MASTER'S THESIS | MAGISTRITÖÖ

IMPLEMENTATION OF CIRCULARITY IN POST-SOVIET HOUSING DISTRICT BY EXAMPLE OF LAAGNA, TALLINN

RINGMAJANDUSE RAKENDAMINE PANEELELAMUTE RAJOONIS LAAGNA ASUMI NÄITEL

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MASTER'S THESIS

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AUTHOR'S DECLARATION

Hereby I declare, that I have written this thesis independently.
No academic degree has been applied for based on this material. All works, major viewpoints and data of the other authors used in this thesis have been referenced.

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Käesoleva magistritöö teemavalik sai tõuke Tallinna arhitektuuribiennaali visioonivõistluselt, mis aitas enda jaoks lahti mõtestada ringmajanduse ja arhitektuuri sümbioosi.

Ma tahan südamest tänada oma juhendajat, Kimmo Lylykangast, kes motiveeris ja oli toeks kogu töö perioodi vältel.

Samuti tänan oma pereliikmeid toetava ja mõistva suhtumise eest, ilma kelleta oleks antud teekond olnud üsna raske.

ABSTRACT

The master's thesis explored urban renewal of the post-Soviet prefabricated housing districts, with a specific focus on circularity principles and human-centred urban space. Project is located in the Laagna housing block of Lasnamäe. The aim was to transform the existing residential quarter into a circular block with more functional and spatial diversity, implementing sustainable and reusable resources to improve the living environment. The preparation of the work included the examination of history, current condition and renovation needs of panel buildings which were combined with the current knowledge of circularity. The design proposal was prepared for the building group in the Laagna quarter based on theoretical research. The developed solution is suitable for wider application in respective suburban areas.

The study found synergies between the principles of circular economy and people-centred urban space, aiming at ensuring a more enjoyable and diverse living environment. Panel districts built in the spirit of modernism and standardisation are characterized by monofunctional car-centric suburban spaces lacking human scale and positive stimulation. The European Union's goal of climate neutrality by 2050 means green transitions of built environment based on sustainable measures. Therefore, solutions to revitalise problematic areas need innovative approaches.

The construction industry is one of the most energy-intensive sectors. If existing panel buildings are demolished and substituted with new and more economical buildings, the amount of waste from demolishing is enormous. On the other hand, retrofitting saves on demolition costs and preserves the homes of local people while improving their living environment.

Guided by the need to renovate the building envelopes of prefabricated panel houses, the transition towards more diverse living environment was based on the rethinking of the facades. To this end, case studies were carried out on the renovation of Soviet-era panel buildings, improving the quality of physical space and thermal comfort. The project part included an urban spatial analysis of the selected location, identifying problematic areas and introducing a new planning proposal. Based on the location characteristics, revitalisation plan was created for a group of buildings on Varraku, Virbi and Arbu in Lasnamäe, Laagna district, which would be chosen considering high-potential urban area between the buildings. The solution includes changes in the courtyards during the implementation of the small-scale new construction and interventions in the existing building. As the prefabricated residential area is based on standard solutions in both architectural and planning terms, it is possible to apply the developed solutions in other part of Lasnamäe as well as in other respective neighbourhoods.

ANNOTATSIOON

Käesolev magistritöö käsitles Nõukogude-aegse paneelrajooni ümbermõtestamist, võttes arvesse ringmajanduse põhimõtteid läbi inim-keskse linnaruumi. Projekti asukohaks on hoonestusgrupp Laagna asumis Lasnamäe linnaosas. Töö eesmärgiks oli luua ringmajandusel toimiv elamukvartal, kus rakendatakse elamiskeskkonna parandamiseks säästvaid ning taaskasutatavaid vahendeid. Teooria osa hõlmas endas paneelelamute ajaloo, hetkeseisundi ja renoveerimisvajaduste uurimust, mis seoti teadmistega ringmajandusest. Projekti ettepanek koostati teoreetilisele uuringutele tuginedes Laagna kvartali hoonerühmale ning seda ümbritsevale välialale. Väljatöötatud lahendus sobib kasutamiseks ka teistes sarnastes piirkondades.

Uurimuses leiti sidusus ringmajanduslike printsiipide ja inim-keskse linnaruumi vahel, mis tagab elanikele nauditavama ja mitmekülgsema elukeskkonna. Modernismi ja standardiseerimise vaimus rajatud paneelrajoonid on täna defineeritavad monofunktsionaalse autokeskse linnaruumina, kus puudub inimsõbralik keskkond. Euroopa Liidu 2050. aastaks püsitatud kliimaneutraalsuse eesmärk tingib linnaruumi kohandamise jätkusuutlike meetmete alusel. Seetõttu tuleb leida lahendused probleemsete piirkondade taaselustamiseks integreerides innovaatilisi lähenemisi.

Ehitussektori puhul on tegemist ühe suurima energiakulu nõudva valdkonnaga. Olukorras, kus tuleb kõne alla olemasolevate hoonete järk-järguline lammutamine ning asendamine uute energiasäästlike hoonetega, tuleb arvestada tohutu hulga jäätmemahuga. Seevastu rekonstrueerimine ning energiasäästlikumaks muutmine hoiab kokku lammutuskuludelt kui ka võimaldab säilitada kohalike elanike kodud, tõstes sealjuures nende elukvaliteeti. Juhinduvalt paneelelamute renoveerimise vajadusest lähtuti mitmekesise elukeskkonna rajamisel ka fassaadide ümbermõtestamisest. Selleks töötati läbi juhtumiuuringud, mis käsitlevad Nõukogude ajal rajatud paneelhoonete tänapäevastamist, tõstes lisaks soojusmugavusele füüsilise ruumi kvaliteeti. Projektiosa hõlmas endas valitud asukoha linnaruumilist analüüsi, probleemsete kohtade välja toomist ning sellest lähtuvalt uue planeerimisettepaneku koostamist. Linnaruumilise asukoha põhjal loodi ettepanek Varraku, Virbi ja Arbu tänavate äärsele hoonegrupile Lasnamäel Laagna asumis, mis osutuks valituks potentsiaalikate sisehoovide tõttu. Lahendus hõlmab sisehoovide planeeringulist muudatust väikehoonestuse rakendamisel kui ka olemasolevasse hoonestusse sekkumisi. Kuna paneelelamurajooni puhul on tegemist piirkonnaga, kus on rakendatud standardlahendusi nii arhitektuurses kui planeeringulises aspektis, on võimalik rakendada välja töötatud lahendusi ka teistes sarnastes asukohtades.

KOKKUVÕTE

Modernistliku linnaplaneerimise tüpoloogiad leidsid rakenduse paljudes Nõukogude-aegsetes elamurajoonides standardiseeritud paneelelamute näol. Kuigi toona oli tegemist uuenduse sümboliga, on tänast konteksti arvestades tegemist iganenud rajoonidega, mis vajavad kohest sekkumist energiasäästlikuse kui ka nauditavama linnaruumi tagamise seisukohalt. Käesolev magistritöö käsitles Nõukogude-aegse elamukvartali ümber mõtestamist ringmajanduslikuks kvartaliks, lähtudes keskkonnasõbralikest ja taaskasutatavatest materjalidest.

