53% : boring, depressing, incoherent**
			47% : unpleasant, annoying, discordant
	Positive: 3%	Of positive reaction:	33% : iinteresting, stimulating, coherent
			67% : pleasant, calming, harmonious
	Neutral: 13%	Of neutral reaction:	12% : aacceptable, undisturbing
			88% : does not evoke specific emotions
Case 9			
	Predominant reaction		Causes for reaction
	Negative: 72%	**Of negative reaction:**	**19% : boring, depressing, incoherent**
			81% : unpleasant, annoying, discordant
	Positive: 8%	Of positive reaction:	90% : interesting, stimulating, coherent
			10% : pleasant, calming, harmonious
	Neutral: 20%	Of neutral reaction:	39% : acceptable, undisturbing
			61% : does not evoke specific emotions
Case 10			
	Predominant reaction		Causes for reaction
	Positive: 64%	**Of positive reaction:**	**84% : interesting, stimulating, coherent**
			16% : pleasant, calming, harmonious
	Negative: 12%	Of negative reaction:	29% : iinteresting, stimulating, coherent
			71% : pleasant, calming, harmonious
	Neutral: 24%	Of neutral reaction:	39% : aacceptable, undisturbing
			61% : does not evoke specific emotions

Conclusions

Densely built urban environments that do not allow window views comprising distant elements, sky and ground are challenging to design. Especially because the users are bound to observe such motives though their windows continually for a long time. This study showed that only two out of ten cases received a slightly favourable response and none of them reached a high level of agreement from respondents. The research also showed that it is very difficult to incite and retain enough visual interest with classical architectural approaches and restrained architectural language.

The research indicates that the near window view that restricts the building from the context of the space, obscures the legibility of the buildings' tectonic structure. Thus, the more important become details. This, for example, was demonstrated by the reactions of the respondents in relation to e.g., maintenance of building surfaces, where in case of poorly maintained façades, the respondents generally opted for

declaratively negative responses. If the façades were well maintained and at the same time not visually appealing, the reaction was predominantly negative, but not declaratively dismissive. In such cases, a considerable share of reactions was also in the neutral range. Basically, treated façade surfaces, even when combined with various architectural elements, also received rather negative reactions. It is also worth noting that the neutral colour scheme of the façades, which is characteristic of most buildings, had rather negative feedback. Respondents reacted positively to more pronounced surface treatments like rich textures and bold colours. Since the respondents reacted very consistently to similar window views, it can be noted with considerable certainty that in densely built urban environments that do not allow a variety of views through the windows, predominantly negative reactions from observers can be expected.

The New European Bauhaus refers to a beautiful project as one that "reactivates the qualities of its context, enhances physical and mental well-being, connects places and people, fosters a sense of belonging through shared collective experiences, and integrates lasting cultural and social values through creation." As demonstrated in the survey people cherish rich, cared and contextually stimulating views. It is therefore indicative, that on one hand the urban densification must be carefully considered to avoid decreased quality of built environment and deprivation of a stimulating aspect out, but on the other hand this can be leveraged by incorporating beauty and natural elements in the design of the building façades in dense urban settings.

Acknowledgement: This study was funded by the Slovenian Research and Innovation Agency through projects No. J5-3112, J7-4599 and P5-0068.

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Approach to the dilemma between investment in human resources or long-term care residences based on fuzzy results of curds

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ABSTRACT

In Slovenia, there is a shortage of human resources and funds for long-term care (LTC) systems and facilities to construct suitable facilities for long-term care needs. These two problems are self-evident in rural areas, which are not attractive enough for the human resources needed there for the care of older adults. Labour shortage can be assessed using the fuzzy set method and CURDS approach (fuzzy evaluation of Travel-to/work areas), as considered in Feng's article on the fuzziness of travel-to-work areas (TTWAs). TTWAs have been used widely by governmental agencies and academic institutions. However, their use has been criticised because the boundaries separating travel-to-work areas are imperfect because commuting trips cross them. This paper aims to investigate the fuzziness of travel-to-work areas by applying fuzzy set theory and upgrading this characteristic with the factors of wages and housing in the gravity model. In the article, we show how, with limited funds, limited public building areas and limited human resources for financing long-term care, we can decide between investments in new facilities and the provision of human resources in case municipalities have limited available land for the construction of social housing for the older adults from their municipalities and caregivers needed for the LTC services, but do not have sufficient financial resources or human resources for care. With linear programming, we want to follow population projections and meet the LTC needs by providing adequate human resources and investing in long-term care community homes. The fuzzy assessment of the availability of human resources in the Lower Sava region and its municipalities is presented, from where the necessary attractiveness to caregivers is evaluated, and the essential dynamics of supply regarding demand for social housing units for attracting the caregivers and older residents dispersed through municipalities in this functional region is scheduled.

Keywords: long-term care, housing dynamics, spatial hierarchy, linear programming, Lower Sava region, fuzzy evaluation, CURDS

1 INTRODUCTION

1.1 Geo-gerontological aspects of the social housing programs

A good, dynamic long-term care (LTC) program can also help to stop the exodus of young people from rural areas looking for work elsewhere and the older adults who can only find care in larger urban centres. The construction of available and accessible suitable housing is one of the factors that can mitigate emigration from rural areas and, therefore, mitigate the population decline. To meet demographic changes with adequate housing, we must consider the decreasing number of young people – young families and the increasing number of older people with declining functional abilities. In spatial planning, a long-term housing program is essential to finding the best solution within limited resources and prioritising social housing goals.

We shall demonstrate how spatial data, fuzzy evaluation of Travel-to-work areas (TTWAs), and its projection based on results of the gravity dynamics, age structure projections, and housing needs dynamics can be integrated using linear programming and how the regional financial capabilities influence social housing policy. The case of programming construction of social housing for LTC users and LTC providers in municipalities of the Lower Sava region is presented.

1.2 Human resources for the Long-term Care services - Projections on the base of the fuzzy regionalisation

1.2.1 How to analyse the availability of human resources

When analysing human resources (HR) availability over a longer time horizon, we often start from the demographic structure by spatial units, population flows between spatial units and their association in hierarchical spatial systems. In the context of demographic and technological changes, regions are a generalisation of changing social and economic functional contexts in a particular area. They are often analysed based on economic interactions, with functional regions (FRs) usually presented as local/regional areas and nodes of systems for implementing specific functions and flows of human resources within them and between other units.

Based on the concept of human resources in such systems, FRs encompass one or more areas of the local labour market. Commuting to work, especially daily, as well as immigration and emigration, are the most common and stable forms of population movement. Minor changes in the labour market do not significantly affect the pattern of daily flows to and from work; changes in the boundaries of FRs occur only when there are significant changes in the pattern of these flows. In the study, we assumed FRs are local and regional labour market areas for caregivers of vulnerable older adults in the region who are involved in LTC.

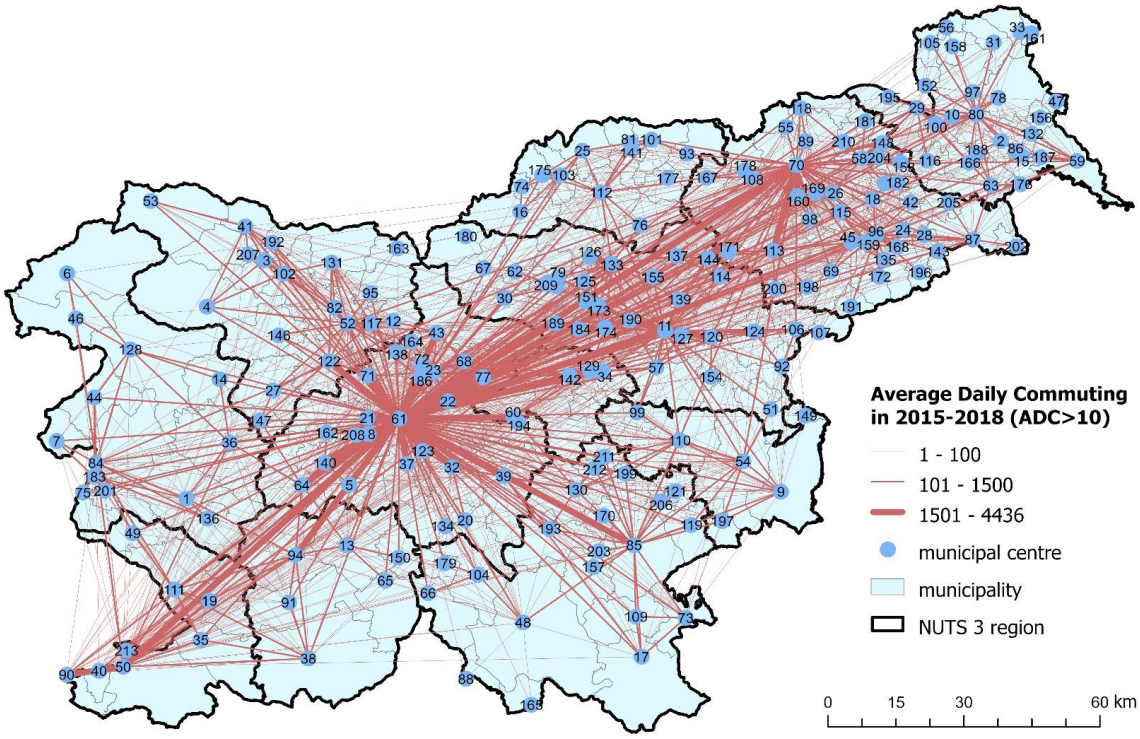
1.2.2 Source of data

In this paper, we proceed from the results of modelling FRs in Slovenia using the CURDS method (»Centre for Urban and Regional Development Studies« by Coombes, Green, and Openshaw, 1986; Coombes and Bond, 2008), which is based on internal rules for grouping basic spatial units (municipalities) into FRs.

The Statistical Office of the Republic of Slovenia (SORS, 2019a) has regionalised Slovenia into twelve statistical regions at the macro level. The regionalisation was carried out based on an extensive analysis of the gravitational areas of commuting to work and school and population supply, as shown in the work of Vrišer (1974). The Regulation on the Standard Classification of Territorial Units of Slovenia (SKTE) (OGRS, 28/2000) ensured that the boundaries of the twelve statistical regions are now aligned with the boundaries of the municipalities. These boundaries allow for the homogeneous aggregation of statistical data from lower to higher levels (SORS, 2019a). In 2003, Regulation (EC) No 1059/2003 of the European Parliament and of the Council on the establishment of a standard classification of territorial units for statistics - NUTS (OGEU, 2003) was adopted and implemented as a tool for unified European

datasets, which was updated with the accession of the new Member States in 2004 (OGEU, 2005). From this year onwards, the statistical regions of Slovenia are NUTS level 3. In this respect, it is essential to consider the criteria defining the number of inhabitants in each unit at each NUTS level, according to which a NUTS3 region, measured by the average number of inhabitants, must have a population of between 150 000 and 800 000 inhabitants (OGEU, 2003). The NUTS level 3 data have constraints in the number of inhabitants in each NUTS level. In practice, this means that Slovenia can have a minimum of three and a maximum of 13 statistical regions at this level (SORS, 2019a). Still, the borders of areas could also be modified to a functional region.

In our study, we have drawn on statistics on labour force participation among 212 Slovenia municipalities in 2015-2018. These data were obtained from the Statistical Register of the Working Population (SRWP; SORS, 2019b), where the place of residence and the place of work of the employee are available. We considered labour mobility flows in a square interaction matrix of dimension 212x212 from origin i to destination j. We evaluated the statistical regions or NUTS 3-level regions using data on average daily labour commuter flows between Slovenia municipalities in 2015-2018. Spatial data on statistical areas and municipalities in Slovenia are available from the Surveying and Mapping Authority of the Republic of Slovenia (GURS, 2019a, 2019b). In this study, we use the official codebook of municipalities in the Republic of Slovenia and consider their belonging to the region or the flow across "soft" borders in terms of human resources. This result is demonstrated in Figure 1.



(data source: GURS, 2019a; SORS, 2019b; own calculation)

Figure 1: Average daily flows of labour mobility between municipalities in Slovenia in 2015-2018

Using

(A) data on average daily flows of commuting between municipalities in Slovenia in 2015-2018 (see Figure 2),

(B) results on gravity forces from migration factors in the gravity model,

(C) projections of the LTC demand and

(D) availability of social housing units due to financial and land constraints,

(E) results on the impact of distances for willingness to move into sheltered housing units for those who need LTC support,

We will develop the model for social housing allocation and construction dynamics in the next 20 years. The basic methodology, upgrading fuzzy approach of Feng (2009), is given in Section 2.1, including suggestions for improvement with factors of gravity model. The method of evaluation parameters for forecasting demand, including examples for the Lower Sava Region, is presented in

Section 2.2. The numerical example for the Lower Sava region is demonstrated in Section 3. The conclusions are available in Section 4.

2 METHODS

2.1 Fuzzy values of available human resources in spatial units of a region on a higher level

Using data on average daily commuting flows between municipalities in Slovenia in 2015-2018 (see Figure 2), we analysed the membership of a municipality to a statistical/NUTS 3 region. We evaluated the membership of each municipality to a region and to the formed Local Action Groups (LAGs) as presented in Bogataj et al. (2023a) according to the principles of fuzzy set theory as proposed by Feng (2009) and Watts (2009, 2013) and with an extension by Drobne (2021). According to this approach, the degree of membership of a municipality to a region or LAG, i.e., the fuzzy value of membership, is lower when more labour mobility from a municipality takes place to another region or LAG and higher when most labour mobility takes place within a region or LAG. The fuzzy value approach allows for identifying a municipality to many areas while helping to identify potentially poorly defined regions. The fuzzy value of a municipality's membership to a region is calculated using two parameters – with the reference to the fuzzy residential area and with the reference to the fuzzy workplace area (see the details of developing fuzzy areas in Feng, 2009).

The fuzzy value of the municipality's residential membership to the m-th region M'_{im} is calculated:

$$M'_{im} = \sum_{j \in (g)m} f_{ji} / f_{\cdot i} \quad (1)$$

where municipality i like all j belongs to region m ($j \in (g)m$) based on regionalisation and f_{ji} is the labour mobility (commuting) from j to i in the region, while $f_{\cdot i}$ is the number of all commuters to i. The fuzzy value of local employment of workers in municipality i in region m is calculated as:

$$M''_{im} = \sum_{j \in (g)m} f_{ij} / f_{i\cdot} \quad (2)$$

where $f_{i\cdot}$ is the number of all commuters from i.

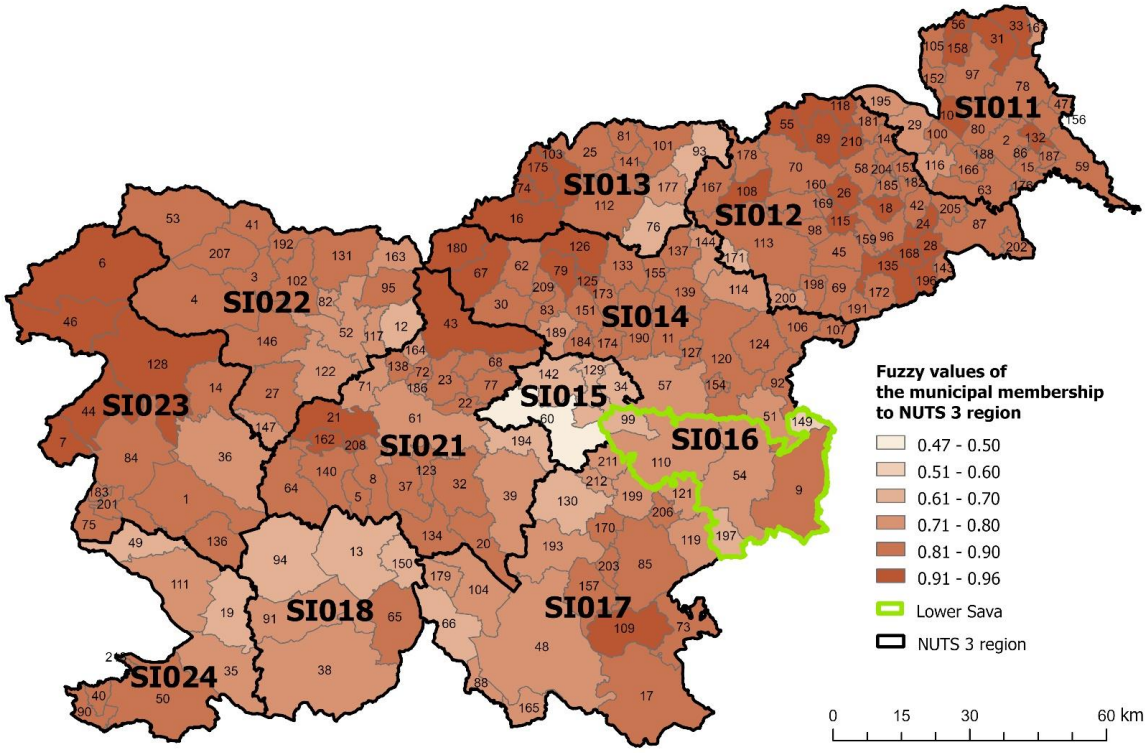
Feng (2009) proposes to calculate the fuzzy membership value of each municipality to region m, M_{im}, as the arithmetic mean between M'_{im} and M''_{im}. As both fuzzy values are relative numbers, Drobne (2021) proposed that the geometric mean should be used to calculate M_{im}:

$$M = M_{im} = \sqrt{M'_{im} \cdot M''_{im}} \quad (3)$$

Similarly, we calculated the fuzzy membership value for each region as the geometric mean of the fuzzy values of the municipalities in the region.

Using the fuzzy approach according to (1), (2) and (3), we can calculate the fuzzy membership values of the municipalities to the NUTS 3 regions in Slovenia as the geometric mean of the fuzzy membership values of the municipalities in the region. The results for the municipalities are shown in Figure 2, the results for the NUTS 3 regions are shown in Table 1, and the results for the municipalities in the Lower Sava region are shown in Table 2.