Standardiseerimine aitas hooneehituse rajada enneolematu kiirusega uusi elamukvartaleid. Paneelidest kokku monteeritud suurkorterelamud defineerisid uudset lähenemist elamurajoonide rajamisel. Üheperekorterid olid paljude jaoks kättesaamatu unistus, mille võis endale saada eriloa alusel. Kaasaegse koduna defineeriti paika, kus oli küll kõik vajalik igapäevaelu toiminguteks olemas, kuid mis soosis pigem sotsiaalse elustiili järgimist, veetes vaba aega kodust väljaspool. Siiski jäid paljud planeeritud ideaalid kokkuhoiupoliitika varjus teostamata, mistõttu mõjusid kvartalid üksluisete magalarajoonidena. Le Corbusier'lik 1930. aastate ideaal on pöördunud tänases valguses külmaks monofunktsionaalseks masinakeskseks lahenduseks, mistõttu hakkas tekkima vastukaalukaid ideoloogiaid inimsõbraliku linnaruumi saavutamiseks.

Lasnamäe puhul on tegemist suurima Tallinnasse Nõukogude-aja lõpul rajatud piirkonnaga, kus rakendati kõige selgemalt Le Corbusier'liku planeerimise tüpoloogiaid, eraldades sihilikult transpordivahendite kiirliiklus elamukvartalitest. Arvestades käesoleva sajandi autostumise määra kiiret kasvu, valitseb nii Lasnamäel kui teistes paneelrajoonides autode dominant, mis defineerib ümbritseva keskkonna monotoonseks parkimisalaks. Paneelelamute osakaal on Tallinna elamufondis üsna märkimisväärne, mistõttu tuleb silmas pidada hoonete renoveerimise vajadust. Teema aktuaalsus ilmnes 50 aasta möödudes esimeste suurpaneelelamute püstitamisest. On kindlaks tehtud, piirdetarindite efektiivne renoveerimine takistab niiskuse ligipääsu kandekonstruktsioonile ning seetõttu pikendab eeldatavat hoonete eluiga. Lisaks vananenud piirdetarindite lahendustele on rekonstrueerimata korterites puudulik sisekliima kvaliteet, millele projekteerimise ajal tähelepanu ei pööratud. See mõjutab lisaks ümbritsevale keskkonnale ka elanike elu kvaliteeti ning mugavustunnet. Renoveerimise aktuaalsuse muudab kriitiliseks Euroopa Liidu poolt kehtestatud eesmärk saavutada aastaks 2050 kliimaneutraalsus. Seetõttu vajab suur osa möödunud sajandil ehitatud elamufondist renoveerimist.

Linnade laienemine muudab paratamatult kunagised eeslinnad linna osadeks, mistõttu muutuvad elamupiirkonnad multifunktsionaalsemaks. Uute elamurajoonide rajamisel peetakse silmas mitmekesise linnaruumi loomet, kus elanik võib end tunda turvaliselt. Seetõttu on oluline integreerida uusi lahendusi varasemalt loodud elamurajoonidesse, muutes linna seeläbi ühtsemaks tervikuks. Arvestades paneelrajoonide suurt osakaalu Tallinna linnapildis, on oluline muuta sealne monofunktsionaalne keskkond mitmekesisemaks ning luua parem sidusus ülejäänud linnakeskkonnaga.

Kuigi paneelrajoonide saatuse kohta on spekuleeritud erinevaid versioone, sealhulgas hoonete järk-järgulist lammutamist ja asendamist uute energiasäästlike ehitistega, tuleb silmas pidada olemasoleva elamufondi potentsiaali renoveerimisel. Vana hoone lammutamine ning uue ehitamine on kordades kulukam kui vana hoone ehituslike tingimuste parandamine. Kaasaegsed ventilatsiooni ning piirdetarindite soojustamise võimalused pikendavad konstruktsioonide eluiga pikkadeks aastateks. Samuti esitab paneelhoonete renoveerimine väljakutseid uute tehnoloogiate ning jätkusuutlike võimaluste välja töötamiseks.

Maakondade rahvaarvu kahanemine mõjutab otseselt olemasolevat korterifondi, mis selle tulemusel elanikest tühjeneb. Kortermajade tühjenemine viib suure tõenäosusega nende lammutamiseni, mistõttu avaldub otsene mõju lammutusjäätmete käitlemisele. Keskkonnaministeeriumi poolt tellitud aruande põhjal ilmneb, et seni on Eestis takistanud ehitussektori poolt tekkinud jäätmete suuremahulisemat ringlusesse võtmist finantsiline aspekt. 2019. aasta seisuga suunati ringlusesse vaid 0,7% ehitusjäätmetest. Kuigi vanade hoonete lammutamine võib olla paratamatu, saab sellest tulevaid jäätmeid maksimaalselt ära kasutada neile uue funktsiooni leidmisega.

Sellest lähtuvalt on ringmajanduse rakendamine ehitussektoris äärmiselt oluline. Euroopa Komisjon avaldas 2020 aastal juhendi, mis käsitleb ringmajanduse seisukohast lähtuvaid printsiipe, millega tuleb arvestada ehitiste konstrueerimisel. Lisaks konstruktiivsete komponentide jätkusuutlikkuse ning taaskasutuse aspektidele tuleb tähelepanu pöörata elanike tarbimisharjumustele. Seetõttu on paljudes ringmajanduslikes lahendustes olulisel kohal mahepõllundus, andes elanikele võimaluse ise omale toitu kasvatada. Toidu kasvatamise sidumine urbanistlikusse keskkonda mitmekesistab piirkonda, vähendab transiidi kulusid ning kasutab maksimaalselt ära hoovid, katusepinnad ja fassaadid.

Kuigi ringmajanduse käsitlus on tänases ühiskonnas aktuaalne teema, on tegemist üha areneva ja võimalusi otsiva valdkonnaga. Aina enam rakendatakse jätkusuutlikust ning ringmajandusest lähtuvaid aspekte uute elamurajoonide puhul. Paljud neist on arendamise järgus ning seetõttu kontseptuaalse projekti faasis, kuid on vähe näiteid olemasolevate piirkondade taaselustamisest antud printsiipe arvestades. Seetõttu tuli antud projektilahenduse välja töötamisel luua sümbioos paneelelamute renoveerimisest ja ringmajanduslike elurajoonide printsiipidest taaselustamaks monofunktsionaalset elukeskkonda.

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1. INTRODUCTION

The principles of modernist urban planning developed in the first half of the 20th century have influenced the construction of Soviet-era panel districts. The panel districts symbolize the triumph of standardization and once-innovative solutions, continuing to be a significant indicator of Soviet idealism. Today, more than 50 years have passed since the first districts were built in Tallinn, which raises questions about the lifespan of buildings and outdated technologies. At that time, car dependency and high-density residential buildings reflected the possibilities of future technologies. Unfortunately, car domination is a primary element due to densely populated areas with no functional outdoor space within the quarter.