Table 1 shows that the (geometric) mean fuzzy value of the municipal membership to the NUTS 3 region in Slovenia is 0.831. According to the data in Figure 2, most municipalities in the southern part of Slovenia have a lower fuzzy value than 0.83, which means that workers mainly commute to work in neighbouring regions. Low values are especially found for the Lower Sava region, where the fuzzy membership values range from 0.528 (Bistrica ob Sotli) to 0.803 (Brežice).



(*data source: GURS, 2019a; SORS, 2019b; own calculation***)**

Figure 2: Fuzzy values of the municipal membership to NUTS 3 regions in Slovenia

Table 1: Fuzzy membership values of Slovenian NUTS 3 regions (*M*) as the geometric mean of the fuzzy values of the municipalities in the region

NUTS 3 ID	NUTS 3 region	*M*
SI011	Mura	0.865
SI012	Drava	0.876
SI013	Carinthia	0.830
SI014	Savina	0.860
SI015	Central Sava	0.629
SI016	Lower Sava	0.673
SI017	Southeast Slovenia	0.789
SI018	Littoral-Inner Carniola	0.722
SI021	Central Slovenia	0.846
SI022	Upper Carniola	0.804
SI023	Gorizia	0.876
SI024	Costal-Karst	0.784
	together (Slovenia)	***0.831***

(data source: GURS, 2019a; SORS, 2019b; own calculation)

From this data, we can assume that in the Lower Sava region, 1/3 of workers should be attracted from other regions as immigrants and that we must provide for their accommodation. The question is whether it would be enough to provide them with public housing. From the number of yearly immigrants and the percentage of those who are working in Slovenia in LTC (*IRSSV*; q = 0.8%), we can calculate how high the increase of available housing or wages at given α(GEAR) and α(NDEW) in formula (4) to attract enough caregivers should be.

Table 2: Fuzzy membership values of municipalities (M) in the Lower Sava region, the related average of yearly inflow of human resources 2015- 2018 ($f_{.i}$) and those suitable for the LTC workplace.

Municipal ID	Municipality	M	$f_{.i}$	$q \cdot f_{.i}$
9	Brežice	0.803	1771	14
54	Krško	0.782	3406	27
99	Radeče	0.621	350	3
110	Sevnica	0.724	1696	14
149	Bistrica ob Sotli	0.528	131	1
197	Kostanjevica na Krki	0.622	550	4
	together (Lower Sava region)	*0.673*	*7904*	63

(data source: GURS, 2019a; SORS, 2019b; own calculation).

Thus, from the funds and spatial constraints for the construction of residences for LTC users and caregivers, we must separate the necessary parts for caregivers at the given total area for available housing units in LTC. The gravity model for permanent migration of the working-age cohort can tell us whether we will achieve such attractiveness in the selected area on a higher level (Drobne, Bogataj, 2024). From equation (2) in that paper (here written in equation 4) and results in Table 2 of Drobne and Bogataj (2024, here presented in Table 3), we may conclude that 30% higher housing supply will attract approximately 35% more working-age inhabitants, while 40% higher salary will attract 41% more human resources.

$$M_{ij}^{(c,s)} = k\, K(d_{ij})^{\beta} \prod_r K(r)_i^{\gamma(r)}\, K(r)_j^{\alpha(r)}, \qquad (4)$$

Table 3: Required increase of dwellings for caregivers and wages for them to attract p% of caregivers to Lower Sava region.

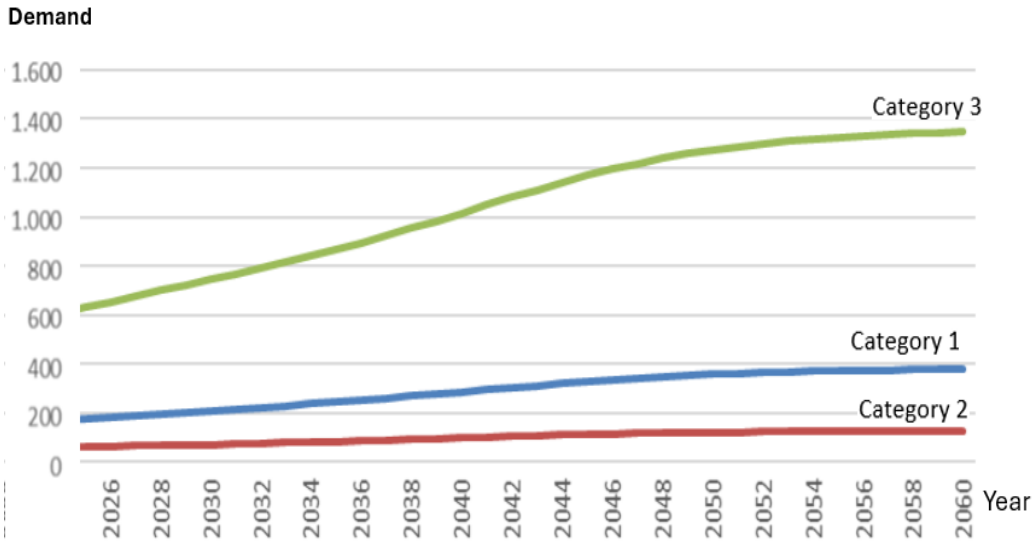
				Increase of factors of attractiveness for human resources				
	α	**X**	**=**	**0.1**	**0.2**	**0.256**	**0.3**	**0.4**
GEAR	0.017	(1+X)^0.017		10%	20%	26%	31%	41%
NDEW	0.154	(1+X)^0.154		12%	23%	30%	35%	47%

(data source: Drobne, Bogataj, 2024; own calculation)

We can see in Table 3 how much stronger this factor is relative to the attractiveness of increased wages.

2.2 Geo-gerontological projection of LTC demand

Considering the demographic projections of cohorts of the age groups in the studied time horizon $N(s,t)$ for the studied area – region or municipality (Directorate-General for Economic and Financial Affairs-DGEFA, 2024) and percentage of those who need LTC in categories *KAT1, KAT2 and KAT3* (GURS 2023a), we calculated the geo-gerontological projections of demand in Slovenia in the time horizon for the inhabitants of the studied area (Bogataj et al., 2023a). Here N is the number of inhabitants in the cohort s, and t is the year in the horizon. Example of the projected number of LTC users according to the known age cohorts given in DGEFA and percentage of those who would need LTC of one of the categories ($p_{KAT1}, p_{KAT2}, p_{KAT3}$ in that cohorts), as given by Bogataj et al. (2023a), calculated from the internal data of the Social Insurance Institute of the Republic of Slovenia in a given age cohort s in year t for the Lower Sava region is given in Figure 4. Namely, knowing the probability that a person of an age group s will be in care category $KAT1(s)$, $KAT2(s)$ *or* $KAT3(s)$ we can also calculate the demand of LTC and therefore according to the norms and standards for LTC; also the number of required caregivers is calculated.



(data source: GURS, 2023a; SORS, 2019b; own calculation)

Figure 3: Projections of the number of residents aged 65+ who will need some category of care in the Lower Sava region from 2025 to 2060 (no migration scenario – NMGR).

Projections of demand $D(s,t)$ is calculates as

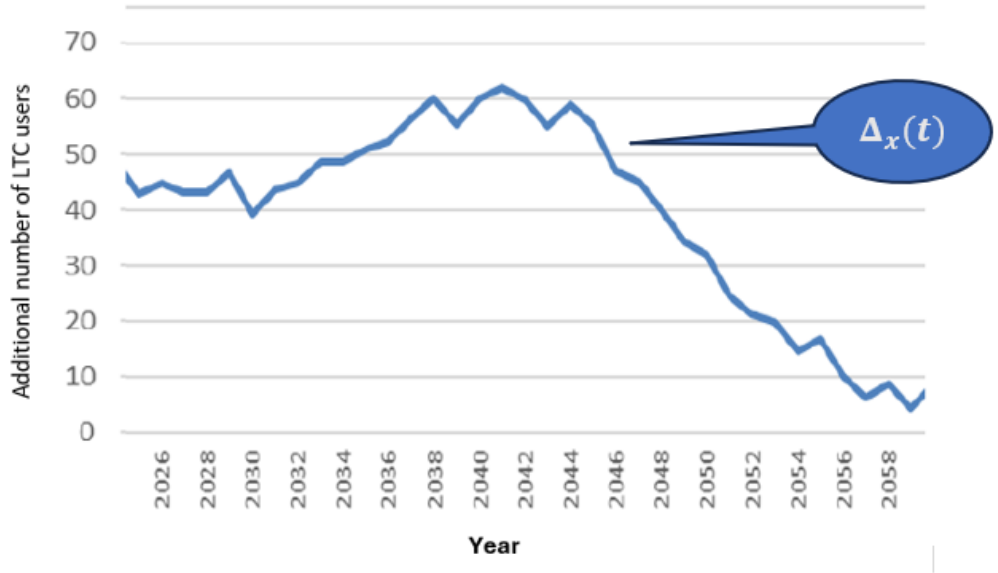
$$D(s,t) = p(s) \bullet N(s,t) \quad (5)$$

The notation *p*(*s*) here means a share of those in cohort *s* who need LTC services, which was developed from the basic data of the Society of Social Institutions of Slovenia (SSZS, 2023). Still, some will stay in the homecare network, and others must go to one of the CCUs or nursing homes (half of *KAT3* – *Kat3b*).

New yearly demand which requires additional LTC housing to be built and services which require additional human resources would be

$$\Delta_x(t) = \sum_j \sum_s [D(j,s,t) - D(s,t-1)] \quad (6)$$

The results for the Lower Sava region are given in Figure 4.



Source: Bogataj et al., 2023a.

Figure 4: Projections of the additional number of LTC users in CCU or CH per year *t* in Slovenia in the Lower Sava region until 2060 (no migration scenario – NMGR).

2.3 Choosing plots for social housing in ownership of the municipality

2.3.1 Choosing plots for social housing suitable for LTC

Each municipality should consider where to build the CCU for LTC and the dynamics of building the housing units for LTC. Usually, they already have some plots for social housing available. From the data of inhabitants (Ministry of the Interior of the Republic of Slovenia – MIRS, 2021) and the location of their housing units (coordinates of their homes available at GURS), we can estimate the plot most suitable for the construction of CCUs. We should consider the distances d_{ij}, from family homes of older persons i and potential community housing units j. We should focus on the distances d_{ij} between the potential LTC demand i and the location of the supply, community care unit CCU_j. Forecasting the demand for housing in a community care unit j (CCU_j) for older people with reduced functional abilities should be guided by demographic projections and data on the percentage of those who need to move due to loss of their functional capacities to the extent that they need to adapt their part of the family home or move into a *CCU*. The location of family houses, where demand can appear, can be forecasted if we have data on the age and gender of the persons living at individual addresses (we got it from MIRS, 2021). To this data, we added the coordinates of the addresses kept by the Geodetic Administration of the Republic of Slovenia (GURS 2019a). Based on these data, the demographic projections as a whole and the data on the proportion of those who need long-term care in each age cohort (*GURS, 2023, 2023a)*, we can determine the demand for services in CCU_j, if we know how much those who need LTC are willing to move from their family home to the CCU_j. It depends on the distance between family home and CCU_j.

2.3.2 Calculating the distance between family home and CCU_j.

We can forecast the yearly new demand at each municipality $D(CCU_j, t)$ dependent of distance d_{ij}

$$D(CCU_j, t) = \sum_s D(j, s, t) = \sum_s \sum_i p(d_{ij}|s) \cdot p(s) \cdot (N(s, t) - N(s, t\text{-}1)) \quad (6)$$

Where $p(d_{ij}|s)$ is the probability that a person at a distance d from their family home is willing to move into a CCU_j. As studied by Black and Hyer (2020), in the USA, $p(d_{ij}|s)$ differs among age cohorts, but in our paper, we shall take that they do not; therefore, we operate with averages, taking our statistics, given in Table 4.

Therefore:

$$p(d_{ij}|s) = p(a(l)) \quad (7)$$

Here $a(l)$ is the maximum distance at which an older adult from a distance d_{ij} is willing to move in a CCU_j. Table 4 presents the data for the Lower Sava region.

Table 4: Distance still acceptable for moving to adapted housing by percentage of respondents $p(a(l))$.

distance	percentage of users
up to 1 km	20%
(1-5] km	34%
(5-10] km	28%
more than 10 km	18%

Source: Rajer et al., 2022

Table 4 shows that nearly 20% of LTC users would stay home and that almost 50% of older adults do not wish to move more than 5 km from their family home. For the Lower Sava region, we can see the data for 2023 in Table 5. Table 5 shows that if each municipality built a **CCU** in their municipality centre, 1/3 of the area where family homes are located would be more than 5 km from potential CCUs.

Table 5: Distance of potential nearest CCU from senior citizens' family homes.

	years old

	65-79				80+			
Distance	under 5 km		over 5 km		under 5 km		over 5 km	
	number	%	number	%	number	%	number	%
Slovenia	249,007	70.4	104,875	29.60	83,868	71.8	32,924	28.2
Lower Sava region	6,300	51.8	5,860	48.2	2,098	52.5	1,901	47.5

Source: MIRS 2021 and GURS, 2019a

We shall assume that for a potential client i, the expected cost to move to CCU_j is $E(c\ (d_{ij}))$ If $l_k \leq d_{ij} \leq l_{k+1}$, $E(c\ (d_{ij}))$ is equal to $l + M[l - a(l_k)]^+$ where distance $a(l_k)$ is the lower limit of the class from Table 4 in which the value l is given.

$$c(i,j,l) = \sum_i \sum_j x_{ijt}\, E(c\ (d(\mathrm{i,j})) = \sum_i \sum_j x_{ijt}\ (d_{ij} + M\left[d_{ij} - a(l_k)\right]^+ \qquad (9)$$

Here, in time of allocation t, user i goes to only one CCU; therefore, we have: $\sum_j x_{ij} = 1$
M is very high and $M[l - a(l_k)]^+$ is the cost of distance in case that it is higher than the critical value $a(l_k)$. The minimum affordable distance between i and j : c (i, j, l) is calculated with the geographic information systems' analytics. Estimating distances or travel time between a set of origins and destinations in a transport network is a common spatial analysis task in geographic information systems (GIS).

We want (our partial goal) that the sum of the costs of all these migrations should be minimal over the whole horizon under consideration. However, in doing so, we are limited by the funds available and the vacant land owned by the local communities that could be included in the spatial plan to construct these facilities. Therefore, we can formulate the partial goal:

$$\min \sum_{t=0}^{T} \sum_{j \in B_j} \sum_{i=1}^{\Delta_x(t)} \sum_i \sum_j x_{ijt}\ (d_{ij} + M\left[d_{ij} - a(l_k)\right]^+) \qquad (10)$$

Here $B_j(t)$ is the set of available housing units for new LTC users in the year t and $\Delta_x(t)$ is their total number over *CCUs* if demand is lower or equal to supply.

2.3.3 Optimisation of construction dynamics choosing yearly CCU_j, it's capacity and structure

The construction dynamics $B_j(t)$ for any *CCU* and its structure regarding housing for the LTC users $\Delta_x(t)$and caregivers $\Delta_y(t)$ depends on the budget available and the empty community plots in each municipality. The dynamics of available plots should be considered already in the spatial plan of municipalities; therefore, the dynamics should be forecasted many years before housing units are available.

In R, we set up the program and solve a linear programming dynamic decision problem, minimising the differences in supply and effective demand so that the solutions are as close as possible to clients' wishes regarding staying close to the family home and their social networks. In the results of optimal supply, we assume that Δ_y(t) is the sum of all housing units of β size regarding the size and costs of units for the LTC users (in our case, it is equal to 2) that will be available for LTC caregivers. Criterion is therefore: $\min f$, where f is the sum of all costs of moving clients to CCUs, as evaluated by users, and investments in housing units.

$$f = \sum_t \left\{\vartheta[p(s) \cdot \sum_i \sum_{j \epsilon B_{j(t)}} c\left(d_{i,j,t}\right) \cdot x_{ij}(t)] + \mu \sum_{j \epsilon B_{j(t)}} (\gamma_j \cdot d_j^+(t) + \vartheta_j \cdot h(t)\right\};$$

$\boldsymbol{x_{i,j}}$(t)={0, 1}.

$$j \epsilon B_{j(t)};\quad r \epsilon B_{r(t)}; B_{j(t)} \cup B_{r(t)} = B;\quad B_{j(t)} \cap B_{r(t)} = B = 0 \qquad (11)$$

Here ϑ / μ is the proportion between the importance of providing LTC in CCUs and the importance of the budget, which is taken equal to 1 in our case study.

Here $\boldsymbol{B_j}(t)$; is a set of opened *CCUs* available at time *t*, $\boldsymbol{B}(t)$ is the total set of CCUs potentially available in t; $d^+_j \in \{0, 1\}$; $d^+_j(t)=1$ if the plot is open to construction in the year *t* and $d^+_j(t)=0$ if it is not.

$$\text{If } \sum_{\tau=0}^{t} d_j^+(t) = 1 \rightarrow h(t) \geq 0; if \ \sum_{\tau=0}^{t} d_j^+(t) = 0 \rightarrow h(t) = 0 \qquad (12)$$

where γ_j measures the construction cost of a block of facilities inside unit j, and ϑ_j is the cost of opening the facility without the units inside. Here x_{ij} *(t)* has the values 0 (not to be linked in the graph) or 1 (to be connected in the graph). The further constraints are:

1) Each new potential user (*i*) goes to exactly one available facility:
$$\sum_{j \in B_j} x_{ij} = 1 \qquad (13)$$

for each *i*; $\boldsymbol{x_{i,j}}(t) \in \{0, 1\}$ for any *t*; See also (5-6):

2.) There is a growth in demand with the cumulative *GK*(*t*). In the case of growth *KG*(*t*), the development is expressed in constraints: According to the size of plots and the spatial planning regulations:

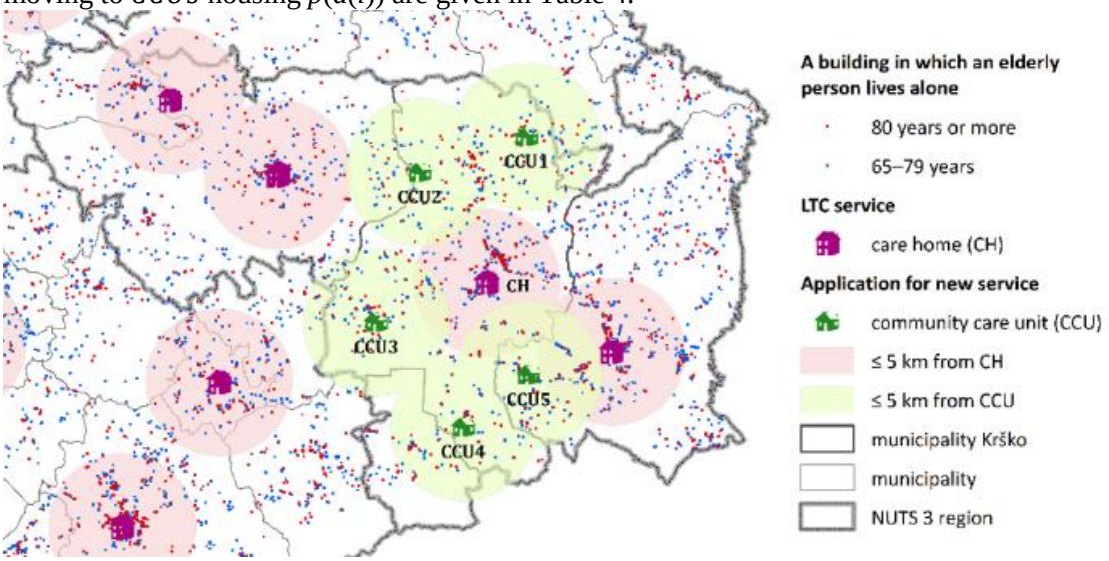
$$GK(t) = \sum_{\tau=0}^{t} (\Delta_x(t) + \beta \Delta_y(\tau)/3) \leq \sum_j \sum_{\tau=0}^{t} \omega_j(\tau) \cdot d_j^+(\tau) \leq \sum_j \sum_{\tau=0}^{t} inv_{j\tau}$$

Here β is the size of housing units for caregivers relative to the size of studios and ω_j is the number of basic units in blocks of elementary units – studios, available at time τ, where also housing of caregivers which size is β the size of the studio) per plot in *CCUj* according to the spatial and construction plans in *CCUj*. Notation $inv_{j\tau}$ is the available investment in the municipality j in timeτ (sum of all municipality investments) equal to the available budget reduced for additional salaries according to formula (4), if needed. *GK(t)* is the cumulative demand for housing units – studios for the attracted new caregivers- sized as elementary care units.

3 NUMERICAL EXAMPLES FOR THE LOWER SAVA REGION

3.1 Implementation area

As described in sections 1 and 2, the studied area is the Lower Sava region. The map of this region is given in Figure 5. The communities have five available locations of community or state-owned plots and existing nursing homes (care homes-CH), among which one could be extended in the proposed program (marked with CH on the map). *CCU1-CCU5* are publicly owned plots where housing units for LTC users and caregivers can be provided. We assume that the values of distances still acceptable for moving to $CCUs$ housing $p(a(l))$ are given in Table 4.



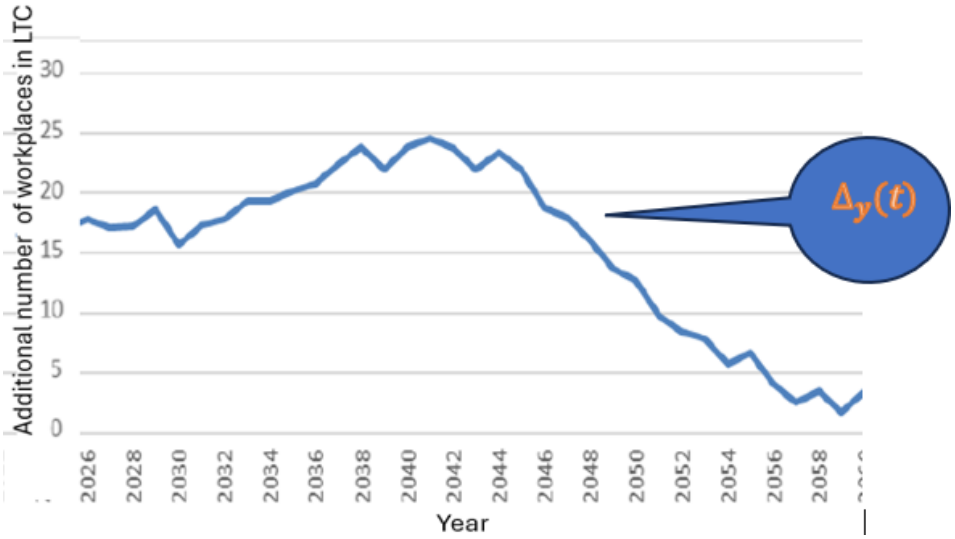
Source: Ministry of the Interior of the Republic of Slovenia – MIRS, 2021; Institute of the Republic of Slovenia for Social Welfare – IRSSW, 2021; Statistical Office of the Republic of Slovenia, SORS, 2021; GURS, 2021; own calculation).

Figure 5: Areas within 5 kilometres of Nursing Care Homes (CH), potential Community Care Centers (CCU), and locations of buildings in which senior citizens live alone in the Lower Sava region (2021).

The distances lower than 5 km are colored in Figure 5. It means that 48% of those not covered with these two coloureds will never move to a CCU. In case of falling in *KAT3*, there is a probability of 0.5 (being in KAT3b) that they will need to move to a nursing home, but this is assumed to be under the responsibility of the national LTC program. Also, inside this circle, we assume that 20% of LTC users require home care, as interpolated in Table 4.

3.2 Attracting the human resources

From the Rulebook on standards and norms of social welfare services (OGRS, 2024), data by The Association of Social Institutions of Slovenia (SSZS, 2023) and Projections of the additional number of LTC users per year in Slovenia in the Lower Sava region until 2060 (our calculations, Figure 5) we can calculate the required number of new caregivers each year (Figure 6).



Source: SURS 2024, EUROSTAT 2024, SSZS, 2023, OGRS 2024

Figure 6: Projections of the needed additional social care workers and nursing staff in the Lower Sava region by year until 2060 (actuarial calculation for the scenario without migration – NMGR).

- From section 2, it follows that 1/3 of caregivers should be attracted from other regions $(\Delta_y(t)/3)$. Therefore, we shall build housing units for them on municipally owned land where CCUs are planned. Therefore, fewer housing units for the LTC users will be available in one block of buildings, and the dynamics of opening new plots will be higher. Table 3 shows that we can attract them by increasing salaries by more than 31% or increasing the available housing for caregivers by at least 35%.
- Considering the available money for opening a new *CCU* and building some ten-studio blocks or fewer studios and additional housing for the caregivers, the municipality should follow the constraints, where *Inv*(*t*) are the funds released during *t*.

- There are limited possibilities to build studios: We can add modules (blocks) of exactly ten studios to the basic construction yearly if the *CCU* is already open, up to plot constraints. Here, for each j , $\beta_j = 10$. In this case, one of the solutions could be, for example, that the construction in time t would be two homes for caregivers and six studios for the LTC users

The overview of the spatial planning solution for caregivers is given in Table 6, and the allocation of all housing units, if the home for caregivers is equal to the size of 2 studios for the LTC users, is presented in Table 7.

Table 6: Requirements for additional housing units for the LTC providers yearly.

Year	2026, 2027	2028, 2029	2030, 2031	2032, 2033	2034, 2035
Needed no. of new caregivers per year	17	18	16	18	20
Needed no of additional housing units	6	6	5	6	7

Let us now assume that we shall provide CCUs to all of those who are willing to move to the nearest CCU available (80% of all) if they will not need to go to CH (50% of KAT3) and to all LTC caregivers (for care in CCUs, homecare and nursing homes)who should be attracted from other regions (1/3 of all newly employed). In total demand for LTC, we assume that 30 blocks should be constructed in CCUs in the first decade; starting with construction in 2025, 37 blocks should be built in the second decade. Because of the decision that CCUs will not be appropriate for KAT3b users (50% of KAT3 users), up to 10 blocks of CH units should be constructed in the first decade and 23 blocks in the second decade.

Table 7: Dynamics and allocation of building blocks - in each could be up to ten basic units (studios for LTC users) or fewer studios and the required number of flats for caregivers.

		Blocks of 10 basic units					**beds**
Years		***CCU1***	***CCU2***	***CCU3***	***CCU4***	***CCU5***	***CH***
2026/30	All blocks	7	4	0	4	0	63
	For LTC clients- basic units	40	24	0	26	0	
	No. of homes for workers	15	8	0	7	0	
2031/35	All blocks	9	4	0	4	1	78
	For LTC clients- basic units	60	24	0	26	10	
	No. of homes for workers	15	8	0	7		

The financial resources in the Lower Sava region are limited for financing the construction of 15 blocks of buildings in the first 5 years, having ten basic units each, or to attract a proportional quantity of caregivers for all modes of care with a part of this money and plots (1/3 of all needed newly employed each year, as presented in Table 6). The availability of plots in the next 10 years already owned by municipalities is assumed to be 20 blocks in CCU1 and up to 10 blocks in each CCU2 to CCU5. Nursing care homes could extend to 200 beds in the next 10 years. These constraints are put in the model. The results are given in Table 7.

4 CONCLUSIONS

The number of residents in Slovenia who need or will need LTC housing and services is increasing, and the projections are given in Figure 3. For many of them, the housing conditions in the family environment (the current environment in which they live) are inappropriate, like in almost all EU member states. Therefore, it will be necessary to subsidise housing adaptation for disabled older adults or enable them to move to an appropriate housing unit in community care buildings or nursing homes (care home CH here). European directive suggests creating long-term care systems in the communities. Communities have spatial and financial constraints for doing so, but there has been a lack of human resources in recent years. Therefore, some sources for accommodating senior citizens in CCUs or HCs should now be reserved for the necessary human resources in the LTC services. Thus, we suggested considering the availability of human resources in the region and each municipality through the study of the fuzziness of travel-to-work areas, as indicated by Feng and improved by Drobne, by applying fuzzy set theory and upgrading this characteristic with the factors of wages and housing availability in gravity model (like here, using equation 4) to consider the impact of the attractiveness of areas that provide housing solutions for incoming workers. The housing needs for human resources influence constraints on available public plots and budgetary constraints like in our numerical example of allocation and dynamics of the construction of the prefabricated studios for older adults in a block of 10 such studios. If the availability of public housing for new workers from other regions is not attractive enough, the standard of housing units (higher β) or higher salaries according to formula (4) should be considered.

Acknowledgements: *The authors acknowledge the financial support from the Slovenian Research and InnovationAgency (ARIS) through the research project Hierarchical Design and Financing of Social Infrastructure of Smart Silver Villages (L7-3188) and Evaluation of the Sustainable Development of Urban Space Through the Parameters of Social Infrastructure Development and Life Satisfaction (J5-3112).*

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Strategies for urban resilience

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Problem Statement:

The city-scape consists of domains for households and public space for infrastructure. Public urban elements such as streets and city squares are spaces of community life where social cohesion between people comes through regardless of ownership of the buildings and facilities which surround them. Public Property Management, building and reconstruction of land, urban plots and public facilities is under the public jurisdiction of the Municipality. The management of state-owned land, which is of local importance, is the competence of local governments subsidiarily responsible for the execution of works of public interest and local importance. The problem of this regulation methodology is lack of research process before execution of the final design project. Participation of community members as final users is completely absent in this process, which creates a sense of uncertainty and understanding of the evolution of their urban environment.

Purpose of Study:

Community members express their common interests in the public space. To develop a livable and healthy community is guaranteed by OECD standards, where municipalities have responsibility to create strategies of developing capacities for urban resilience from future impact on the natural and urban environment. The purpose of this study is to create guidelines and prioritize strategies for future projects.

Methods:

To be able to define the scope of Public Property Management, this study recognizes, analyzes and proposes quantities of survey methods. To establish Sustainable Management which guarantees quality of design proposal, this research proposes a heuristic methodological approach regarding the strategy of Public Property Management.

Findings and Results:

Findings from this study should present several critical positions in the present methodology and propose improvements in strategy for Public Property Management:

- Stakeholders as a partners;
- Introducing of Process Management (PM) as a systematic approach to ensure effective strategies for urban resilience;
-Integration of community members in the decision-making process through participative actions.

These strategic goals should be tested in a series of participative actions between stakeholders: academic members, local municipality sectors, citizens and third parties. Participative actions will be presented on selected spots on urban territory of Municipality of Center, Skopje.

Conclusions and Recommendations

All involved parties in this study should learn that participation of the public sector in Process Management (PM) is the key part of the decision making process of urban politics. The strategies will improve the adaptations and development in a way to preserve the present balance and not be driven under question for future generations.

Key words:

resilience, process management, participation, Public-Private-People Partnerships (PPPP), public buildings.

1. Introduction - Political Economy

Public Property Management, building and reconstruction of land, urban plots and public facilities is under the public jurisdiction of the Municipality. The management of state-owned land, which is of local importance, is the competence of local governments subsidiarily responsible for the execution of works of public interest and local importance.

We can realize that the role of urban planning is taking under consideration the correlation between the economy of the land and politics.

This Biopolitical form of government exemplified the role of urbanization as a tool that optimizes urban infrastructure. Organizational structure of property management has its roots in scientific approach of Cerda's General theory of urbanization (Cerda, 1867) which implies (have implications) on social and economical growth and give the possibility of enabling a fertile ground for the reproduction of the labor force and its control, or governance (Aurelly, 2011: 11).

In Socialist period, in societies such as Macedonia before the independence, urban planning of Doxiadi's theory of Ekistics together with Polservice was primarily implemented in Skopje reconstruction after the earthquake in 1963. According to Tsiambaos (2019) social survey study from Doxiadis team was not granted by politicians and administrators where many local physical planners seem to prefer to rely on personal experience and intuition rather than invest in essential research and studies. Political decisions with their pragmatic and usually economical reasons shape the cities physically.

Contemporary urbanization in pluralistic political democracy shifts the paradigm of previous modernistic scientific tone toward economy of the land which becomes visible during the modernistic era.

In transition societies today it is obvious that the economy acts politically, but its politics ultimately aims to establish economic criteria as the primary organization of the human environment. After the industrial revolution the global economy transformed the world, but it transformed it into a world of economy.

With the coming of the industrial revolution, Debord (1995: 27-29) explains that the division of labor specific to that revolution's manufacturing system, and mass production for a world market, the commodity emerged in its full-fledged form as a force aspiring to the complete colonization of social life. It was at this moment too that the political economy established itself as at once the dominant science and the science of domination.

Political economy as an interdisciplinary system is a combination of multiple academic disciplines from several fields like sociology, anthropology, psychology, economics, and acts as one government policy. Privatization of natural resources and the state-owned land introduce completely new approaches considering the public property management.

At the center of this explicit principle, from Cerda on, the fundamental space of human association shifts from the political space of the city to the economic space of the house (Aurelly, 2011: 13).

Transformation of the city-scape became operated by private interests. Within this frame, any distinction between public space and private space, between political space and economic space, collapses in favor of a totalizing, organic understanding of the city as devoid of any limit, where urbanity itself is conceived as one domestic space (Aurelly, 2011: 16).

2. Oppositions (Public vs. Private)

2.1. Private Domain

Politics as rule of a group of people with collective identity organized for governance emphasize the importance of the economy of household management. Pluralistic character of contemporary governance is recognized as a principle of collective decisions which usually are not common in their interest. This dichotomy creates a condition of correlation between private domain of personal identification and public interest.

Self identification with space is strong cultural phenomenon where Hannah Arendt states that things and man form the environment for each of men's activities, which would be pointless without such location; yet this environment, the world into which we are born, would not exist without the human activity which produce it, as in the case of fabricated things; which take care of it, as in case of cultivated land; or which established it through organization, as in the case of the body politic (Arendt, 1998: 22).

The city-scape consists of domains for households and public space for infrastructure. Public urban elements such as streets and city squares are spaces of community life where social cohesion between people comes through regardless of ownership of the buildings and facilities which surround them.

Our public interest, our political life could be only established in public space. According to Greek thought, the human capacity for political organization is not only different from but stands in direct opposition to that natural association whose center is at home (*oikia*) and the family. The rise of the city - state meant that man received "besides his private life a sort of second life, his *bios politikos*. Now every citizen belongs to two orders of existence; and there is a sharp distinction in his life between what is his own (*idion*) and what is communal (*koinon*). Beside the theory of Aristotle the history of the *polis* was preceded by the destruction of all organized units resting on kinship (Arendt 1998: 24).

From a psychological point of view one can realize that urban living is not a pure question of rights of citizens but rather an obligation to participate in the politics of planning processes.
Arendt (2005: 95) states that politics is based on the fact of human plurality. Unlike desires, imagination, or metaphysics, politics does not exist as a human essence but only happens outside of man. Man is apolitical, she claims, politics arises between men, and so quite outside man. There is no real political substance. Politics arises in what lies between men and it is established as a relationship.

2.2. Public Domain

The Council of Local Municipality administration is a political body which makes decisions regarding future development of the municipality. The members of the council are citizens who live in the same Municipality. Their political aspirations and decisions strongly influence the future development of the city.

According to Aureli (2011: 27) politics occurs in the decision of how to articulate the relationship, the infra space, the space in between. The space in between is a constitutional aspect of the concept of form, found in the contraposition of parts. As there is no way to think about the political within man himself, there is also no way to think about the space in between in itself. The space in between can only materialize as a space of confrontation between parts. Its existence can only be decided by the parts that form its edges.

Public interest usually takes shape in that space in-between, the space of infrastructure. The importance of representation is visible only in that infra-space. Cultural identity is a representational category. Urban environment is a mirror of societal conditions.

In pluralistic society democratic politics are characterized by negotiation and are constituted by demos, a heterogeneous strata of different professions and intellectual capacities. Institutions of local self-government and their councils are constituted from different political parties.