As a goal of the European Union for achieving climate neutrality by 2050, it raises the question of prefabricated apartment buildings' suitability to accomplish this goal. Since the panel buildings built in the last century are dominant in the housing stock of Tallinn, their condition affects significantly the quality of the surrounding environment. Therefore, the Ministry of Economic Affairs and Communications, in cooperation with TalTech, has developed a long-term strategy for the reconstruction of buildings (2020), aiming to renovate the existing building stock to reach the level of energy class C (TalTech, 2020). Although energy efficiency in buildings is an essential aspect of moving towards climate neutrality, one of the key elements for sustainability is the circular economy. As one of the largest producers of waste, the construction sector needs rapid changes to make its processes more environmentally friendly with the implementation of recycling.

Implementing the circular economy in architecture involves creating sustainable and resource-friendly solutions using materials that can be reused or deconstructed (European Parliament, 2015). The drive for a greener society has an impetus to search for new technologies and outputs to construct climate-neutral buildings. Therefore, the circular economy principles have been applied mainly in the concepts of new or future projects. However, there are only few examples of the implementation of circularity in the form of reconstruction projects in existing developed areas.

The master's thesis aims to turn the existing Soviet-era residential quarter into a circular economy unit by applying environmentally friendly and reusable materials to improve the existing living environment. The research question lies in a discussion of why it is essential to reconstruct the existing panel districts and follow the principles of implementing the circularity. The solution is based on a qualitative research method, gaining a thorough knowledge of the architectural applications of the last century - the main principles of modern urban planning and the opposite critique based on a human-scale urban space. In order to get a more precise overview of the peculiarities of architectural planning during the Soviet period, a survey will be conducted with architect Irina Raud, who worked in Mart Port's planning team during the construction of the Lasnamäe district. The historical approach to architecture contrasts with the challenges of today's reconstruction needs and urban space qualities. The topicality of the circular economy in both past and present architectural solutions has also been discussed to get acquainted with the capabilities of the field.

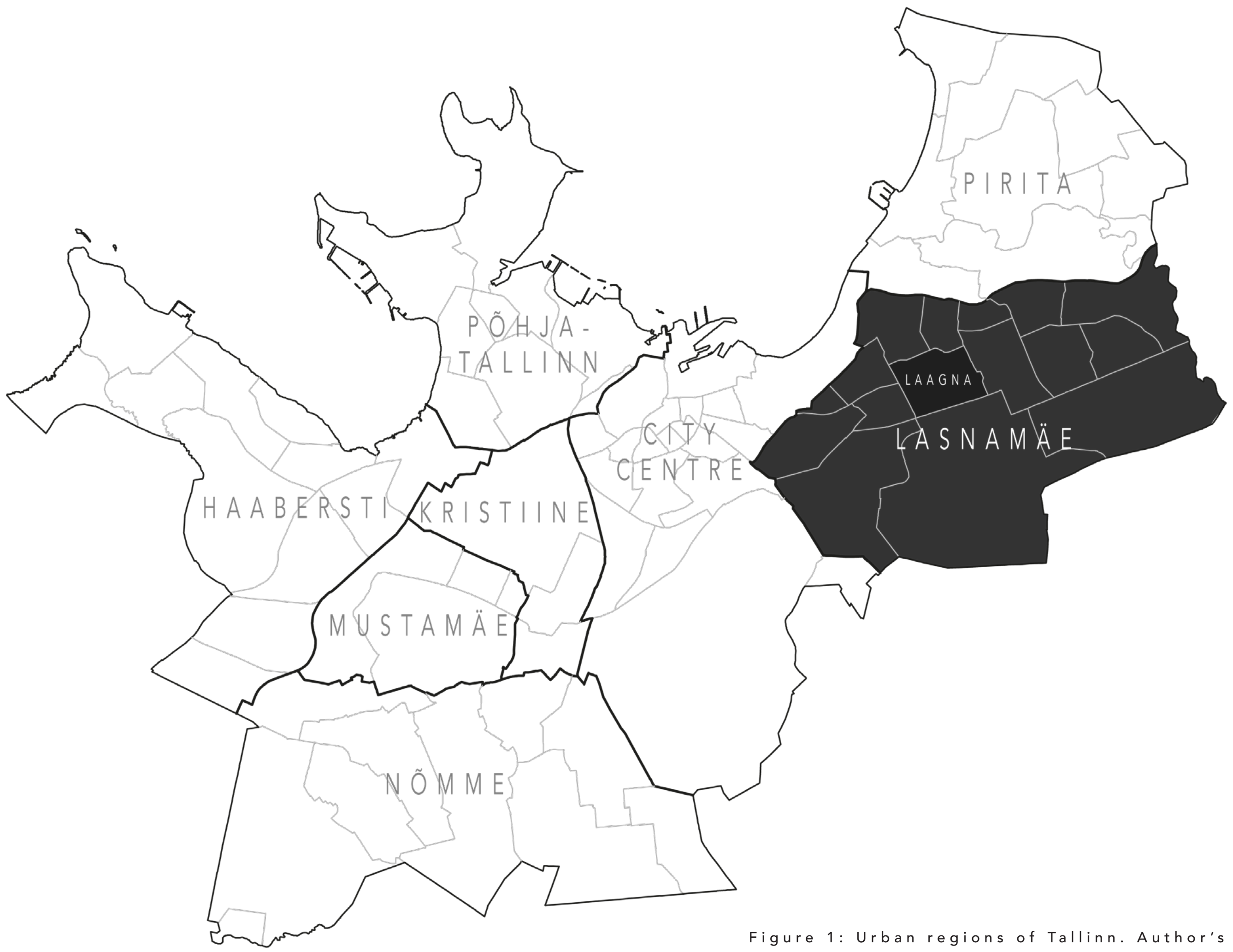

Figure 1: Urban regions of Tallinn. Author's illustration

2.THE ROOTS OF SUBURBIA

2.1 MODERNISM IN CITY PLANNING

To acknowledge the means of urban planning principles in the Soviet Union, including the urban development in Estonia, the roots of modernist urban planning views need to be considered. The modern approach to urban planning grew out with the continuing industrial revolution ideologies and the desire for innovation in the new housing stock. Due to World War I, Classicism was questioned as a dominating architecture style, and association with imperialistic motives felt obsolete and overused. Growing industrial areas brought up the urbanisation and demand for working-class housing districts. Therefore, Classicism, with its immediate attention on public buildings and upper-class mansions had fallen behind the new developing society (Lopez, 2012). The city needed an innovative approach and a redefinition of its conventional principles.

New residential areas had to be built more efficiently than previous traditions to keep pace with growing industrial areas. The demand for innovative technology made architects follow the cutting-edge technologies of the time, so the principles of mass production began to be analysed. Contemporary industries were mainly implementing method study, standardisation, and planning to accomplish the highest possible quantity of mechanisation. Standardisation guided simplification and affordability, allowin g us to produce more with lower costs and approach a more significant number of customers. (Guillén, 2006).

2.1.1 The agenda of modernist urban planning

One of the 20th-century production influencers was Henry Ford, whose innovative theory of the socioeconomic conception of the factory, called Fordism, induced other contemporary manufacturers. The principle was built upon an assembly line that reduced production costs and enabled the production of more units. Each employee had a specific repetitive motion; thus, the division of the process was fast, and the line was in constant motion. Modern architects saw an opportunity to implement the same principles in the new buildings, which had to observe the criteria of affordability, thoughtful design, and fast production (Lopez, 2012).