What liberal democratic politics requires is that the others are not seen as enemies to be destroyed, but as adversaries whose ideas might be fought, even fiercely, but whose right to defend those ideas is not to be questioned. To put it in another way, what is important is that conflict does not take the form of an 'antagonism' (struggle between enemies) but the form of an 'agonism' (struggle between adversaries) (Mouffe, 2013: 18).

Consensually is respecting and adopting ideas other than mine. The possibility to cohabitate in a community with diverse cultural identities suppose inclusiveness, opposite the rule of minority over majority.

For the agonistic perspective, the central category of democratic politics is the category of the 'adversary', the opponent with whom one shares a common allegiance to the democratic principles of 'liberty and equality for all', while disagreeing about their interpretation. Adversaries fight against each other because they want their interpretation of the principles to become hegemonic, but they do not put into question the legitimacy of their opponent's right to fight for the victory of their position. This confrontation between adversaries is what constitutes the 'agonistic struggle' that is the very condition of a vibrant democracy (Mouffe, 2013, ibid).

3. Drawing the Boundaries

The problem of regulation methodology under the public jurisdiction of the Municipality is lack of research process before execution of final design project. Participation of community members as final users of public space is completely absent in this process. This procedure of management creates a sense of uncertainty and understanding of the transformation and evolution of their urban environment of self identification.

The governing methods of economy transcend the boundaries between public space and private space, instituting the latter—the despotic administration of the house—as the principal mode of governance for the whole of urbanity (Aureli, 2011: 16).

Community members express their common interests in the public space. It is inevitable not to receive confidence in urban policies when basic principles such as public service are avoided.

Therefore the essence of urbanization becomes the destruction of any limit, boundary, or form that is not the infinite, compulsive repetition of its own reproduction and the consequent totalizing mechanism of control that guarantees this process of infinity. The process of urbanization transcends not only the difference between public and private, but also any difference that matters politically, such as the difference between built space and open space, or between what Arendt identified as the three spheres of the human condition: labor, work, and 'vita activa' (Aureli, 2011, Ibid).

Such politics of urban management inverted the declaration of livable and healthy community which is guaranteed by OECD standards, where municipalities have responsibility to create strategies of developing capacities for urban resilience from future negative impact on the natural and urban environment.

New European policies involve striving to achieve the Sustainable Development Goals across all areas, pressured by climate change, population growth, and the burden on urban infrastructure. Particularly significant is SDG 11 – Sustainable Cities and Communities, a goal directly related to creating resilient cities with strong communities that manage the city and its infrastructure in the most sustainable manner possible.

All of these differences are absorbed within a process of growth that is no longer dialectical but incremental and therefore infinite. It is not by chance that the key concepts of contemporary urbanity—such as network, landscape, globalization—share the same conceptual and ideological common ground: the infinite continuity of movement propelled by production, which systematically metabolizes anything within a process that always changes, and is thus able to preserve its stability (Aureli, 2011, ibid).

When discussing urban resilience strategies, it is about a serious and holistic approach to city policies, integrating all aspects of urban living, including culture, public health, cultural heritage, ecology, biodiversity, safety, science, economy, and politics. For cities to be resilient, a comprehensive approach and unified action are required not only from local and central authorities but also through cooperation with citizens, the civil sector, and the business community.

These strategies derived from sustainable policies are not limited to the macro level but are also applicable and useful at the micro level, such as in the management of public facilities. Public facilities of societal importance, which significantly define the city, play a crucial role in providing services to citizens, especially during crises. For example, during the global COVID-19 pandemic, open public spaces played a key role in recreation and mental health, while hospitals and health facilities were under immense pressure. Proper design and subsequent maintenance of these facilities are crucial for alleviating and resolving crises.

Many citizens in Macedonia, as a post-transition country, have developed civic behaviors from past systems, where citizens paid taxes to the state in exchange for the state maintaining and operating public facilities and spaces. During the transition period, there was a shift in value systems and the disintegration of political governance structures, as well as a decrease in the state's governing capacity. Under these conditions, many public spaces and community facilities that symbolized the past solidarity society have become abandoned and dilapidated. Citizens accustomed to a well-organized state often did not take personal initiative and frequently showed indifference towards public and common goods, believing they were neither their property nor their responsibility. In such social, moral, and economic degradation, many public facilities without proper management faced the brink of collapse.

4. Multi-Sector Partnerships;

4.1. Public-Private-People Partnerships (PPPP)

As we mentioned earlier that contemporary political economy is an interdisciplinary system which is a combination from several humanistic and societal fields it is important to introduce a heuristic methodological approach as a strategy of Public Property Management.

In Macedonia, responsibility for public facilities is divided among several institutions at different levels of government, depending on the type and purpose of the facility. The Real Estate Cadaster Agency is responsible for registering all public facilities and lands, which enables monitoring and management of these assets at the national level. Responsibilities for community facilities are divided as follows:

Central Government: Ministries (some public facilities, such as state hospitals, universities, courts, and ministries, are under the direct jurisdiction of the respective ministries) and agencies and funds.

Local Government: Municipalities and the City of Skopje. Municipalities are responsible for managing public facilities within their boundaries, such as primary schools, kindergartens, local sports halls, cultural centers, and other public spaces. Mayors and municipal councils make decisions related to the use, maintenance, and development of these facilities. As a special unit of local government, the City of Skopje is responsible for public facilities and infrastructure of city-wide significance, such as public transportation, major sports and cultural facilities, and secondary schools.

Agency for the Management of Confiscated Property: This agency is responsible for managing property confiscated from former owners or companies and which has become state property. This may include public facilities repurposed for other uses.

Governmental policy as a facilitator of public needs has the responsibility to act according to their interest. Recent theoretical research based on participative actions between citizens and local government administration recognized the Public-private-people partnerships (PPPP) model of Multi-sectoral Partnership as the best methodological approach.

In multi-sectoral organizations the model of Public-private-people partnerships (PPPP), creates collaboration between "public" which means government departments, "private" refers to private for-profit enterprises, while "people" represent citizens.

Public-Private Partnerships (PPP): At this moment some public facilities may be managed through public-private partnerships, where private companies participate in the development, maintenance, or modernization of facilities in collaboration with state institutions.

As Yan Xue at all (2020: 10) states in the public-private partnerships (PPP) model, the main applicable sectors are government agencies and private-sector companies. Unlike the other partnership modes, it does not include the citizens, which sometimes leads to missing the actual need of the citizens

The scope of Public Property Management is necessary to emphasize the participation of the people and makes the existing cooperation more diverse and realistic, thus considering the social aspect, which brings it closer to the complexity of real urban ecosystems. In the process of participation, the roles of the public, private, and people are usually facilitators, providers, and end-users, respectively. Different participating entities provide assets or services according to their own characteristics (Yan Xue at all 2020, Ibid).

Public-Private-People Partnerships (PPPP): Consideration must be given to the characteristics of the 21st century, such as late capitalism, postmodernism, and neoliberal markets. Globalization and market openness are altering citizens' lifestyles and the functioning of state systems and business structures. Hence, there is a need to advance the management of public property and actively involve citizens in the participatory process which needs to be improved.

This multi-sector form of public-private people partnerships (PPPP) is missing in communication with the public (non-professional, but also professional). Education and familiarization with the planning process, as well as education of investors and planners as one of the links in the spatial planning process is considered by experts employed in planning sectors of public administration.

Public Property Management is a process that includes managing, maintaining, and optimizing public facilities and spaces owned by the state or municipalities. This encompasses a wide range of activities, from planning and developing new public facilities to maintaining and adapting existing ones, as well as rational resource usage. Key aspects include: efficient use of public property (e.g., using schools for cultural and sports activities after school hours), maintenance and renovation (e.g., a partially preserved old railway station in Skopje used as a museum), flexibility to new needs, public-private-people partnerships, and digitalization. Aspects to be considered for sustainable management of community facilities include: energy efficiency, sustainable materials, infrastructure resilience to natural disasters, functional resilience such as flexibility and continuity, inclusive and transparent management: community involvement and responsible management, and the introduction of innovations: smart technologies and educational and informational platforms.

According to Yan Xue at all (2020: 9, 10) the government departments can provide corresponding institutional guarantees and enforcement rights, and the private companies can provide investment capital and operational management experience, but citizens have neither the authority nor the money, making it difficult for them to have an equal position. Ignorance of the situations and processes is what

creates uncertainty in the reaction of the public which usually triggers aggressive and unconstructive reactions. Citizens do not practice at a satisfactory level the obligation to understand and participate in the complex processes of spatial planning. Moreover, ordinary citizens rarely have enough knowledge to participate in the discussions, and often fail to provide effective strategies. It seems that both the theory and the application of this mode are underdeveloped (Yan Xue at all, 2020, Ibid).

To be successful, there are four pillars of urban environment management that are important in the process: citizens, processes, facilities, and technology. These four pillars together create a framework that enables a holistic (heuristic) approach to managing urban environments and facilities, ensuring sustainability, efficiency, and a better quality of life for all users.

In Macedonia, the Law on Local Self-Government defines the functioning of the City of Skopje and municipalities. Article 5 of the law addresses the exercise of local self-government rights and states: "Citizens exercise their right to local self-government directly and through representatives in municipal bodies." (Local Self-Government Law)

Article 8 of the same law addresses public information and states: "Public Information (1) Municipal bodies, council committees, and public services established by the municipality are obliged, free of charge, to inform citizens about their work, as well as about plans and programs that are significant for the development of the municipality, in a manner prescribed by the statute. (2) The municipality is obliged to provide citizens with access to basic information about the services it provides, in a manner and under conditions prescribed by the statute." (Local Self-Government Law)

Nevertheless, citizens are often uninformed and uninterested in events in their living area. Although these processes are legally enabled, the real situation and environment are often obstructive. Civil initiatives are often rare, and those that exist are frequently hindered by legal and administrative complexities. To involve citizens in the processes of managing public goods and public facilities and introducing new technologies, a clear strategy must be established.

Citizens are aware of their rights, especially the common fact that they give legacy to the members of the Local Municipality Council through the election cycles. On the other hand, community organizational partnerships and PPPP are often formed to create value for mainly the citizens. The applicable sectors for community organizational partnerships commonly include organizations, stakeholder communities, interest groups, or citizen groups in the same geographic location. For PPPP, the applicable sectors are more focused on the resources and differences between the public and private sectors, as well as the opinions of the citizens. End-user oriented partnerships also emphasize the opinions of citizens; however, the goal is commonly to make them prosumers. The applicable sectors are the organizers and the people that ultimately use the good, service, or technology (Yan Xue at all, 2020: 10).

What actually happens is legal procedures where the Municipality Council decides how and where with whom to spend public money for projects without public opinion in the decision making process.

5. Recommendations

The following phases there will be established activities between all stakeholder-parties involved in the participatory actions:

Phase 1: Actions related to Public space (Local municipality)
-Mapping public spaces and community facilities and assessing their condition.
-Analyzing current neighborhood or city needs through citizen surveys, and assessing new trends, growth, and future needs.
-Join projects (architectural workshops) with academic members and students.
Actions related to citizens (People):

-Increasing awareness and education about local government processes through informational campaigns, workshops, and calls.
-Strengthening urban and local communities through municipal support and organized community participatory actions.
-Engaging citizens in the needs of the local community.
-Creating spaces with various cultural, informational, and educational content for citizens.

Phase 2: Actions related to Private sector:
-Informing and educating the private and business sectors.
-Informing and educating local investors.
-Involving the business sector in the process.
-Creating a strategy for project financing.
-Join projects (architectural workshops) with academic members and students.

Phase 3:
-Developing a project for the enhancement, sustainability, and management of the public facility.
-Agreements with citizens, investors, and the business sector for the management of the community facility.
-Forming public-private partnerships.
-Engaging additional smaller actors in the process.

Phase 4:
-Developing and testing the upgraded facility and planning its future sustainability.

6. Conclusion

Urban planning is a multisectoral process between professional expertise and politics where all stakeholders have their activities as organizational structures. Either public or private, their procedures are described in state legislation. Citizens as community members even if they appear in all state acts aren't organized properly to act as constitutive members in decision making processes. Political systems offer a possibility to act through members of Council of Local Municipality, but usually they are without professional competences and under strong influence of interest of their native political party. Positive practice which shows results is organizing educational workshops and joint projects between academic members and local Municipality. Participative actions between students and local neighborhood members emphasize research process management and creates strong cohesion between involved parties in real projects.
One of the most important aspects for the healthy functioning of public spaces in a city, public facilities, and the common good is a robust and cohesive urban community. This community comprises all residents, including authorities, the civil sector, the business sector, as well as young people, children, and retirees. It is crucial to work on raising awareness about the public good and public spaces through inclusive care and usage by all members of the community. Citizens need to recognize their responsibility towards the urban space. Political mechanisms are merely tools for managing the public good; however, behind this, there must be a sense of identification with one's place of residence. By involving citizens in decision-making processes within municipal councils and assigning roles in neighborhood care, this sense of identification and self-recognition within the environment is enhanced.

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Tourism: As a trigger for transformative typologie in individual housing units in the city of Struga

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ABSTRACT

Problem Statement: Tourism is one of the largest economic sectors in the world today. Tourism as a profitable industry is constantly evolving, along with the accommodation sector, which offers various possibilities and opportunities. The city of Struga as a tourist destination on Lake Ohrid attracts non-residents, tourists and visitors, some of whom require accommodation in conventional tourism facilities, weekend settlements, hotels and private apartment. A significant number of them ask for a different type of temporary accommodation, where the owners of existing facilities initiate their transformation (conversion, re-adaptation) into tourist facilities. This phenomenon, which causes the transformation of already built objects and established typologies (recognizable patterns) and at the same time offers us the opportunity to explore (new patterns), we call a problem area of program-integrated typologies and contents that require detailed investigation in order to understand the genesis of their appearance in social reality.

Purpose of Study: The aim of the architectural research is to recognize the connection between the phenomenon of transformation of the individual housing units in the last thirty years of transition and to evaluate the effects on the already built spatial structure in the housing accommodations.

Methods: Through the analysis and architectural documentation of several buildings in which the phenomenon of tourism occurs in a comparative way in the individual dwelling units, considering the transforming morphological and functional typology, we can have a clearer understanding of the phenomenon through the use of quantitative methods using comparative interpretation.

Findings and Results: The study could examine the different forms of tourist accommodation in individual dwellings, which would provide a basis for understanding the different functional and morphological typologies of these types of accommodation.

Conclusions and Recommendations: The claims will influence and encourage to open inclusive constructive debates with the responsible authorities from the fields of architecture, urbanism, municipalities and the local community. The new program contents with integrated typologies would provide a framework for the development of new program integrated contents and forms with accommodation facilities in individual housing units for tourism that would be more integrated into the local community and urban environment, and in the specific case of the city of Struga.

Keywords: Tourism, transformative typologies , individual housing units, Struga

INTRODUCTION

Tourism is one of the most important global economic sectors, the third largest in the transport category and accounted for 7% of global trade in 2019 (unwto.org, 2023). Today, tourism is no longer just a leisure activity, but also a strong economic sector that is primarily profit-oriented. The world of tourism is in constant flux, and tourism theory must also change to discover such changes. Much of the tourism literature focuses on tourists and what they do and why they are motivated to visit certain places at certain times of the year. There are different relationships between buildings, their design and places that tourists can see and observe (Urry & Larsen, 2011).

Residential tourism accommodation has a great potential to increase in the future compared to hotel accommodation (Russo, A.P, 2002), a finding that raises the possibility of the residential tourism phenomenon. What is tourist accommodation in individual facilities? According to Agyeiwaah E, (Агива E, 2019), tourist accommodation in a house is one of the terms that characterize the accommodation of tourists in individual housing units owned by families, known as "B&B" (bed&breakfast), house-accommodation, house for guests, boutique hotel, etc.

Why accommodation in individual residential buildings is constantly increasing? This type of accommodation has fewer operational regulations and norms that regulate the accommodation of tourists in houses, which facilitates their establishment (Collado Baldoquín and others, 2020). Aside from the operational standards for accommodation in individual housing, the cost of accommodation is the most pronounced factor reinforcing the emergence of these facilities as opposed to traditional facilities such as hotels, which have higher operational requirements, standards and higher prices (Guttentag D, 2015). Behind the rise of tourism in individual housing units are several factors, one of the most basic are booking agencies such as ("Airbnb" and "Booking"), of which rentals are often illegal and which help to promote the rapid expansion of informal tourism in these accommodation units (Guttentag D, 2015).

The impact of transformative typologies in morphological and functional aspects on individual housing capacities generated by the phenomenon of tourism cannot be done without a theoretical reference to the concept of "Type". In architectural theory, the concept of 'type' was first masterfully elaborated by Quatremère de Quincy, who formally introduced the concept of type into architectural discourse and according to whom the concept of type is not so much an image as something to be copied or fully imitated, but the idea of an element that is itself intended to serve as a rule for the model, for him a type is the idea or symbolic meaning embodied in an element, object or thing (Leupen, B. & H. Mooij, 2011). According to Argan, the emergence of a type depends on the existence of a series of buildings between which there is an obvious formal and functional analogy. Argan argues that in the process of comparing and adding individual forms to determine the "type", the particular characteristics of each individual building are eliminated, leaving only those that are common to each unit of the series, after which the type emerges through a process of reduction of formal composite variants to a common basic form (Argan, C. G., 1963).

In the individual residential buildings that provide accommodation facilities for tourists, we have the occurrence of transformations in their typology in a morphological and functional aspect, prompted by the phenomenon of tourism for accommodation in individual housing units accompanied by informal activities, and suddenly through them the object is transformed into an object with programmatic integrated content that contains in its structure two or more functional purposes. Examples are the individual residential buildings in the town of Struga, which are the target of this research and whose program content, in addition to housing as the main functional purpose, is supplemented by complementary purposes such as commercial areas and spaces for tourist accommodation, which informally act as generators of new typologies and new program content in the existing and newly planned individual residential units.

MATERIALS AND RESEARCH METHOD

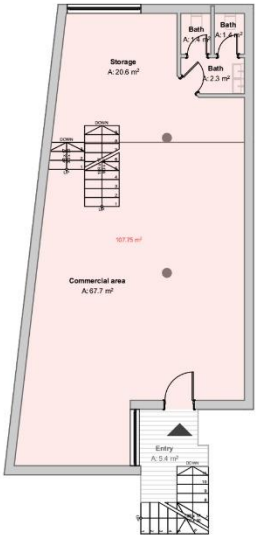
In order to define the relationship between the impact of tourism on individual accommodation facilities in terms of their functional and morphological transformation in the town of Struga, research using quantitative methods will enable us to create a new typology of facilities with integrated program content.

All these transformative typologies in the program content of the individual housing units would not have been highlighted if tourism had not emerged as a trigger that brings about changes not only in the individual housing units studied, but in the entire urban context and in the city as a whole.
Through its economic benefits, tourism is driving various changes in society and in accommodation establishments. Architecture is used as a tool to discover new program typologies and patterns that make accommodation tourism in the individual housing units as efficient as possible from an economic point of view.

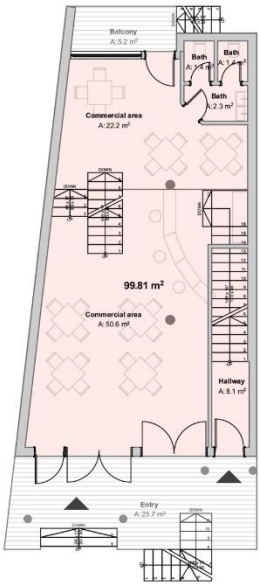
Even though we are dealing here with a phenomenon that does not follow a set of standards and norms for architecture and urban planning, it has emerged in all areas of the city, but we will analyze three examples of buildings in the central urban area. The researched objects with the main function of individual housing were observed and analyzed how they were transformed into objects with integrative program content, triggered by tourism as an activity, which is contrary to the legal regulations in force in the Republic of N. Macedonia.

The individual objects are named with the letters A, B and C, whereby we make a quantitative analysis of their functional purpose assignment from all objects and create an object with program-integrative content from an arimetric point of view on the basis of concretely researched functional premises. All three samples taken for the research are present in their functional structure with more than two purposes, which is evidence that we have avoided the main functional purpose, namely housing. Looking at the functionally distributed structure of these buildings, tourist accommodation facilities dominate in percentage terms, in contrast to residential and commercial facilities, which only make up a small proportion of the building structure.

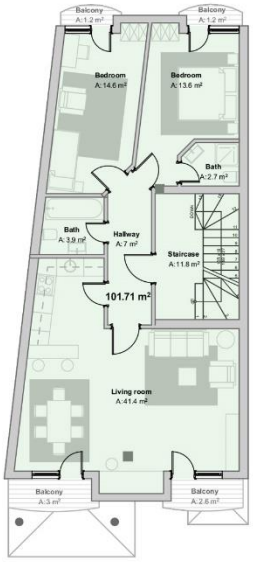
Behind this dominance is the phenomenon of tourism in individual residential buildings, which also serves as an indicator for the generation of new program content in the context of these building types. Schematically, tabularly and figuratively, the three examples will be explained below, which will help us to define the results arising from the phenomenon.



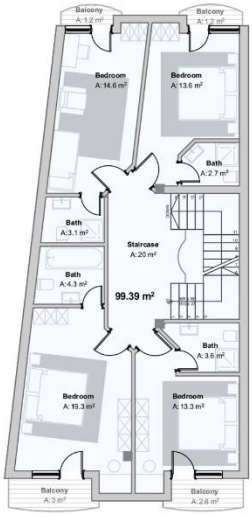
-1. Underground



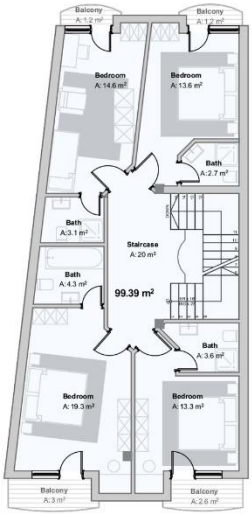
0. Ground floor



1.Floor 1



2.Floor



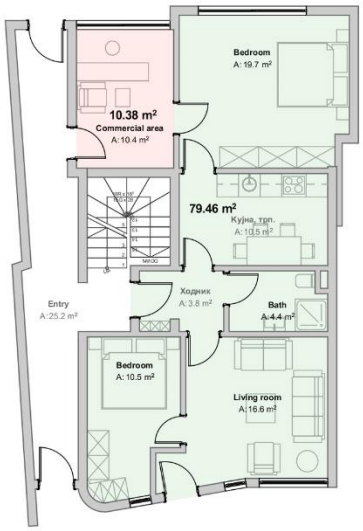
3.Floor

Building exterior view

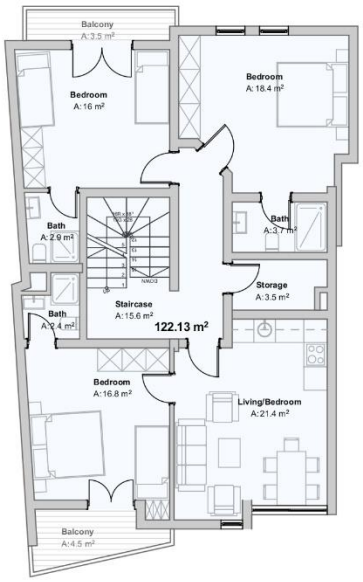
BUILDING NAME:	B	
BUILDING YEAR	2005	
BUILDING HEIGHT:	U+G+3	
FUNCTIONAL PURPOSE TOTAL AREA;	506.7 m²	100%
TOURIST ACCOMMODATION:	198 m²	39%
HOUSING:	101.7 m²	20%
COMMERCIAL AREA:	207 m²	41%

Scheme of the percentage distribution of the facilities

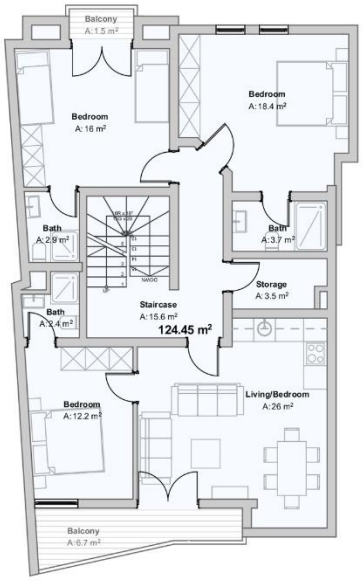
Figure - Scheme 1: Building A, Readapted individual house with tourist facilities, source: author (2024)
Figure - Scheme 2: Building B, individual house with tourist facilities, source: author (2024)



0.Ground floor



1. Floor



2. Floor

Building exterior view

BUILDING NAME:	**C**	
BUILDING YEAR	**2008**	
BUILDING HEIGHT:	**G+2**	
FUNCTIONAL PURPOSE TOTAL AREA;	**336.42 m²**	100%
TOURIST ACCOMMODATION:	**246.58 m²**	73%
HOUSING:	**79.46 m²**	24%
COMMERCIAL AREA:	**10.38 m²**	3%

Scheme of the percentage distribution of the facilities

Figure - Scheme 3: Building C, individual house with tourist facilities, source: author (2024)

RESULTS

From the three analyzed examples selected for this research, we have approximate results that indicate that the main functional purpose, residential or housing, is avoided, otherwise the other functional purposes take priority. If we convert the functional square meter areas into a percentage distribution (Table 1), we get results where more than half of the functional areas function as accommodation for tourists and the other part as commercial and housing.

It is known that with three samples of such buildings we cannot obtain maximally precise results, but

Name of Object	**Tourist accommodation percentage**	**Housing percentage**	**Commercial area percentage**
Building A	39	25	36
Building B	39	20	41
Building C	73	24	3
Total Average percentage %	**50.33 %**	**23 %**	**26.66 %**

Table 1: Tabular presentation of the distribution of square percentage by functional purpose for each facility and the overall average of the same facilities

this study, which is broader in scope and research, gives us indications that even if we include even more
samples in the study, the results will be almost as approximate as in Figure 4, where the percentage distribution of functions is schematically shown. Not all buildings have a commercial part in their functional structure, but the context in which the locations of these buildings are taken is close to the central core of the city of Struga, and therefore we have the appearance of the commercial part, especially on the first floors. The facilities that are far from the city center and serve as tourist accommodation mostly have two functions: Tourism and residential.

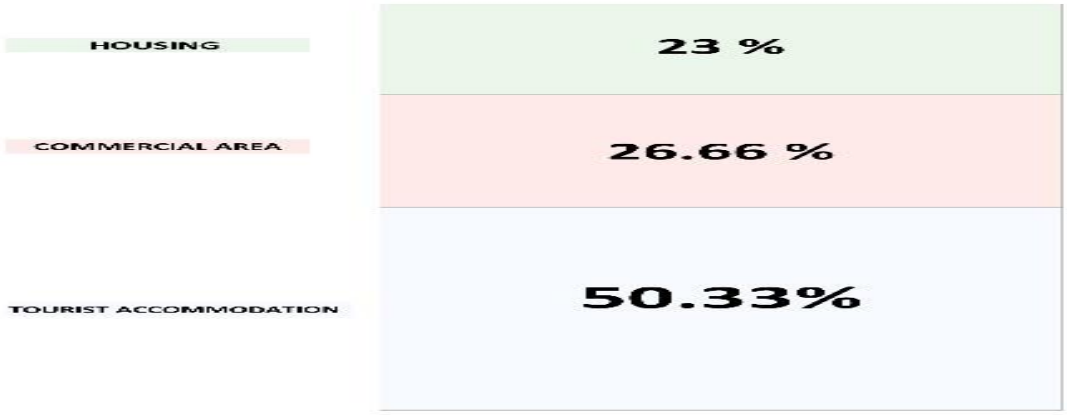


Figure - Scheme 4: **Schematic representation of the average percentage distribution of functional purposes for the buildings analysed**

Looking at the schematic representation, it can be seen that the number of tourist accommodations is increasing in contrast to the main purpose, residential, and in the central city core, where the commercial part is also found, residential is almost completely reduced, and the phenomenon of gentrification of certain properties is also emerging.

CONCLUSIONS

In this study, architecture and tourism are closely linked to the creation of new program content and patterns. Architecture is used as a tool to satisfy market needs, with owners transforming their facilities offering tourist accommodation in functional and morphological aspects for economic reasons. This study goes beyond the results presented here and is part of a larger study that aims to confirm the results of these three samples in more detail. All these new program contents have emerged in the last 30 years of transformation in the city of Struga, which is expanding year by year into the urban whole of the city. This expansion is a phenomenon that needs to be studied in detail because it has major implications, both positive and negative. The positive aspects are that the residents or owners of these establishments that offer tourist accommodation always have the right to use their properties for economic benefits, but otherwise they act in an informal way contrary to legal regulations and bring negative changes to the urban space and the city. Therefore, it is necessary for local authorities, non-governmental organizations and professionals to closely monitor and research the same phenomenon and improve their mutual interrelation, which will benefit all residents and visitors of the tourist town of Struga.

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Housing characteristics and living conditions in Slovenia: A comparative analysis of 2005 and 2024 national surveys

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Abstract

Housing surveys are essential tools for understanding and addressing various aspects of housing provision. However, in Slovenia, data collection has been neither systematic nor continuous, despite the state's responsibility to maintain housing registers and collect information. The initial national housing survey was conducted in 2005, followed by an update in 2024, facilitating a comparative analysis of the results from both years. The paper presents the results of a survey from 2024 and a comparative analysis with the survey conducted in 2005. This comparison presents preliminary findings that systematically monitor developments in housing characteristics, such as the type of residence, presence of amenities (such as elevators and private outdoor spaces), and size of housing. Additionally, it investigates living conditions with an emphasis on privacy and housing tenure, explores rental market dynamics encompassing various types of rental apartments and the terms of rental agreements, and analyses trends in residential mobility, including moving patterns and reasons for relocation. Notably, the most significant changes were observed in housing tenure. This comprehensive approach provides valuable insights into the trends and changes observed across these areas over nearly 20 years and explores their potential interpretations.

Key words: housing, housing quality, national housing survey, comparative analysis

1 Introduction

In 2005, Slovenia conducted its first national housing survey. The Housing Survey 2005 was developed as a research project funded by the Housing Fund of the Republic of Slovenia, a public fund, along with the Ministry of Environment and Spatial Planning. Its purpose was to determine the situation in the field of housing provision in Slovenia, considering sociological, economic, and urban-architectural perspectives. It took place after the end of the transition period, which lasted from 1991 until Slovenia's accession to the European Union in 2004. This was a time of great change, as Slovenia, like other former socialist countries, began to introduce a new socio-political system. Even after the conclusion of the transition period, various global, European, and domestic developments continued to influence housing provision and its characteristics in Slovenia. Although it is the state's responsibility to maintain records, registers, and statistical databases for monitoring and implementing housing policy, as well as overseeing housing provision, comprehensive registers necessary for accurately tracking the housing market have not yet been established. Data collected by the Statistical Office of the Republic of Slovenia is not consistently analysed, and in certain segments, data collection has even been discontinued. Additionally, few in-depth studies are conducted to offer a comprehensive understanding of the trends and changes in Slovenia's housing stock over time. To obtain a partial understanding of the changes in Slovenia's housing stock over time, the Housing Survey 2005 was revisited and, in certain sections, updated in the first half of 2024, under the initiative of the Ministry of Solidarity-Based Future. The paper presents the results of a survey from 2024 and a comparative analysis with the survey conducted in 2005. The research question addresses differences in the housing characteristics, living conditions, rental market dynamics and residential mobility in Slovenia based on the surveys conducted in 2005 and 2024. The discussion highlights potential reasons for these changes, framed within the context of relevant social developments.

2 Theoretical backgrounds

Following World War II, many European countries experienced significant housing shortages, which were addressed through the enhancement of housing policy measures. In Western European countries these included the development of large housing estates construction projects and the provision of construction subsidies, including to private investors (Boelhouwer, Heijden, 1993). The housing stock in most countries expanded significantly in the first two decades after the war, accompanied by a sharp rise in public debt, particularly due to the impact of the oil crisis between 1973 and 1979, which substantially increased construction costs. During this period, housing policy measures underwent changes as governments aimed to reduce growing public expenditure (Boelhouwer, Heijden, 1993). Governments gradually withdrew from active participation in the housing market, opting to rely more heavily on market dynamics. This shift led to a reduction in construction subsidies and the phasing out of other targeted financial supports. Large-scale new construction programs were replaced with smaller projects or focused solely on the maintenance and improvement of the existing housing stock. Subsidies were increasingly limited to the most vulnerable households (Boelhouwer, Heijden, 1993). Simultaneously, states sought financial relief by encouraging homeownership, which emerged as the preferred form of housing tenure across all societal groups (Boelhouwer, Heijden, 1993).

A situation similar to that of the West was observed in Central and Eastern European countries, commonly known as socialist states, following World War II. These countries shared common ideological beliefs and governance structures, which led to the development of distinct characteristics in their housing markets and housing provision methods. In the early post-World War II years, these countries focused their investments on heavy industry, only later shifting their attention to residential construction in line with the principle of equality, which recognized housing as a fundamental right for every citizen (Balchin, 1996; Tsenkova, 2003; Broulíková, Montag, 2020). Like Western European countries, socialist states experienced significant growth in housing construction during the 1970s (Balchin, 1996). A notable difference when compared to Western countries is that the socialist states underwent significant political, social, and economic changes around 1990s (see Balchin, 1996; Hegedüs et al., 1996; Tsenkova, 2003), which interrupted the continuity of development in housing provision.

Centrally planned economies in socialist states emphasized rental housing ideologically, leading to only 28% of homes being privately owned in Eastern European cities by 1990, in contrast to 65% in comparable Western European cities (Hegedüs et al., 1996). Private ownership was primarily concentrated in smaller towns and rural areas (Balchin, 1996; Hegedüs et al., 1996). In comparison to other socialist states, Slovenia (then part of Yugoslavia) had a notably high rate of homeownership during the socialist period, attributed to the self-management model of socialism, which was less centralized and created a complex network of institutions that took on various state responsibilities (Mandič, Clapham, 1996; Broulíková, Montag, 2020). In the 1970s, the number of privately owned homes began to rise in other socialist countries as well, largely due to the unpopularity of large housing estates and the inability of governments to provide adequate housing for all citizens (Balchin, 1996).

The factors contributing to the rise in privately owned homes in socialist states also account for why these governments did not seek to eliminate private rental markets, which were never officially recognized (Sendi, 1995). It was generally accepted that all rental housing stock was publicly owned, with public authorities permanently assigning rental units (Broulíková, Montag, 2020). Rent levels were low, accounting for up to 5.7% of an individual's income, and additionally, housing costs were subsidized by the government (Hegedüs et al., 1996). Low rental rates discouraged individuals from residential mobility (Balchin, 1996) and, in comparison to high market purchase prices, contributed to long waiting lists for government-subsidized housing (Hegedüs et al., 1996).

As political changes began around 1990, leading to the dissolution of socialist states, the differences in the perception of housing stock and policies in the newly established states compared to their predecessors became increasingly pronounced (Balchin, 1996). Countries began to implement principles of democracy and market-oriented policies (Hegedüs et al., 1996; Tsenkova, 2003). Housing stock was redefined from a social good financed by taxpayer resources and public institutions to a private commodity that individuals could acquire on the market (Broulíková, Montag, 2020). The primary objective of the newly established states was to eliminate key elements of the previous system, specifically by reducing state control, enhancing individual property rights, and limiting the indiscriminate allocation of government subsidies (Hegedüs et al., 1996).