While Henry Ford impacted the simplification and standardisation of mass production of the buildings through an assembly line, engineer Frederick Winslow Taylor influenced architects with principles of working efficiency and optimisation that were later known as Taylorism. He examined the solutions of most rational working movements and the tools for more efficient operations, called time-and-motion studies. Different workers investigated each task, divided it, and generally performed it to maximise productivity. The above-mentioned methods were studied to increase work and output effectiveness to benefit labour and capital (Schröter, 2005).

Although Fordism and Taylorism were the ideologies of American modernism, the leaders of the architectural movement in Europe were inspired by contemporary American architecture and the new wonders of technology. Le Corbusier, Mies van der Rohe, Gropius, and others from Bauhaus saw it as inspiring. Even though their design language was different, a common influence of Fordism and Taylorism was still recognised. For instance, Walter Gropius designed and built over three hundred houses in Dessau-Törten based on only a few prototypes. Influenced by Ford and Taylor, the construction was rationalised, transported to the location by rail, and assembled in place. Considering contemporary building traditions without mechanisation, prefabricated construction was innovative and remarkable, representing the technological revolution (Schröter, 2005).

Based on previously mentioned impacts, a universal design implemented in architecture as an International Style movement became one of the leading design strategies in the last century. The design language contrasted Victorian-era styles with aesthetic yet affordable disposal of wealth and classes reflected in ornamented and striking architecture. Simple materials, including glass, steel, and concrete, were understandable as universal construction resources, which led to the global implementation and the oblivion of local patterns and building traditions (McDonough & Braungart, 2002).

2.1.2 Main influencers

One of the last century's modernist movement and International Style leaders, Le Corbusier, was an exploiter of Machine Age opportunities in architecture mass-producing technologies. He believed that the urban environment should reflect the contemporary findings of technologies and work as a reincarnation of machines. This principle is reflected in his early designs for modern houses, described as "machines for living" (LeGates & Stout, 2015).

Le Corbusier's proposal for the Contemporary City of Three Million Inhabitants in 1922 is considered the 20th-century modern urban planning framework that sets the fundamentals which can be implemented on different scales. Starting with the empty ground, the project unites high-density buildings and diverse solutions for traffic and greenery for people's health. Reflecting the modern possibilities in architecture, the city centre is built up of 24 skyscrapers for rising density in the business area for natural marketing. The concept united the principles of the machine and living organism, surrounding the residential areas with greenery that works as the lungs of the city, considering the intensity of rapid environmental effects on health. Transportation holds a remarkable meaning in the light of evolving means of transport as a part of the contemporary city: traffic is divided into various

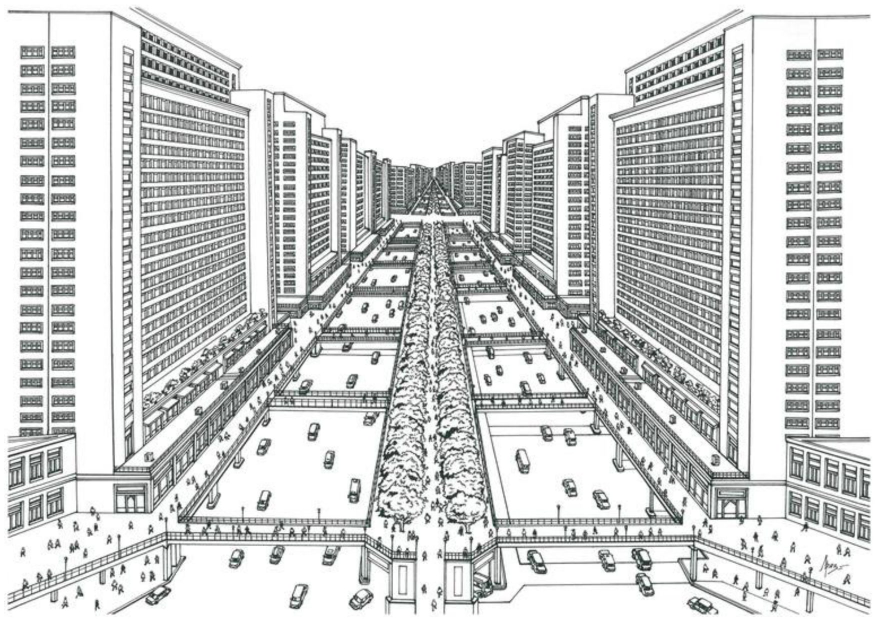

Figure 2: Le Corbusier's Future City in 1929

categories to separate heavy traffic from the lighter one. Therefore, it should ensure a citizen-friendlier environment that takes into account the risks of growing technological development in the field of transport (Le Corbusier, 1987).

The idealistic city approach was developed in 1930 by the project of Radiant City, where the previous considerations took an even more specific scale. Both of Le Corbusier's projects consider society as a neat and efficient environment where an ideal city structure helps to have control over society. Therefore, it excludes the slums, mixed-use areas, and narrow streets and replaces them with systematic transportation structures and specified zones for each function (Watson, 2009). High-density city centre for business and wealthier people surrounded by apartment building suburbias creates a systematically organised city model that uses sites economically and still has the elements of nature.

To contrast European modernist 20th-century city planning principles with contemporary American architect Frank Lloyd Wright, the ideas of urbanism are seemingly different. Known for making architecture in harmony with nature, their urban planning standpoints are similar ideologies. For instance, fascinated by automotive industry developments, the project of Broadacre City by Frank Lloyd Wright used motives likewise to car-dependent planning.

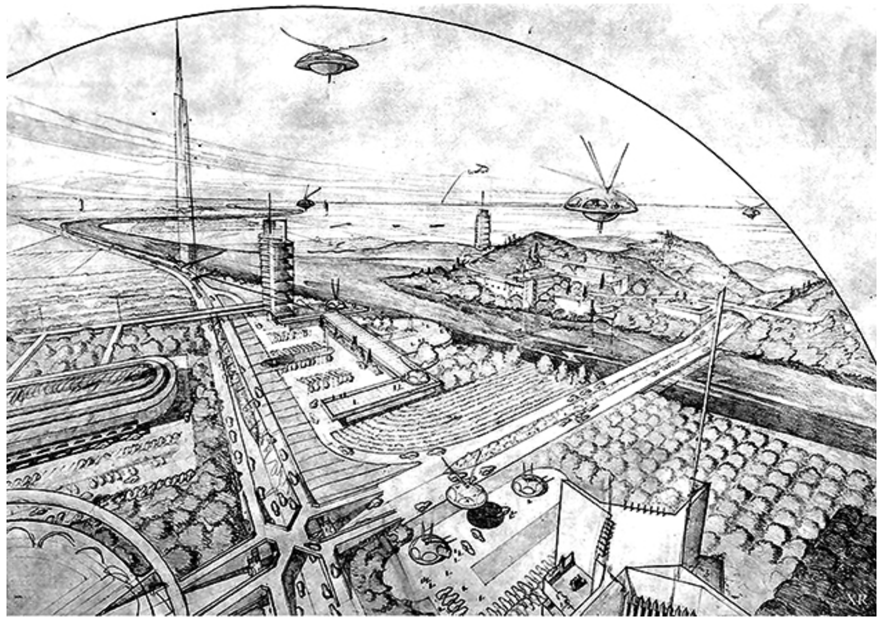

Figure 3: Frank Lloyd Wright's Broadacre City, 1932

The Broadacre City concept, first introduced in 1932, is a low-density suburban utopia, giving every person an acre (~0,4 ha) of land related to vast highways. Without any high-rise buildings, Broadacre City consists of private housing and small-scale buildings implementing recent modern technologies. Contrasting Le Corbusier's ideal centralised city, Wright's approach seeks the opposite outcome with decentralising. A new rural landscape offers people enough privacy and closeness to nature, nevertheless helping to maintain a sense of community through the new communications and transportation (LeGates & Stout, 2015). The project was never realised; comparisons between Wright's vision of low-density single-unit housing development and America's land-use practices are frequently drawn (Wise, 2013).