Given that ex-socialist states (also Slovenia) were required to manage the mandated reduction in public expenditure (Balchin, 1996), the housing policy of these countries was significantly marked by the transfer of public housing stock to private ownership through restitution and privatization processes (Balchin, 1996; Tsenkova, 2003; Broulíková, Montag, 2020). Studies across different countries demonstrate that public housing was privatized at a maximum rate of 30% of the market price of comparable units (Sendi, 1995; Mandič, Clapham, 1996; Lis, Zwierzchlewski, 2015). Whereas the privatization of state-owned enterprises enhanced their competitiveness, the privatization of public housing led to a predominant shift toward homeownership, with ownership comprising 80% or more of the total housing stock (Tsenkova, 2003). The sale of public housing at reduced prices created the impression that governments had reduced their debts and relieved themselves of the substantial maintenance costs associated with an aging housing stock. It was widely assumed that the private market would manage housing more efficiently and, that private owners would be better stewards of these properties (Balchin, 1996). Contrary to expectations, the opposite outcome was observed. New homeowners frequently found themselves unable to meet the financial demands of maintaining their newly acquired properties, as the shift to a market-based economy imposed the full burden of service costs on property owners (Tsenkova, 2003). The transition to a market economy led to the elimination of state subsidies that had previously supported housing costs, or they were restructured to target only low-income individuals (Balchin, 1996).

In addition to the characteristics of housing provision and policy during the socialist and transition periods previously described housing provision and markets in former socialist countries, including Slovenia, were influenced by broader global and European developments. Between 2000 and 2007, the European Union experienced a prolonged period of economic growth, with annual rates ranging from 1% to 4%. In contrast, Slovenia exhibited even more robust economic growth during this period,

surpassing 7% annually (Eurostat, 2022). Following the period of economic growth, a significant financial crisis emerged in 2008. During this crisis, GDP in Europe declined by 4%, while Slovenia experienced a more substantial decline of nearly 8% (Eurostat, 2022). This global financial crisis led to a decrease in property prices, a reduction in construction investment, and tighter credit conditions (Stiglitz, 2009; Rakic, 2020). This was followed by a sharp reduction in interest rates on housing loans (European Central Bank, 2024). From 2014 onwards, a noticeable trend of economic growth was observed across Europe again. Property prices rose rapidly until 2019 when the COVID-19 pandemic emerged. The result of the pandemic was a significant decline in GDP, which in Slovenia was slightly lower than the European average (Eurostat, 2022). Following the outbreak of the COVID-19 pandemic, various measures were implemented at both the European Union level and within individual member states, aimed at stimulating economic activity and alleviating financial and cash-flow constraints (see e.g., Demertzis et al., 2020; European Central Bank, 2024). Additionally, these measures were designed to mitigate the effects of significant social changes, such as work restrictions, which prompted many companies to facilitate remote work for their employees (see e.g., Bick et al., 2020; Ipsen et al., 2021). Soon after the COVID-19 outbreak, there was a notable increase in interest among individuals in relocating to rural areas or moving away from urban centres (see e.g., Tønnessen, 2021; Wolff, Mykhnenko, 2023). In early 2022, Russia revived its war with Ukraine, which had been unfinished since 2014, which for other countries manifested itself as an energy crisis, with a huge increase in operating costs, a further increase in construction costs, which had already risen sharply during the pandemic, and countries facing unforeseen migration flows and general economic uncertainty (Boungou, Yatié, 2022; Khudaykulova et al., 2022).

Although Article 141 of the Housing Act (*Stanovanjski zakon (SZ-1)*, 2003) in Slovenia mandates that the state must maintain records, registers, and statistical data to monitor and implement housing policy—and consequently housing provision—there is a lack of adequate registers, and data is not collected systematically. As a result, it remains unclear how specific events impact the real estate market. Consequently, Slovenia faces numerous challenges that have persisted since the transitional period, such as a highly segmented housing structure based on tenure, reduced investment in public housing, growing issues with housing affordability, and problems related to maintenance and comprehensive renovations (Hegedüs et al., 1996), all of which have been exacerbated by recent events. Moreover, since the introduction of a market economy in Slovenia, housing policy measures have largely been adopted uncritically, without sufficient research or consideration of the country's unique characteristics (Hegedüs et al., 1996). In the first 30 years after the transition to a new socio-political and economic system, only one nationwide survey on housing was conducted. This took place in 2005. The next survey was conducted nearly 20 years later, in 2024. The 2005 Housing Survey and its partial repetition in 2024 represent the initial attempts to systematically monitor developments in housing characteristics, providing insight into the trends and changes that have occurred during this period across various aspects of housing provision.

3 Methods

For the purposes of this paper, an attempt was made to compare the results of two comprehensive housing surveys in Slovenia: the first conducted in 2005 and the second in 2024. Some questions from the 2024 survey are entirely comparable to those from the 2005 survey. For other questions, a full comparison was not possible as certain questions in the 2024 survey could not be fully replicated. A comparative analysis of the following variables is presented in the paper: 1. place of residence, 2. the type of residence, 3. the presence of an elevator, 4. size of the residential real estate and number of rooms, 5. space for the privacy of adult household members, 6. household status within the residential real estate, 7. type of rental apartment, 8. conclusion of the rental agreement, 9. characteristics of residential real estate (balcony or terrace, courtyard or garden, study or separate room for work), 10. issues related to residential real estate or the neighbourhood, 11. residential move, 12. housing status after residential move, 13. type of residence after residential move, and 14. reasons for residential move. A comprehensive comparison of the following variables could not be fully realised, as the response options in the 2024 survey were slightly modified compared to those in 2005: type of rental apartment,

issues related to residential real estate or the neighbourhood, residential move, and type of residence after residential move.

The 2005 survey was conducted between April and May, with 4,009 surveys completed using the Computer-Assisted Telephone Interviewing (CATI) method. The sampling was based on a comprehensive list of landline phone numbers from the telephone directory, ensuring even distribution across 12 statistical regions. The data were weighted based on the number of households in individual statistical regions, households by the number of members/type of settlement, residential real estates by the number of rooms, and residential real estates by the year of building construction. The 2024 survey was conducted between March and June, with 2,114 surveys completed. The sample was derived from the Central Register of Population of Slovenia. A systematic random sampling method was employed, ensuring everyone in the population had an equal chance of being included. The sampling process incorporated prior stratification based on 12 statistical regions and 5 types of settlements. Participants in the survey had the option to respond either online, via a web-based questionnaire, or by mail, using a paper questionnaire. Individuals selected from the sample list were sent a written invitation that included a personalized code for accessing the online survey, or details for contacting a representative if they chose to participate using the paper questionnaire. Following the initial invitation to participate, two reminders were dispatched to potential respondents, with the second reminder including an incentive of a 5-euro gift card to enhance participation rates. The survey interface was developed using the "EnKlik anketa – 1KA" tool. In 2024, data were weighted based on sex, age of respondents, statistical regions, and type of settlements. The weighted samples match the population of Slovenian households. In 2005, the gender distribution of respondents was more uneven compared to the 2024 survey, as female respondents made up more than two-thirds of all respondents (67.6%). The uneven gender distribution observed in the 2005 survey is consistent with the findings of Rohit Vishal Kumar, who, in his analysis of various respondent selection methods in household surveys, concluded that women are frequently overrepresented (Kumar, 2013). This uneven sample can also be explained by the findings of Judith Treas and Tsui-o Tai (2012), who identified that women frequently undertake household management responsibilities. The respondent selection method employed in the 2005 survey focused on identifying the household member most informed about housing-related issues. Consequently, according to the findings of the aforementioned study, women are often the household members most knowledgeable about these issues (Treas, Tai, 2012). In the 2024 study, the distribution of participants is more balanced, with the proportion of female respondents at 49.6%, which is only 0.8 percentage points lower than the 50.4% proportion of male respondents. In 2005, the highest proportion of respondents had a secondary education (39.2%), while in the subsequent survey, the highest proportion of respondents had higher, tertiary, or university education (44.4%). Over the years, the proportion of people with only primary education or no formal education was about 10.0 percentage points lower, while the proportion of people with vocational education was 3.4 percentage points lower. The average number of household members remained almost unchanged. The age distribution of respondents in the two studied years shows that in 2024, the sample included a higher proportion of younger respondents (up to 30 years old) and older respondents (61 years and older) compared to 2005, while there were fewer respondents in middle age. Regarding the type of settlement (urban or rural), the sample from 2005 was similar to that of 2024, with more than half of respondents living in urban settlements.

Table 1: Descriptive statistics of respondents in the 2005 and 2024 sample

Variable	2005	2024
Sex (%)		
Male	32.4	50.4
Female	67.6	49.6
Education (%)		
Primary or less	17.2	7.6
Vocational	18.5	15.1
Secondary	39.2	32.9
Higher, tertiary, or university	25.0	44.4
Average number of household members	2.9	3.1

Age of respondents (%)		
up to 30 years	11.7	15.3
31 to 45 years	28.6	25.8
46 to 60 years	34.1	25.4
61 years and above	25.5	33.6
Type of settlement (%)		
Urban	55.5	52.7
Rural	44.5	47.3

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

4 Results

4.1 Place of residence

The places of residences where the respondents in the 2005 and 2024 survey lived were classified into four main categories: a) family house, b) apartment, c) studio apartment, and d) other. To enable a comparison of data between the 2005 and 2024 surveys, it was necessary to combine certain categories: in the 2005 survey, the categories "special room", "emergency housing", and "other" were merged into the "other" category, while in the 2024 survey, the categories "single-family house" and "family house with separate households" were combined into the "family house" category. The results in Table 2 indicate that two-thirds of respondents lived in family houses in 2024. In that year, there were more respondents living in family houses (by 11.2 percentage points), studio apartments (by 0.1 percentage points), and other types of residential real estates (by 1.6 percentage points) compared to the same categories in 2005. In 2024, the proportion of respondents living in apartments was 12.9 percentage points lower than in 2005.

Table 2: Place of residence (%)

	2005	2024
Family house	55.4	66.6
Apartment	41.7	28.8
Studio apartment	2.6	2.7
Other	0.3	1.9

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

4.2 Type of residence

In this variable, the data from survey respondents who did not live in houses were compared. Therefore, in the analysis of the 2005 survey questionnaire, the data from respondents who indicated that they lived in a family house or in a non-residential real estate were not included, as these data could not be compared with those from the 2024 survey. The type of residence these respondents lived in during 2005 and 2024 was categorized into three categories: a) high-rise residence or block with 5 or more floors, b) block with up to 4 floors, and c) other multi-dwelling residences (for example, villa block, historic town house etc.). The results of the comparison in Table 3 show that in both years, the largest number of respondents were found to have lived in a block with up to 4 floors. In 2005, about half of the respondents were recorded as living in this type of residence, while in 2024 this proportion was 5.4 percentage points lower. In 2024, fewer respondents were reported to have lived in a high-rise residence or block with 5 or more floors compared to 2005, specifically 0.5 percentage points less. On the contrary, the proportion of respondents who indicated living in another type of multi-dwelling residence was found to be 5.8 percentage points higher between the years studied.

Table 3: Type of residence (%)

	2005	2024
High-rise residence or block with 5 or more floors	34.5	34.0
Block with up to 4 floors	50.1	44.7
Other multi-dwelling residences	15.5	21.3

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

4.3 The presence of an elevator

For respondents who indicated that they do not reside in a family house, an additional variable was examined regarding the presence of an elevator in the building. Respondents were therefore divided into two categories: "yes", an elevator was present, and "no", an elevator was not present. The results in Table 4 show that in 2024, almost two-thirds of respondents did not have an elevator in their residence, while in 2005, this proportion was even larger, with more than 70% of respondents not having an elevator in their residence. The proportion of respondents with an elevator in the residence was 8.7 percentage points higher between the two years compared, meaning that in 2024, an elevator was present in the residence for more than one-third of respondents.

Table 4: The presence of an elevator (%)

	2005	2024
Yes	27.5	36.2
No	72.5	63.8

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

Both surveys also investigated whether respondents who did not have an elevator in their residence considered its absence to be an issue. In 2005, nearly 80% of respondents did not feel the absence of an elevator as being an issue for them. In 2024, approximately two-thirds of respondents felt the same way. However, the proportion of respondents who missed having an elevator in their residence was 14.2 percentage points higher between the years compared, meaning that in 2024, more than one-third of all respondents without an elevator missed having one.

Table 5: Missing the presence of an elevator (%)

	2005	2024
Yes	20.1	34.3
No	79.9	65.7

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

4.4 Size of the residential real estate and number of rooms

For this variable, the average size of residential real estates in square meters was compared between the years studied. According to respondents' answers, an increase of 28.50 square meters in the average size of residential real estates was observed in 2024 compared to 2005. However, the results differ significantly when family houses and apartments are analysed separately (see Table 6). Additionally, the average number of rooms in residential real estates was examined. Similarly, an increase of almost one whole room was noted between the years compared, from 2.90 rooms in 2005 to 3.86 rooms in 2024.

Table 6: Size of the residential real estate and number of rooms

Variable	2005	2024
Average size of residential real estate (m^2)	78.64	107.14
Family house	97.47	130.41
Apartment	56.46	60.7
Average size of residential real estate per person (m^2)		
Family house	28.7	37
Apartment	21.5	23.9
Average number of rooms	2.90	3.86
Family house	3.52	4.58
Apartment	2.13	2.43
Average number of rooms per person		
Family house	1.1	1.3
Apartment	0.8	1

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

4.5 Space for the privacy of adult household members

Both surveys also investigated whether adult members of the household felt they had enough space for privacy in their residential real estate. Respondents were divided into two categories: those who believed they had enough space for privacy (answer "yes") and those who believed they did not have enough space (answer "no"). The results of both surveys in Table 7 show that in both years, most adult respondents felt they had enough space for privacy. This proportion was slightly higher in 2024 compared to 2005, specifically by 1.9 percentage points. In 2005, 13.6 % of adult respondents felt they did not have enough space for privacy, whereas in 2024, this proportion was 11.7 %.

Table 7: Space for the privacy of adult household members (%)

	2005	2024
Yes	86.4	88.3
No	13.6	11.7

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

4.6 Household status within the residential real estate

For this variable, respondents were asked what their household status within the residential real estate was. In the survey questionnaire, both in 2005 and 2024, respondents could choose from four categories regarding their status: a) at least one member of the household is an owner or co-owner, b) the household lives in a rented apartment, c) the household uses the residential real estate without paying rent (e.g., in a relative's or friend's residential real estate), and d) other. In 2005 83.6% of respondents indicated that at least one member of the household is the owner or co-owner of the residential real estate. This proportion was 2.8 percentage points lower in 2024 than in 2005, amounting to 80.8%. The proportion of respondents who indicated that their household uses the residential real estate without paying rent was 0.3 percentage points lower in 2024. The proportion of respondents who indicated that their household lives in a rented apartment or that their household has another position was in 2024 1.9 percentage points higher in the first case and 1.3 percentage points higher in the second.

Table 8: Household status within the residential real estate (%)

	2005	2024
At least one member of the household is the owner or co-owner	83.6	80.8
The household lives in a rented apartment	9.3	11.2
The household uses the residential real estate without paying rent	6.5	6.2
Other	0.6	1.9

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

4.7 Type of rental apartment

In the following variable, the type of rental apartment in which the (sub)tenants lived at the time of the survey in 2005 and 2024 was of interest. Rental apartments were categorized into three categories: a) non-profit apartment, b) company apartment, and c) profit apartment. These three categories were available to respondents in the 2005 survey questionnaire as well. In the 2024 survey questionnaire, more categories were available, so for comparison purposes, certain categories had to be merged: the category of public rental company apartment with a non-profit or market-based rent, and the category of company apartment into a single category of company apartment; because public rental apartments with market-based rent have_market-based rent the categories of public rental apartment with market-based rent and market rental apartment were merged into a single category of profit apartment. The category of other apartments from the same survey had to be excluded from the analysis since this category was not present in the 2005 survey questionnaire. In 2005, more than half of the (sub)tenants were reported to be living in non-profit apartments, while in 2024, 60.0% were reported to be living in profit apartments. This means that in 2024, compared to 2005, the proportion of (sub)tenants living in non-profit apartments was 24.8 percentage points lower, while the proportion of those living in profit apartments was 26.2 percentage points higher. In company apartments, the proportion of (sub)tenants was 1.4 percentage points lower in 2024 than in 2005. Because public rental apartments with market-based rent are still public apartments for public rent, and because the rent for them is not as high as for market rental apartments we also looked, how the results change if we include public rental apartments with market-based in the "non-profit apartment" category instead of "profit apartment" category. The results show that the shares in this case are more comparable to each other. This means than in 2024 there was 54.3% of respondents living in non-profit apartments, which is 0.2 percentage points lower than in 2005. Also, in 2024 there was 35.4% of respondents living in profit apartments, and that was 1.6 percentage points higher than in 2005.

Table 9: Type of rental apartment (%)

	2005	2024
Non-profit apartment	54.5	29.7 (54.3)*
Company apartment	11.7	10.3
Profit apartment	33.8	60.0 (35.4)**

Note: * Public rental apartments with market-based rent were included; ** Public rental apartments with market-based rent were excluded.
Unanswered questions (missing values) and "I do not know" answers are not included.

4.8 Conclusion of the rental agreement

For this variable, the focus was on whether a rental agreement was concluded by the (sub)tenants, resulting in the respondents being divided into two categories. In the 2005 survey questionnaire, the answers were restricted to simply "yes" or "no", indicating whether a rental agreement was concluded or not. In the 2024 survey questionnaire, for those respondents who had a concluded rental agreement, further detail was sought on whether it was for an indefinite or a fixed term. For comparison purposes between the two surveys, these latter categories were combined into a single category encompassing all respondents with a concluded rental agreement. In both years compared, the majority of (sub)tenants had a concluded rental agreement—with more than 97% in 2024. In 2005, slightly more than one-tenth

of (sub)tenants (13.9%) reported that a rental agreement was not concluded, whereas in 2024, the proportion of respondents without a concluded rental agreement was 11.3 percentage points lower (2.6%).