Although both architects cultivated different scales and focused on urban planning – Le Corbusier's high-density compact city and Frank Lloyd Wright's small scale but a much broader utopia, they shared the aspiration of structured idealism of the city. The goal of both architects was to understand nature as an essential part of the living environment and the application of innovative technology opportunities. Their utopian projects that were never implemented became relevant in other urban planning realities and, therefore, considerably impacted contemporary architects.

2.1.3 Soviet-era urban planning in Estonia

Estonian architecture has been influenced by Soviet-era urban planning, which has left a marginal impression on history and is characteristic of many former suburban areas. The growth of the cities is increasingly linking former suburbs to the city centre, challenging the integration of different ideologies. An excellent urban environment has acquired a new meaning, making former visions of an ideal city obsolete

The standardisation and optimisation that characterised the architectural language of the last century were also transferred to Soviet-era urban planning. Although significant standard projects are frequently related to the prefabricated panel district construction in the 1960s, standard planning was also implemented during the Stalinist period as an ornamented massiveness. Stalin's death caused a change of power, marking the beginning of Khrushchev's "meltdown" period, which led to the distinction of current design policies and gave an impulse to implement new measures (Kalm, 2001).

The housing shortage and the growing number of immigrants required a practical solution; therefore, a new regulation was introduced in 1957 to eliminate the housing deficiency in twelve years. A solution was to build economical small apartments with the aim of creating more living units per building. Although Stalinist housing architecture with its high ceilings appeared more majestic, the shared apartment principle and scarcity of privacy were unsuitable for most inhabitants. While apartments nowadays are designed as homes to spend time with the family, cook comfortably in the kitchen, and host guests, panel housing was framed with a sociality principle of spending the majority of time outside the apartment. The new planning was represented by the principle of Existenzminimum, introduced in Germany, according to which dwellings should be as large as necessary; however, as small as possible (Väljas & Lige, 2015).

The development of the prefabricated panel housing districts got impulse by establishing Tallinn's housing construction factory in 1961, which led to the production of large prefabricated houses from the 1-464 series (Kalm, 2001). To make an observation, the aforementioned serial numbers refer to Soviet-wide building typologies applied elsewhere in the Soviet Union; hence, local architects had no authority to design the building. Therefore, the construction process was rapid, and the main task of architects was urban planning – positioning the buildings on the construction site based on insulation.

The panel districts built in Tallinn were constructed in the suburban areas, where the existing infrastructure did not have to be considered, and the buildings could be conveniently built. The location of the housings depended on the insulation and the working radius of the crane - the aim was to build as many residential units as possible as quickly, efficiently, and cheaply (Kalm, 2001).

The panel districts are based on the theory of microrayons, where 6,000 to 12,000 inhabitants are planned to live in one free-plan cluster, where all the services for everyday life are concentrated. According to this principle, the building complex includes shops, grocery stores, and one kindergarten and school building. Therefore local students can attend a school nearby and do not have to cross major roads to school. Unfortunately, this education theory did not work in practice, and the multilingual population caused the need for two schools (Bruns, 1993).

The first implementation of central prefabricated panel housing districts in Tallinn was Mustamäe, built in the 1960s under the lead of Mart Port. It stood out with the innovative idea of free planning – the placement of residential buildings was abandoning the formal structure, thus striving for harmony with the surrounding environment (Paulus, 2019). As preproduced panel elements defined the size of the room, the apartments of that time were characterised by narrow and long-living rooms, which were disproportionate compared to other rooms (Kalm, 2001). Nevertheless, the modern innovative approach appeared as a symbol of a new era that had gained recognition elsewhere in the world for decades, whereas new and unique in Estonia.

To compare the units of living space per person at that time with today's indicators, the standard of living space has increased considerably. As one element of optimisation, family structure surveys were conducted to determine which apartments are in tremendous demand. In 1940, before implementing shared apartments, the area per capita was 13,8 m² (Bruns, 1993). At the end of the 1950s, the living space per person in the apartments was about 7 m², but the goal was to increase it to 9.5 m² by 1970 (Kalm, 2001). The final regulation, issued in 1999, provides for a total living space of at least 18 m² per family member (Riigi Teataja). However, the regulation has not been updated for more than 20 years, and this value has probably increased during that time.

Figure 4: The construction of Mustamäe 5th district

Urban planning got a new meaning in Väike-Õismäe, built in the 1970s by architects Mart Port and Malle Meelak. Compared to Mustamäe, Õismäe was not divided into microrayons but represented one entire district - a macrorayon. Initially designed for up to 36 000 inhabitants, the quarter stands out with two circular streets centred on an artificial pond surrounded by greenery. Perimetrical roundabouts divert the main transit out of the quarter, ensuring a more pedestrian-friendly environment. The buildings were diversified by 16-storey tower blocks located on the inner circle, contributing to a better understanding of the urban space. Nevertheless, the rhythm of the monotonous facades created integrity but caused difficulties in navigating between the buildings. Consequently, a compact and logical structure was created, which was recognised in 1986 by the USSR State Prize (Bruns, 1993).

2.1.4 Urban development of Lasnamäe

The previous mentions are essential for understanding the primary planning and housing principles in the Soviet Union and the prerequisites of the last and biggest Soviet-era prefabricated housing districts in Tallinn – Lasnamäe. As a result of migration growth and continuing housing shortage, the construction of the largest panel district so far was started in the city's eastern area, with the concept of eleven microrayons creating an urban environment for 200 000 residents. The planning project, from 1973 by a team of architects in the lead of Mart Port, began to be constructed in 1977 with the project's perspective for 15 years (Bruns, 1993). Nevertheless, the restoration of Estonian independence and the end of the Soviet Union stopped the construction of mass-housing districts. Thus Lasnamäe remained incomplete from the original vision.

Even though the exterior of the houses had remained unchanged over time and the monotonous facades seemed to cause boredom, the master plan of Lasnamäe stands out with the previously unimplemented road network system. Geographically, Lasnamäe is located on the limestone bank, foremost to prevent noise, exhaust gases and separate the flow of traffic from the residential quarter, the fundamental idea was to deepen two main roads into limestone bank to a depth of 6,5 meters. The project provided a fast connection between a suburb and a city centre with a multi-lane freeway and high-speed tram line (Kalm, 2001).

Although, according to the standards at that time, the aim was to achieve the highest possible density to accommodate more residents on a small area, the intention was to create a pedestrian-friendly urban space by separating cars from the people. Considering the concept, the aspiration was to maintain the ground level for pedestrians. Bridges connected the zones divided by the canal near the service centres: the stairs were provided from above to the canal for public transport. Two-storey parking lots recessed into the limestone bank were provided for car parking to create a car-free residential area (Estonian Academy of Arts, 2021).

Almost all the initially planned panel houses and schools, and kindergartens were completed at a rapid pace. An amendment to the project in 1981 abandoned the further deepening of Laagna Road to simplify and reduce the project's cost. The original vision of a human-centred urban space and

Figure 5: The construction of Lasnamäe

the separation of traffic and noise remained as a blueprint. Due to restrictions, only one partially dredged speedway was realised, and no tram line was built (Bruns, 1993).

While the panel buildings of Lasnamäe were noticeable to the specifics of prefabricated panel architecture, which has already become customary by the exterior, the buildings are widely designed according to the standard of the 111-122 series. The developed solution, which emerged from previous standard projects, made it possible to plan three-room 80 m² apartments (Estonian Academy of Arts, 2021). Solutions with a larger hallway and kitchen are more convenient than the standard projects implemented in Mustamäe or Lasnamäe.

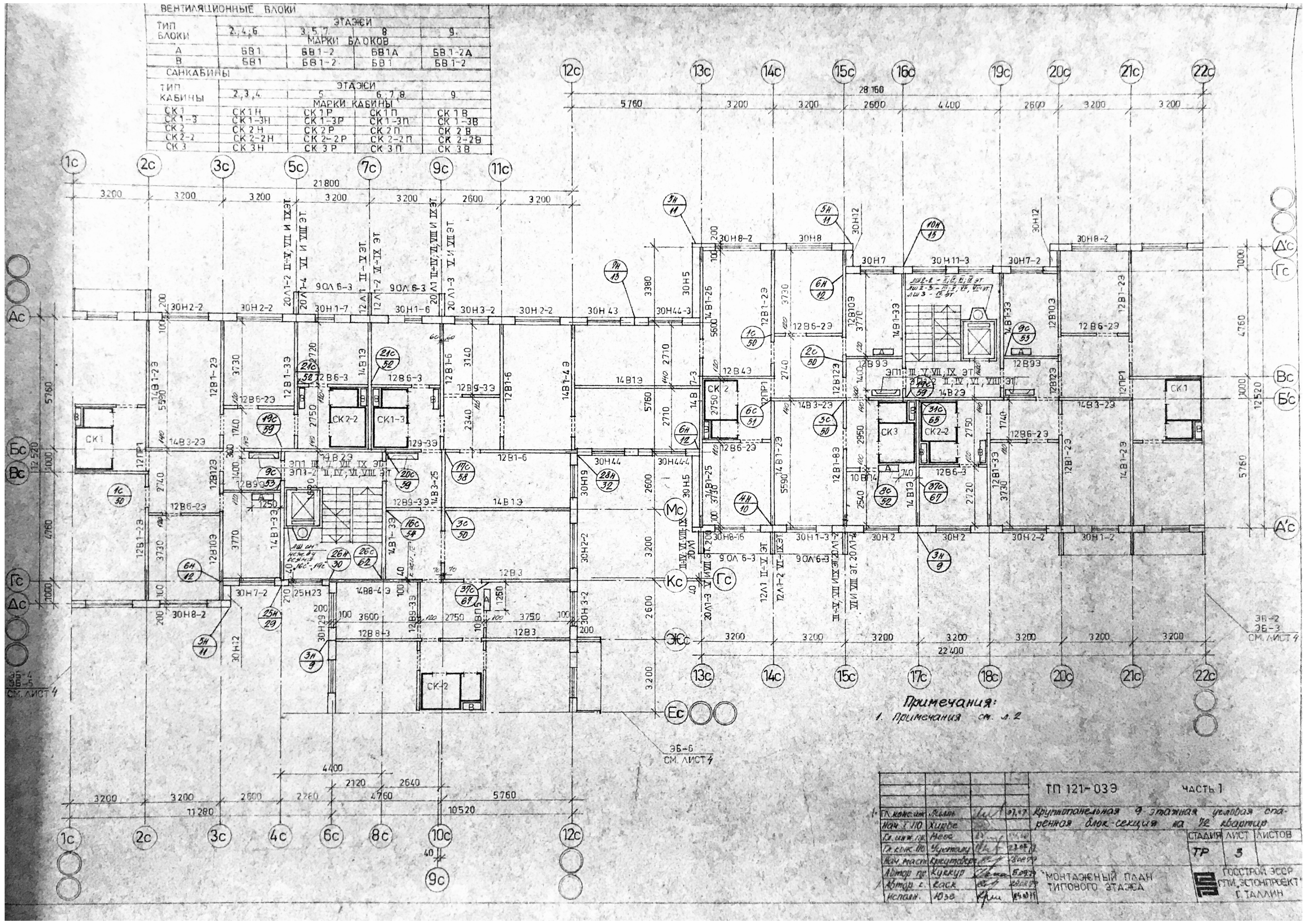

Figure 6: Standard floor plan of 9-storey prefabricated building in Lasnamäe

2.1.5 Reflections from Irina Raud

The interview was held with Irina Raud, Mart Port's team member for Lasnamäe's project, to understand the main issues and challenges. The main intention was to understand the current ideals, issues, and differences between prefabricated urban planning. The main concern of rapid construction was the unfortunate building quality. According to Irina Raud, the prefabricated panels were mainly defective; therefore, individual elements influenced the result. The idea of a green boulevard for pedestrians did not materialise due to the incorrect work by the plumbers, which prevented the regular planting of trees. Although the original project in Lasnamäe stood out in terms of previously unimplemented solutions, the cuts and lack of order affected the final solution. The intentions of human-friendly urban space were valid for the idea of the Lasnamäe project as well as for nowadays projects (Raud, 2022).

Figure 7: Laagna road. Author's illustration

2.2 CRITIQUE OF MODERNIST CITY

2.2.1 New Urbanism

In contrast to modernist urban planning, several movements and new theories emerged that departed from the idea of the city as a machine and analysed the human aspect of urban space. New Urbanism grew out in America in the 1980s by architects and urban planners who opposed the planning implemented since the end of World War II. Continued car-centric suburban planning was radically understood as a catastrophic outcome. Moreover, high levels of car use cause congestion, reduce community cohesion and create an unsafe living environment with poor urban design. Based on this criticism, New Urbanism has been built upon walking-friendly neighbourhoods where all the necessary is a 5-minute walk away; emphasis has been placed on the availability of public transport to reduce car use and the integration of buildings with different functions, including shops, workplaces and homes (Fulton, 1996).