Table 10: Conclusion of the rental agreement (%)

	2005	2024
Yes	86.1	97.4
No	13.9	2.6

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

4.9 Characteristics of residential real estate

The study examined the characteristics of residential real estate, with particular attention to the presence of balconies or terraces, courtyards or gardens, and dedicated study or work rooms. Respondents were thus divided into those who reported having any of the listed features and those who did not. In both years compared, it was indicated that more respondents had balcony or terrace present in their residential real estate: 78.1% in 2005 and 85.1% in 2024. Similarly, in both years, the fewest respondents indicated that a study or separate room for work was present, with fewer than half of all respondents reporting this in both years. In 2024, there were 12.3 percentage points less respondents who did not have a study or separate room for work compared to 2005. The results regarding the presence of a courtyard or garden show that in 2005 57.9% of respondents had one, while in 2024, this proportion was 3.5 percentage points higher (61.4%).

Table 11: Characteristics of residential real estate (%)

	2005	2024
Balcony or terrace		
Yes	78.1	85.1
No	21.9	14.9
Courtyard or garden		
Yes	57.9	61.4
No	42.1	38.6
Study or separate room for work		
Yes	34.1	46.4
No	65.9	53.6

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

4.10 Issues related to residential real estate or the neighbourhood

For the variable "issues", the survey questionnaire aimed to find out whether respondents perceive any issues related to their residential real estate or neighbourhood, as listed in Table 12. The issues listed in the 2005 questionnaire (such as uncertainty about losing a home, bothersome pets, household restrictions on the use of the residential real estate, air pollution) and those in the 2024 questionnaire (such as too few rooms, poor energy efficiency, and seismic safety of the residential real estate) could not be directly compared, as each set of issues was only included in a single comprehensive housing survey. It is also important to clarify that in 2005, respondents rated issues in their residential real estate or neighbourhoods on a scale from 1 to 5, where 1 meant "no issue" and 5 meant a "severe issue". In 2024, the questions about issues were framed differently: respondents answered each issue with either "yes", indicating they have the issue, or "no", indicating they do not have the issue. To compare the results, responses from the 2005 survey where respondents rated issues from 4 (major issue) to 5 were combined and equated with the 2024 responses of "yes" (indicating they have the issue). Responses from the 2005 survey where respondents rated issues from 1 to 2 (minor issue), were equated with the 2024 responses of "no" (indicating they do not have the issue). Those responses from the 2005 survey where respondents rated issues as 3 (medium issue) were excluded from the comparison, so that responses from both surveys could be compared. Additionally, it is worth noting that in the 2024 survey questionnaire, the categories of adult privacy and child privacy were combined to compare data with 2005 (household

lacks sufficient privacy). Furthermore, the 2005 data on neighbourhood safety were compared with the 2024 data, where respondents were asked how safe they felt walking in their neighbourhood at night.

The survey results from 2005 showed that the most frequently perceived issue related to the residential real estate, or the neighbourhood was high operating costs (43.9%), followed by the absence of recreational areas (21.2%) and children not having a safe place to play outdoors (20.7%). In the subsequent survey conducted in 2024, high operating costs were again the most frequently mentioned issue (37.8%). In 2024, the second most reported issue was moisture (22.3%), followed by noise pollution (20.4%). Moisture, however, was ranked only eleventh as an issue in 2005 (8.6%). The absence of recreational areas, which was the second most frequent issue in 2005, dropped to the eighth position in 2024. In 2005, the least frequently mentioned issue was insufficient household privacy (4.0%), followed by poor relations with neighbours (4.2%) and insufficient daylight (6.3%). In 2024, the least frequently mentioned issue was insufficient daylight (8.2%), followed by high rent or mortgage payments (9.3%) and poor relations with neighbours (9.7%). Neighbourhood safety, which was the eight most frequent issue in 2005, was the tenth most frequent in 2024 (12.1%), while insufficient household privacy, the least frequent issue in 2005, was the ninth most frequent in 2024 (13.6%). Poor relations with neighbours were the thirteenth most frequent issue in 2005 (4.2%). In 2024, the survey responses revealed a drop in the position of several issues compared to 2005. Insufficient living space dropped by two position, insufficient daylight by two, high rent or mortgage payments by two, neighbourhood safety by two, absence of recreational areas by six, and children not having a safe place to play outdoors by eight positions. Meanwhile, during this period, among the survey respondents' answers, the following issues have advanced based on their position: noise pollution by one, poor relations with neighbours by one, poor transportation connections by two, parking problems by two positions, inadequate or worn-out installations by three, insufficient household privacy by five, and moisture by nine positions. High operating costs remained in the same position between the two surveys. Additionally, the results show that in both surveys, more than half of the respondents indicated they had no problems with any specific issue.

Table 12: Issues related to residential real estate or the neighbourhood (%)

	2005		2024	
	Yes	No	Yes	No
Children not having a safe place to play outdoors	20.7	79.3	11.1	88.9
Absence of recreational areas	21.2	78.8	14.4	85.6
Insufficient living space	15.3	84.7	16.6	83.4
Moisture	8.6	91.4	22.3	77.7
Insufficient daylight	6.3	93.7	8.2	91.8
Inadequate or worn-out installations	10.9	89.1	17.5	82.5
High rent or mortgage payments	8.7	91.3	9.3	90.7
High operating costs	43.9	56.1	37.8	62.2
Poor relations with neighbours	4.2	95.8	9.7	90.3
Parking problems	14.5	85.5	19.0	81.0
Neighbourhood safety	11.6	88.4	12.1	87.9
Noise pollution	20.1	79.9	20.4	79.6
Insufficient household privacy	4.0	96.0	13.6	86.4
Poor transportation connections	15.2	84.8	20.3	79.7

Note: Unanswered questions (missing values) and "I do not know" answers are not included.

Table 13: Issues related to residential real estate or the neighbourhood

	2005	2024
	rank	rank
Children not having a safe place to play outdoors	3	11
Absence of recreational areas	2	8
Insufficient living space	5	7
Moisture	11	2
Insufficient daylight	12	14
Inadequate or worn-out installations	9	6
High rent or mortgage payments	10	13
High operating costs	1	1
Poor relations with neighbours	13	12
Parking problems	7	5
Neighbourhood safety	8	10
Noise pollution	4	3
Insufficient household privacy	14	9
Poor transportation connections	6	4

Note: Unanswered questions (missing values) and “I do not know” answers are not included.

4.11 Residential move

Respondents were asked whether they plan to move in the future. Their answers were divided into two categories: a) those who plan to move and b) those who do not plan to move. It should be noted that in 2005, people were asked how likely it was that they would move in the next five years (“not likely”, “unlikely”, “very likely”), whereas the 2024 questionnaire included the question of whether they plan to move in the next three years (“yes, within the same town”, “yes, to another town”, “no”). The responses of those who answered in 2005 that it was not likely or unlikely they would move were compared with those who responded in 2024 that they do not intend to move. Those who responded in 2005 that it was very likely they would move were compared with those who responded in 2024 that they would move within the same town or to another town. In both years, most respondents indicated that they do not plan to move in the future—86.1% in 2005 and 1.4 percentage points less in 2024. The proportion of those who indicated that they planned to move was a little bit more than one-tenth in 2005 and just over 15% in 2024.

Table 14: Residential move (%)

	2005	2024
Yes	13.9	15.3
No	86.1	84.7

Note: Unanswered questions (missing values) and “I do not know” answers are not included.

4.12 Housing status after residential move

For this variable, respondents were classified into five categories: a) owner or co-owner, b) tenant or subtenant, c) user without paying rent, d) retirement home or assisted living, and e) other. In 2005, most respondents indicated that their housing status after residential move would be owner or co-owner. In 2024, more than half of the respondents said that this would be their new housing status. In 2005, the fewest respondents indicated that their new housing status would be something else (0.4%), and in 2024 that it would be in a retirement home or assisted living (0.4%). In 2024, more respondents reported changes in their housing status compared to 2005 across almost all categories: as (sub)tenants by 20.5 percentage points, as users without paying rent by 4.8 percentage points, and in the category “other” by 1.5 percentage points. Only in the category “retirement home or assisted living” the proportion in 2024 was by 0.1 percentage points lower than in 2005.

Table 15: Housing status after residential move (%)

	2005	2024
Owner or co-owner	84.9	58.2
Tenant or subtenant	9.5	30.0
User without paying rent	4.7	9.5
Retirement home or assisted living	0.5	0.4
Other	0.4	1.9

Note: Unanswered questions (missing values) and “I do not know” answers are not included.

4.13 Type of residence after residential move

Respondents were divided into four categories based on the type of residence after residential move: a) a family house, b) an apartment, c) a studio apartment, or d) other. For comparison purposes, the responses of those who indicated in 2024 that they would live in a single-family house after residential move were combined with those who would live in a multi-family house with separate households into a single category—family house. In the 2005 questionnaire, the categories of special room and other were combined into the single category of other. In 2005 almost 53.1% of respondents indicated that they would live in a family house after moving. This proportion was 5.8 percentage points lower in 2024 compared to 2005. For the other three categories, the proportion of respondents who answered in 2005 that they would live in an apartment, a studio apartment, or elsewhere was in 2024 2.6 percentage points higher for apartments, 2.0 percentage points for studio apartments, and 1.2 percentage points for the category of other.

Table 16: Type of residence after residential move (%)

	2005	2024
Family house	53.1	47.3
Apartment	41.7	44.3
Studio apartment	4.1	6.1
Other	1.1	2.3

Note: Unanswered questions (missing values) and “I do not know” answers are not included.

4.14 Reasons for residential move

Finally, the variable “reasons for residential move” was examined. Respondents were divided into five categories based on their main reason for moving: a) job, b) education, c) housing, d) family reasons, and e) other. In 2005, housing was recorded as the main reason for moving, and in 2024, the main reason were family reasons. Housing was the second most common reason in 2024, with approximately 30%, while family reasons were the second most common reason in 2005, with 33.2% The third most common reason was in both years some other reason not listed in the questionnaire (category “other”), with the proportion of such respondents being 3.0 percentage points lower in 2024. Job and education were recorded as the second-to-last and last reasons, respectively, in terms of the proportion of respondents for whom these were the main reasons for moving. The proportion of respondents in 2024 citing job or education as their reason for moving was higher than in 2005, by 5.2 percentage points for the first reason and 2.9 percentage points for the second.

Table 17: Reasons for residential move (%)

	2005	2024
Job	5.9	11.1
Education	2.1	5.0
Housing	34.0	30.5
Family reasons	33.2	31.7
Other	24.8	21.8

Note: Unanswered questions (missing values) and “I do not know” answers are not included.

5 Discussion

The paper analyses data from two comprehensive housing surveys conducted in Slovenia in 2005 and 2024, comparing the findings to assess changes over time. The comparison of residential place revealed that in 2024, a higher number of people lived in family houses than in 2005. The trend for apartment living showed an inverse pattern, as a higher percentage of individuals resided in apartments in 2005 compared to 2024. This observation may be associated with data suggesting a modest enhancement in the quality of these apartments. Survey results from 2024 indicate that a greater proportion of apartments feature amenities such as balconies or terraces, atriums, or gardens. This trend can be partly explained by the research of Fitwi Wolday and Lars Böcker (2023), who studied shifts in housing preferences during the COVID-19 pandemic. Their research highlighted the critical importance of accessible outdoor spaces, including gardens, terraces, and balconies, for individuals in the (post)-pandemic period. Other changes that suggest minor improvements in housing quality, specifically related to the characteristics of residential properties, are associated with the increased presence of elevators in these buildings. Research data reveal that the proportion of residential buildings equipped with elevators has risen by approximately 10 percentage points from 2005 to 2024. Despite this increase, the overall improvement remains modest considering the significant time interval between the two studies. Specifically, 14.2 percentage points more individuals now report a lack of elevators in their buildings compared to 2005. The reason for this may be attributed to the aging population in Slovenia, as the proportion of individuals aged 65 and over increased from 15.6% in 2005 to 21.8% in 2023[8] (Statistical Office of the Republic of Slovenia, 2024a). In the 2024 survey, respondents aged 61 and over were the most likely to report (nearly 40%) that they miss having an elevator. This year, the proportion of respondents in the elderly category was also higher than in 2005. Older people are more frequently physically impaired, so the presence of an elevator often represents the only option for them to participate in activities outside their homes and thus maintain their quality of life. This is supported by Claudine McCreadie and Anthea Tinker (2005), who noted that older people living in flats or maisonettes without a lift often faced challenges entering and leaving their homes, with difficulties with stairs leading to moves to other accommodations. The recent policy measure, which is expected to have a long-term impact on the quality of life for older individuals (and others) and addresses the need for modernization of Slovenia's outdated housing stock, may positively influence the future installation of elevators. This measure is the 2021 amendment to the Housing Act (*Stanovanjski zakon (SZ-1)*, 2003), which lowers the required owner consent for construction on common areas of residential buildings—including elevator installation—from 100% to 75%.

The analysis of data on the average size of residential real estate indicates that, over the 19 years since the first comprehensive housing survey, a significant increase has been observed in Slovenia, with residential real estates growing by nearly 30 m^2 on average. This observation is supported by statistical data indicating that the average size of residential properties for which building permits were issued between 2005 and 2023 is 134 m^2, closely aligning with the dimensions reported in the survey results (Statistical Office of the Republic of Slovenia, 2024b). However, it cannot be concluded that all new residential real estates have increased in size by this amount during the period, as the statistical data do not provide a separate breakdown of building permits issued for apartments versus family houses. Our survey enables calculations based on this segmentation, which is particularly relevant given that the sample includes 11.2 percentage points more respondents living in family houses. The findings derived from this segmentation indicate that the average size of family houses increased by 32.94 m^2 over the selected period, aligning with both the general calculation and official statistics on building permits for residential properties. Conversely, the average size of apartments increased by only 4.24 m^2 during the same period (see Table 6). A comparable trend of increasing family house sizes, observed in Slovenia from 2005 to 2024, has also been documented by Lindsay Wilson (2024) for the United States, based on data covering a longer time frame starting from the 1970s. Konstantin A. Kholodilin (2024) has reported an opposite trend for several European countries, based on issued building permits, indicating that newly constructed residential properties are smaller. For example, in Germany, the size of residential real estate has been decreasing since 2008; in France, a reduction in property size began shortly after

[8] The most recent comprehensive data for the entire year.

2000. In Italy, a decrease in the size of new residential real estate can be observed from 2000 to 2008, after which larger properties began to be constructed again, with some fluctuations up to the present. In addition to the increase in the size of residential real estate, our research data indicate that the average number of rooms in residential real estate in also increasing. Family houses gained an additional room between 2005 and 2024, while the increase in apartments is less pronounced. This finding is consistent with the data on the increase in the size of residential real estate. Although the data on the size of residential real estate and number of rooms suggest significant improvements from 2005 to 2024, the average number of rooms per occupant in both family houses and apartments during this period does not indicate a substantial enhancement in the spatial standard for individuals. According to the survey data, there were 1.1 rooms per resident in 2005, and 1.2 rooms in 2024. Slightly improved spatial standards are reflected in the 2023 data from the European Commission, which indicate that each resident of Slovenia has access to 1.6 rooms (Eurostat, 2023a). However, it is possible that the discrepancy in results is attributable to methodological differences in data collection. Given the observed increases in the size of residential properties and the number of rooms, it is not surprising that a greater proportion of individuals in 2024 report having adequate space for privacy compared to 2005. Analysis of the data from both years suggests that, overall, individuals have a greater sense of privacy in their homes.

The Organization for Economic Cooperation and Development (OECD) defines housing tenure as "the arrangements under which the household occupies all or part of a housing unit (OECD, 2022, p. s.p.)." Various forms of housing tenure can be identified, with the primary distinction based on whether the dwelling is owned by the household occupying it or not. The OECD identifies five distinct categories of housing tenure, 1) owned outright, 2) owned with mortgage, 3) private rental, 4) subsidised rental, 5) other (e.g., housing provided without charge etc.) (OECD, 2022). In research, housing tenure receives significant attention due to its substantial impact on an individual's life and behaviour (Dieleman, Everaers, 1994). Peter Saunders (1990) identified a "natural" preference for homeownership among individuals, attributing it to the numerous benefits that ownership provides compared to renting. These benefits encompass a sense of autonomy, increased security, financial stability, greater personal satisfaction, stronger community connections, and enhanced participation in social activities (Saunders, 1990; Elsinga, 1998; Bate, 2018). By emphasizing the advantages of ownership, homeownership has been socially established as a key objective in an individual's life, frequently linked to the creation and personalization of a home (Bate, 2018). In various societies, homeownership has thus become the predominant form of housing tenure since World War II (Bate, 2018). The same trend is observed in Slovenia; however, a comparison of survey data from 2005 and 2024 reveals a slight decrease in the proportion of homeowners and a modest increase in the proportion of renters over this period. Eurostat data indicate that a comparable trend is present in several other European countries, though over a shorter timeframe. Between 2021 and 2023, the most notable declines in homeownership were observed in Malta, with a 7.2 percentage points decrease; Greece, with a 3.7 percentage points decrease; and Luxembourg, with a 3.5 percentage points decrease (Eurostat, 2024). According to the model assessing the relationship between homeownership and housing tenure choices throughout the life cycle, considering associated risks, the primary factor driving the reduction in homeownership is the younger generation's inability to purchase residential real estate due to different changes in the economic environment (Paz-Pardo, 2022). The decline in homeownership logically results in an increased proportion of tenants. To explore this further, a comprehensive demographic analysis was conducted to evaluate the applicability of Gonzalo Paz-Pardo's (2022) findings to Slovenia. In his research, he focused on whether the increase in tenants is correlated with a rising proportion of younger individuals choosing (or being forced into) this form of housing tenure. In the comprehensive demographic analysis of tenants, variables such as age distribution, living environment, employment status, marital status, and property size were examined. Data from the 2005 and 2024 surveys were compared, and the findings were contrasted with those of Paz-Pardo (2022) as well as Michal Rubaszek and Margarita Rubio (2020), who investigated the impact of the private rental market on macroeconomic stability in Poland. Since Rubaszek and Rubio (2020) focused exclusively on tenants of profit-oriented apartments in their study, our comprehensive analysis categorized tenants into two groups for comparative purposes: 1) non-profit apartment tenants (which could also be referred to as public sector tenants) and 2) profit-oriented apartment tenants (which could also be referred to as private sector tenants), with the latter being used

for comparison in the analysis. This categorization raises the issue of how to classify tenants residing in public sector apartments with market rents, as such classification could substantially influence the findings. Including the category of public rental apartments with market rents—which was an option in the 2024 survey questionnaire—under the profit apartments category reveals a shift in housing trends. Specifically, the data indicate that, in 2005, most individuals resided in non-profit apartments, while by 2024, the majority lived in profit-oriented apartments. The observed differences in the results are substantial and may be attributable to the fact that individuals residing in public rental apartments with market-based rents in 2005 might have reported these as non-profit apartments. Although this remains speculative, the classification of these apartments as public, despite their market-based rent, distinguishes them from private rental market apartments. Consequently, these public rental apartments with market rents could reasonably be included in the broader category of non-profit apartments. When this classification is applied, the results become more comparable, revealing a similar proportion of individuals residing in non-profit apartments in both 2005 and 2024.

Following the resolution of this classification, the comparison between Slovenia and Poland is significant as both countries, having been former socialist states, now present housing markets characterized by a low proportion of rental housing and other comparable characteristics. The first variable analysed, which provides insight into the typical characteristics of tenants included in the study, is their age structure. This analysis indicates that, between 2005 and 2024, there was a general increase in the proportion of tenants within both the under-30 and over-60 age groups. A detailed analysis that distinguishes between private and public sector tenants reveals that in both years, individuals under 30 constituted most private sector tenants. However, over the 19-year period, this share declined by nearly 10 percentage points, resulting in a more balanced age distribution among public sector tenants by 2024. This trend may be explained by the increased accessibility of public rental housing for younger individuals in 2024 compared to 2005. Despite this improvement, more than half of tenants in the private rental market in 2024 remain under the age of 30, a result consistent with findings from research conducted in Poland, where the private rental sector is also predominantly occupied by individuals under 30 (Rubaszek, Rubio, 2020). Given the proportion of tenants in the under-30 age group, preliminary findings suggest that Paz-Pardo's (2022) model may be applicable to Slovenia. However, a dedicated study would be required for definitive validation. Beyond the age structure, our findings are also consistent with the Polish study in terms of the living environment variable. In both 2005 and 2024, most tenants in Slovenia resided in urban areas. Throughout the study period, a clear trend emerged with an increasing proportion of urban tenants compared to their rural counterparts. This pattern remains evident when examining tenants in the public and private sectors separately, as the majority in both categories were also urban dwellers. The distribution of tenants in the private rental market by residential environment is consistent with the findings reported by Rubaszek and Rubio (2020). Differences in tenant characteristics between Slovenia and Poland are evident when examining employment status, marital status, and property size. In both 2005 and 2024, most tenants in Slovenia were employed, although this proportion decreased by over 10% during the period. Within the private rental market, employed tenants also constituted the largest group, with little change in their proportion from 2005 to 2024. In contrast, the study by Rubaszek and Rubio (2020) highlights a significant difference, as their research in Poland found a higher proportion of unemployed individuals among private sector tenants. Even if the category of unemployed were expanded to include students, apprentices, and retirees, the results for Slovenia would remain consistent. Employed individuals would continue to constitute the majority among tenants in the private rental market. A second notable difference between the findings for Slovenia and Poland pertains to the marital status of tenants. Data on marital status for 2005 were not collected in Slovenia, preventing a comparison across years. However, a detailed analysis of the 2024 data indicates that the largest proportion of tenants in Slovenia are either married or cohabiting with a permanent partner. This trend remains consistent even when examining private sector tenants separately, where the majority are still categorized as married or cohabiting. In contrast, the Polish study identified that the largest proportion of private sector tenants were single (Rubaszek, Rubio, 2020). The final notable difference between private sector tenants in Slovenia and Poland is in the size of their residences. In Poland, over half of the survey respondents live in apartments smaller than 45 m² (Rubaszek, Rubio, 2020). In contrast, in Slovenia, just over one-fifth of private sector tenants reside in such small dwellings. Based on the characteristics of private sector tenants, Rubaszek and Rubio (2020)

determined that their profile is most representative of students or young professionals. Given that their study identified a high proportion of unemployed tenants (Rubaszek, Rubio, 2020), it remains plausible that the profile of private sector tenants more accurately reflects that of students. The predominant characteristics identified in Slovenia—namely that private rental tenants are largely under 30 years of age, employed, and in committed relationships—suggest that these tenants are predominantly young individuals at the start of their careers, who either currently have young families or are planning to establish one soon. The higher employment rate among private sector tenants in Slovenia compared to Poland may influence the size of the dwellings they occupy. In Poland, a larger proportion of tenants live in smaller apartments, whereas in Slovenia, tenants generally reside in larger dwellings. This discrepancy may be attributed to the fact that tenants in Slovenia are more likely to include individuals who already have or are planning to start a family, thereby necessitating more living space. The observed differences in the characteristics of private sector tenants between Slovenia and Poland may be attributed to the fact that young people in Slovenia often remain in their parental homes throughout their studies and typically leave parental home later than the European average and Poles (see Eurostat, 2023b).

In 2024, only a few people did not have a concluded rental agreement. The finding is surprising, as we assumed that the share of the so-called black market in renting or leasing apartments was significantly larger. This is supported by the insights of Elena Bargelli and Ranieri Bianchi (2018), who highlight that the black market is a frequently overlooked real-world phenomenon characterized by unofficial, informal contracts that violate binding legal regulations, particularly those related to public law concerning taxes, registration, and habitability requirements. Consequently, these transactions are typically kept secret by the involved parties (Bargelli, Bianchi, 2018). It cannot be confirmed whether the survey results are accurate. In any case, additional research should be carried out in this area in Slovenia.

Housing is strongly associated with residents' health and overall well-being (see Matte, Jacobs, 2000; Peasgood et al., 2017; Rolfe et al., 2020). Housing conditions can be assessed using a range of indicators, including access to safe drinking water, sanitation, electricity, flush toilets, secure food preparation areas, adequate living space, and the absence of moisture and leaks. While significant improvements in housing standards have been made in developed countries over the past century—rendering some of these issues largely historical or rare—certain challenges remain, and new problems have arisen alongside modern development (Matte, Jacobs, 2000; Mandič, Cirman, 2006). Issues related to residential real estate were also examined in the surveys conducted in 2005 and 2024. The findings indicate that in 2024, the primary concern for individuals remained consistent with 2005: high housing operating costs. However, the proportion of those facing this issue decreased by 6 percentage points over the 19-year period. High operating costs were the only issue that consistently held the same position on the list of 14 identified housing challenges in both 2005 and 2024, while other issues shifted either upward or downward. In both years, a greater proportion of tenants reported high operating costs as a concern compared to homeowners. In 2005, 63% of tenants faced this issue, while by 2024, this percentage had decreased to 59.5%. Our findings are consistent with the research of Marietta Haffner and Kristof Heylen (2011), which indicated that homeowners, including those with mortgages, typically have higher incomes and experience less impact from operating costs compared to tenants. Given that high operating costs predominantly affect tenants, Jack Goodman (2004) proposed a targeted measure to mitigate these costs. He noted that, although the overall impact on operating costs may be limited, these costs include various components, such as taxes, which governments could more easily address. In the United States, these taxes can account for between 18% and 22% of total operating costs, with variations among countries (Goodman, 2004). All governments could consider lowering these taxes to implement policies that enhance housing affordability and support the growing trend of rental housing, as indicated by our survey results.

In examining residential moves or migration intentions, the conventional definition of migration was adopted "as the decision of an individual to relocate from their current residence to another, either within national borders or internationally" (Sironi et al., 2019: 137). A comparative analysis of the 2005 and 2024 surveys revealed that most respondents did not wish or intend to move. In 2005, 13.9% of respondents expressed a desire to relocate, which slightly increased to 15.3% in 2024. However, national

statistics indicate that only 5.2% of the population relocated within the country in 2023 (Statistical Office of the Republic of Slovenia, 2024c). This suggests that a substantial portion of respondents who expressed a desire to move in our survey may have been responding hypothetically, without concrete plans for relocation. Considering the low rate of residential mobility, Slovenia can be classified among other Southern and Eastern EU Member States, which are typically characterized by residential mobility rates below 10% of the total population (Eurostat, 2016). Given that the survey question was designed to encompass international migration, the findings can be tentatively compared to the global analysis of migration intentions conducted by Migali and Scipioni (2018). Their study reported a higher proportion of respondents—ranging from 18% to 28%—expressing a desire to migrate abroad, with a notably stronger intention among individuals in the low-income group (Migali, Scipioni, 2018). Their research further revealed that a minimal percentage of individuals who expressed a desire to migrate had concrete plans to do so, with only 2% demonstrating such intentions (Migali, Scipioni, 2018). This finding is comparable to statistical data for Slovenia, where in 2023, only 1% of the total population emigrated abroad (Statistical Office of the Republic of Slovenia, 2024d). A detailed analysis of respondents from the 2005 and 2024 surveys who expressed a desire to relocate indicates that the intention to move is primarily found among tenants and those residing in urban areas. This finding aligns with data for Europe, which can be partially explained by the higher proportion of tenants in cities (Eurostat, 2016). In the earlier part of the discussion, a profile of tenants was developed based on the results of the research, and this profile was compared with findings from a study conducted in Poland (see Rubaszek, Rubio, 2020). The European Commission reached similar conclusions, noting that tenants are often younger individuals who are either pursuing education or entering the labour market after completing their studies, and tend to reside in urban areas (Eurostat, 2016).

Research on housing tenure in relation to various factors has been well-established in the literature. While numerous studies examine the relationship between migration and tenure choice (see Henderson, Ioannides, 1983; Onaka, Clark, 1983; Clark, Onaka, 1985; Ioannides, 1987; Goodman, 1988, 2003; Ioannides, Kan, 1996; Cirman, 2003; Riley et al., 2015; Ghasri, Hossein Rashidi, 2018), their findings alone are insufficient to explain the substantial differences observed between the 2005 and 2024 survey results. The data show that in response to the question about the expected housing status after relocation, 84.9% of respondents in 2005 became owners or co-owners of their new residence, whereas in 2024, this figure dropped to 58.2%. This indicates a 26.7% decline in the proportion of new homeowners following their anticipated relocation. Consequently, there was a noticeable increase in the proportion of respondents who indicated that their future status would be as tenant or subtenant. The reasons for this shift are likely multifaceted; however, the most evident factor was highlighted earlier in the discussion, where the reduced ability of younger generations to purchase homes was emphasized (see also Cribb et al., 2018; Paz-Pardo, 2022; Dubois, Nivakoski, 2023). Milad Ghasri and Taha Hossein Rashidi (2018) found in their research that most future tenants are already renting their current residence. The findings from our 2024 survey reveal a different trend, with the proportion of tenants who will remain tenants after relocating (46.3%) and those who will transition to homeownership (44.8%) being nearly evenly distributed. This result is not surprising, as it has been indicated by Andreja Cirman's (2003) model that a strong preference for homeownership is prevalent in Slovenia, with renting being viewed mainly as a transitional phase towards ownership. Similar findings were reported by the authors of a more recent study conducted in Poland, where it was revealed that more than half of the respondents would prefer homeownership with a mortgage over renting (Rubaszek, Rubio, 2020). Tenants tend to decide to relocate more quickly than homeowners, as homeownership increases tolerance for imperfections in the dwelling (Ghasri, Hossein Rashidi, 2018). Gum-Ryeong Park et al. (2024) explored how changes in housing tenure after relocation are linked to life satisfaction. They found no significant changes in satisfaction when individuals remained in the same type of housing tenure—whether as homeowners or tenants. However, life satisfaction increased substantially for those transitioning from renting to owning, while it decreased significantly for those moving from homeownership to renting (Park et al., 2024). Park et al.'s study contrasts with earlier research on housing tenure, which found that the benefits individuals experience when transitioning to a different form of housing tenure do not primarily stem from ownership or tenancy as a form of housing occupancy. Instead, these benefits are mainly attributed to enhancements in housing quality, which are associated with different types of housing tenure, particularly in relation to their affordability. Ownership is generally perceived as a more

cost-effective form of housing compared to renting (Kearns et al., 2000). On the other hand, Frank Popham et al. (2015) found no evidence of any changes in the mental health of tenants who, through the right to buy, became homeowners of the properties they had been living in, thus changing their housing status from tenants to owners (Popham et al., 2015).

When examining the reasons for residential move, it is crucial to acknowledge their complexity and multi-dimensional nature (Coulter, Scott, 2015), as well as their changing dynamics over the course of an individual's life cycle (Geist, McManus, 2008). Various authors categorize the reasons for relocation with differing levels of detail, but the primary factors typically include employment, education, housing, family reasons, and quality of life (see e.g., van Ham, 2002; Geist, McManus, 2008; Coulter, Scott, 2015). In the 2005 and 2024 surveys, the same response categories were provided to respondents, and little change in trends was observed. In 2005, the primary reason for a residential move was identified as housing, closely followed by family reasons, which emerged as the most common cause of a residential move in 2024. Housing is generally the most common reason for residential moves, as confirmed by a more in-depth study of housing mobility based on longitudinal data from the British Household Panel Survey (Coulter, Scott, 2015). A possible explanation for the low proportion of relocations related to employment and education in Slovenia is that relocations motivated by these two factors are typically associated with greater distances (Geist, McManus, 2008), which are less common in Slovenia.

6 Conclusion

A broad spectrum of topics related to Slovenia's housing environment is addressed in this paper through comparative analysis. Trends in housing characteristics, living conditions, rental market dynamics, and residential mobility are examined using data from housing surveys conducted in 2005 and 2024, with a focus on both continuities and changes observed over the nearly two-decade period.
In terms of housing characteristics, the analysis revealed a shift toward a greater proportion of the population residing in family houses compared to apartments. This observation is particularly notable, as the findings also indicate an increase in the average size of residential properties, suggesting a possible correlation between these two trends. While the reported property sizes align with official statistics on building permits issued during the studied period, it cannot be inferred that all properties experienced the same degree of size increase. The distinction between family houses and apartments revealed that, during this period, the increase in size was primarily observed in houses, while the differences in the average size of apartments remained minimal. Considering that the comparison of average sizes may be misleading, it is crucial for subsequent analyses to classify residential properties into categories based on usable area, as defined by Statistical office of Republic of Slovenia, and to examine changes within these specific size classifications. It is particularly noteworthy that, despite the increase in the size of residential properties, there has been little change in the average number of rooms per resident. During the validation of the questionnaire, it was observed that respondents encountered difficulties in accurately answering the question about the number of rooms in their residential properties, even with the provision of accompanying written clarifications. Although all suggestions from the respondents involved in the validation process were considered in the final questionnaire design, there is still a likelihood that the ultimate respondents encountered similar challenges, which may have led to inaccuracies in their responses. This challenge could be partially mitigated by connecting respondents to direct extracts of spatial data from the Land Registry, thereby obtaining accurate data and enabling a more straightforward assessment of the spatial standards of residents.

Among the variables associated with living conditions, the most noteworthy results are related to housing tenure, which revealed that, while homeownership continues to prevail, the proportion of tenants has been steadily increasing. This shift raises significant questions regarding the underlying causes. Although the study could not establish a clear causal relationship, it is plausible that rising housing unaffordability is pushing more individuals, particularly young people, into the rental market, despite a persistent preference for homeownership. Another potential explanation is the evolving societal attitudes toward housing status, with tenancy increasingly becoming an accepted alternative. Future

research should aim to clarify the reasons behind these changes, as understanding them is essential to developing effective housing policy.

In Slovenia, the establishment of a rental agreement is a legal requirement for regulating the relationship between the tenant and the landlord. However, the scope of the private rental sector remains unclear due to the absence of a database for recording this information. It is presumed that a substantial number of rental apartments in the private market are being leased without formal rental agreements. In contrast to this assumption, both surveys and their comparative analysis revealed that most tenants have formal rental agreements in place. This finding is surprising, as it suggests the possibility that respondents may not have answered truthfully for various reasons, including fear of eviction or other potential repercussions from their landlords. It is also possible that our presumption is not correct. This should also be researched in the future.

Regarding residential mobility, the results indicate a slight increase in relocation intentions, yet actual relocation rates remain consistently low. A critical finding in this context is the shift in housing tenure intentions, characterized by a declining proportion of individuals, particularly among younger generations, aspiring to homeownership. This trend, in conjunction with findings related to housing tenure within living conditions, reflects the increasing economic challenges faced by these individuals in accessing the housing market.

Based on the research findings and the trends they reveal, several general guidelines can be delineated for future research, for action in the housing market and, consequently, for the formulation of housing policy. Enhancing the monitoring of the housing market through the periodic repetition of the housing survey is crucial. In Slovenia, the survey has been conducted only twice, with an almost 20-year interval between both, which is an insufficient for effectively comprehending the dynamics within the housing sector. The quality of future surveys could be partially improved by developing a method to connect respondents' answers with spatial data from the Land Registry, thus enhancing the accuracy of the data obtained. Regular monitoring of the housing market would help policymakers understand changes over time, thereby facilitating a more informed response through the formulation of appropriate measures to address these changes. Additionally, establishing a comprehensive rental housing registry is essential. However, the lack of official data on the private rental sector limits understanding of the housing market. Given the identified changes in the distribution of the population structure related to housing status, it is essential to undertake more comprehensive research in this specific domain and to establish connections between these changes and their underlying causes. If changes in the population structure are associated with decreased housing affordability, it is imperative to formulate housing policies that promote a variety of housing options, encompassing both rental and ownership opportunities.

Based on the findings and emerging trends, it is recommended that housing policy be designed to give individuals real choices regarding their housing situation. This would allow people to select the housing option that best suits them, rather than accepting a particular solution simply because they have no other choice and have been forced to "get used to it".

Acknowledgment

The findings presented in this paper are the result of a 15-month project titled "Housing provision in Slovenia: A social science survey on the state and trends," which was financially supported by the Slovenian Research and Innovation Agency (grant number V5-2337 and research core funding number P5-0100) and the Ministry for Solidarity-Based Future.

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