Therefore, the New Urbanism approach calls for urban planning with narrower streets, the prioritisation of sidewalks and forgetting zoning through the diversification of the community with multi-purpose centres and public spaces. As a principal value, diversity reflects the goal of strengthening the community. In this strategy, the planning principles before the car dependency became reacknowledged. In particular, the appreciation of the low-rise as a pre-industrial over the high-rise symbolises modernism. (Grant, 2006). Low-rise areas offer open spaces with calm traffic and the opportunity to prefer walking to driving, while high-rise regions do not consider previously mentioned living qualities. Based on the comparison, the traditional suburbia principles are more adaptable to achieve New Urbanistic values (Fulton, 1996).

2.2.2 Jan Gehl

As a development of the New Urbanism movement in America, Danish architect Jan Gehl has built up his whole career on understanding the connection between urban spaces and human psychology. Modernism prioritises individual buildings and the artificial environment without public spaces and pedestrianism. However, the urban environment should first consider life, spaces, and finally, buildings (Gehl, 2010).

Gehl's urban planning principle is based on four keywords: lively, safe, sustainable and healthy cities (Gehl, 2010). Contrasting the domination of automobiles, the main emphasis is on cyclists and pedestrians to create an integrated city space. The diverse flows of people create a vital aspect to ensuring a vivid environment. Moreover, it strengthens the overall safety, which gives the confidence to spend more time in public spaces, provided that comfortable distances and access to various leisure places are ensured. Besides, all previously considered aspects significantly impact sustainable development and create a healthier place to live (Gehl, 2010).

Gehl's strategy plays an essential role in creating a pleasant common space for people. The space in which a person moves must be designed considering the average speed of the pedestrian. This allows noticing the details and value of small-scale planning. It draws a parallel between old cities before the industrial era, where cities were built on people's movement, sight, and environmental usage (TEDx Talks, 2015). Foremost, an essential difference between modernism emerges - large-scale buildings are designed to look at them from a distance and at the speed of a car.

2.2.3 Defragmentation agenda

The transport development has contributed to urban sprawl, making distances less time-consuming. Suburban residential areas are demarcated, offering monofunctionality, separating residential areas from shops and workplaces. Cars are a matter of course in everyday life, whether for driving to work or going to the grocery store. However, it is precise because of the use of means of transport, primarily cars, that carbon emissions have increased, directly impacting the environment around us (Frumkin, 2002).

Although the world is striving for more sustainable solutions, it is not easy to implement these principles in fragmented cities. However, the idea of urban defragmentation is to counter the diversification and compaction of low-density and homogeneous suburbs in the form of a compact city. A compact city aims to reduce car dependency by bringing shops and workplaces closer to home, making walking and public transport a preferable option. The reduction of car usage affects the production of greenhouse gases, which makes it possible to create a more sustainable urban space. Moreover, compact urban planning promotes higher population density, making natural rural areas more likely to remain untouched (Jenks et al., 2008).

However, an idealistic approach to compact land use and the reduction of car culture is rather theoretical. Implementing the idea could lead to overcrowding in the area or even greater transport use. The amount of carbon emissions also depends on the energy source of the transport network (Jenks et al., 2008). Although there are pros and cons to the agenda, the effectiveness of its implementation depends to a large extent on the context of the region and the ability to ensure environmentally-friendly traffic. This approach also illustrates the ideology of a diverse living environment, making regions more inclusive and navigable through functionality.

3. REVITALISATION OF SUBURBAN NEIGHBOURHOODS

3.1 RENOVATION NEEDS

Soviet-era mass construction has left a deep mark on today's housing stock and continues to be the dominant housing choice in Estonia and Tallinn's panel districts. There are 14 000 apartment buildings in the Estonian housing stock, most built in 1950-1990; thereby, 36% are large-panel buildings (Kalamees & Pihelo, n.d.). Although there is a tendency for the population to decrease in almost all counties, the population in Tallinn and Tartu has been increasing over the years (Statistikaamet, 2015). Therefore, it is crucial to ensure the maintenance of the existing housing stock and make it more sustainable through new solutions. According to the Population Register, as of the 1st of April 2022, 444 413 people live in Tallinn, of which 116 906 are the inhabitants of Lasnamäe and 65 767 people of Mustamäe (Tallinn, 2022). Although newer apartment buildings have been built in these areas, the abundance of large-panel buildings is still predominant.

Many countries have opted for demolition, replacing the prefabricated buildings of the last century with new and more energy-efficient constructions. However, this has a marginal social and financial impact, given that apartments are primarily in private ownership. Moreover, it is essential to acknowledge that demolition generates the majority of waste that is often not reused. The EU has issued a Waste Framework Directive, which states that materials should be reused instead of recycled (Huuhka et al., 2015). Based on this, it is essential to ensure the panel areas' survival and consider renovation options.

According to waste analysis 2016, the demolition waste, which is not related to waste from oil shale mining, is responsible for 42% of waste products, totalling 1,7 million tonnes. It is a combination of soil, stone, concrete, bricks, and ceramics (Statistikaamet, 2018). In order to avoid the mass generation of demolition waste and the resource costs associated with new construction, it is reasonable to ensure that the existing building is maintained and made more energy-efficient and visually enjoyable.

In 2009, in cooperation with TalTech engineers and researchers, a research report was completed on prefabricated residential buildings' technical condition and life expectancy. The need for the report arose due to the 50th anniversary of the first panel building's completion. Given the life expectancy of the buildings of 50 years, the concern was quite serious, given the large number of buildings built simultaneously. Although prefabricated panel buildings are constructed according to the standard design, use and maintenance have affected ageing. However, a pattern has emerged that characterises the main concerns that must be considered when renovating the building. The main problematic issues are the condition of the balconies and awnings, lack of ventilation, thermal bridges, quality of façade finishing, soundproofing of partitions and ceilings, and high energy consumption (Kalamees, 2010).

3.1.1 Indoor air quality and thermal comfort

The problems associated with unreconstructed apartment buildings significantly impact the everyday living environment. Planning standards have become more complex, emphasising quality of life and energy efficiency. The influence of the building's indoor and outdoor climate on the building's envelope was a factor that was not considered during the Soviet era (Ilomets, 2017). Based on this, the indoor climate of panel houses is out of date. In addition to energy-saving and thermal comfort, supplement insulation of buildings also leads to better air quality. Thermal bridges at the joints of materials and on the roof lead to the spread of moisture into the structure and the living space, which causes mould to form (Kalamees, 2010). Assessing mould can cause several health problems and respiratory illnesses.

In the case of a single unit, a change in one element affects the system's operation, either in an apartment building. Although the insulation of walls and the elimination of cold bridges are essential for extending the life of a building, other outdated systems must also be considered. The initially planned natural ventilation was due to the inflow caused by the leaking windows and partitions. The exhaust was provided in the kitchen, toilet and laundry room. Therefore, insulation of partitions and the replacement of windows eliminates the supply of fresh air to the apartments. To ensure a comfortable indoor climate and improve energy efficiency, the best solution is to create a heat recovery ventilation system where the extracted air heats the supply air. Although direct financing is more expensive, less energy is used to heat the air, ensuring a more comfortable indoor climate (Kalamees, 2010).

3.1.2 End of service life

About 60 years have passed since the first panel districts were built, which raises questions about the technical condition of the buildings. The traditional life expectancy of buildings of 50 years has exceeded the limit, but does this mean the forthcoming demolition of a large number of housing stock and replacement with new buildings? According to the researchers, the load-bearing elements are in satisfactory condition. However, the need for renovating the facades, balconies and awnings is still vital. In addition to improving the indoor climate, which affects both the building and the users, the corrosion protection of the concrete steel reinforcement, which is directly related to the durability of the building, must be taken into account. (Ilomets, 2017).

Therefore, the protection of structures with new solutions is essential, as is the assessment of the condition of structures. The climate has different effects on the facades of the building depending on the weather. For example, northern facades are 80% less likely to be damaged by wind-driven rain than southern ones (Huuhka et al., 2015).

3.1.2 Renovation wave

As part of the goal of climate neutrality, the European Commission has issued a Renovation Wave Strategy to improve the energy efficiency of existing buildings. The goal is to double the implementation of renovation and the sustainability of resources by 2030. Given the assumption that approximately 90% of the currently existing buildings will remain in 2050, it is vital to ensure that the energy performance of these buildings is improved. Although existing housing stock is responsible for 36% of greenhouse gas emissions every year, only one percent of buildings are renovated to be energy efficient. Therefore, it is mandatory to focus on renovation technologies to achieve the target of climate-neutrality by 2050 (European Commission, 2020).

The objective focuses on three main aspects: reducing the carbon emissions of heating and cooling systems, supporting the buildings in poor condition and renovating public amenities. While Renovation Wave's primary goal is to reduce carbon emissions, it plays a crucial role in making the overall living environment more enjoyable and comfortable. The global pandemic of COVID-19 led to people spending more time at home than usual and working there (European Commission, 2020). This gave an impetus to assess the indoor climate of the room to be occupied, which directly affects the well-being and health of the residents.

In cooperation with Renovation Wave, the project The New European Bauhaus has been developed to make the living environment more visually enjoyable by implementing sustainable solutions. The agenda stands for enrichment through art and culture, sustainability that creates a symbiosis between the nature and environment and inclusiveness in cooperation between different cultural spaces (European Union, n.d.). The conception of creating a more aesthetically pleasing environment through a renovation has a poetic vision that creates a belief in a better and more beautiful future. However, the assessment of beauty and design is subjective, although this project will undoubtedly highlight and encourage the implementation of reconstruction with a more innovative solution.

KredEx is the foundation created by the Ministry of Economic Affairs and Communications that issues the renovation support in Estonia, which has been created to improve the energy efficiency of residential buildings and reduce greenhouse gas emissions through new technical solutions (KredEx, n.d.). The latest strategy for renovating prefabricated buildings is a factory-based reconstruction similar to the original building principles of panel districts. Within the framework of the pilot project, apartment associations can apply for an innovative reconstruction of the building, as a result of which an additional layer of insulated facade and roof panel elements produced in the factory will be installed around the existing façade. Both windows and ventilation pipes are installed in the panels to get the advantage of the speed and better quality. The financing rate by KredEx is 50% or up to 1 000 000 euros (SA KredEx, 2021).

3.2 FROM SUBURBAN TO URBAN

Urbanisation has played an essential role in changing the city's boundaries and focal points throughout history. The increase in population and urban density will lead to the growth of urban centres and an expansion of the suburbs. According to the Tallinn Development Plan 2018-2023, the city has undergone significant changes during the last decade. In addition to the increased land use in the downtown area, the development of former industrial areas for residential and office functions has started to grow (Tallinn, 2018). It illustrates the concept of the transformation of the suburbs into cities and their growing interconnectedness.

3.2.1 Car dependecy

The end of the Soviet era led to the development of a free market and the abolition of car purchase permits, making cars easily accessible to everyone. Since then, the number of private cars has increased steadily over the last decade (Statistikaamet, 2021). Residents of Tallinn have more than 260 000 vehicles, which take up four times the area of the Tallinn Zoo. Considering the standard size of a parking space (2.6 meters by 5 meters), one vehicle takes up 13 m², making a total area requirement of 338 hectares. At the same time, the suburbanisation of Tallinn must be recognised as well, which means that even more vehicles travel to the city from the outskirts on weekdays (Niinepuu & Holts, 2022). This raises the question: is it possible to strive for a more sustainable society and a green urban space with continuing usage of cars?

In order to create a human-friendly urban space, it is necessary to allow convenient movement using public transport or a network of light traffic roads. Amsterdam's cycling culture is a prime example of how urban-dominated cycling displaces car use. Although the city initially followed the modernist urban planning movement, deviations from the idea began in the 1960s. Movements emerged that promoted a people-centred and sustainable urban space. In the 1970s, building the panel districts and highways as a symbolisation of the modern city failed due to public reluctance (Pelzar, 2010). Today, the city is covered by a great network of cycle paths. Unlike the problem of parking spaces in Tallinn, the city is challenged by the overloading of bicycle parks.

The high density of cars stands out most clearly in the panel districts created based on a modernist idea, which was not adapted to serve a large number of automobiles according to the original plan. In the courtyards, which should create a contrast between nature and the artificial technologies, the domination of cars causes nature to be relegated to the background. However, this view is not surprising considering the density of the apartments. For example, in a typical nine-storey building with four staircases in Lasnamäe, there are 144 apartments. If today's parking standards are applied, at least one parking space must be provided for each apartment. Considering the location of the buildings, where 2-3 buildings constitute an area with a closed courtyard, the courtyard should accommodate more than 400 vehicles. According to that, car parks should be set up to accommodate cars. However, given the density of the buildings and the car park's capacity,

Figure 8: Car dependency in Lasnamäe. Author's illustration

they can be set up away from the residential buildings.

In addition to the high cost of space, car ownership has been a significant challenge on unsustainability. Since 2014, greenhouse gases in the transport sector have increased every year. Electric and hydrogen-powered vehicles are being developed in this direction, but even if this improves air quality, it will not improve the problem of space quality. Moreover, the controversy is that the car is parked 95% of the time, and private cars are not even in optimal use (Arenguseire Keskus, 2021). As a result, more and more buildings and areas where vehicles can be kept are being created at the expense of the environment.

3.2.2 Urban space

The definition of good urban space is understood differently depending on the time. Former ideals have become today's concern and have lost their glory. The first goal of the Tallinn Development Strategy 2035, a friendly urban space, is to create a multifunctional urban space in harmony with nature. It is convenient for everyone to move on foot, by bicycle or public transport. The whole of Tallinn is covered by a network of cycle paths and greenery, which ensures comfortable movement close to nature throughout the city (Tallinn 2035 Development Strategy, n.d.). Based on the goal, the aim is to create a sustainable and human-friendly urban space and reduce the incentive to use cars. An abundance of apartment buildings characterises the prefabricated areas, but it lacks business and entertainment functions development. Due to the enormous shortage of apartments, living quarters were the main focus during the Soviet era. Although the master plans for the districts included the parks and entertainment facilities, they were relegated to the background and have not been implemented in their original form. To illustrate the idea, Lasnamäe has 80% of streets, sidewalks and green areas but no places to spend time outside the apartment (Estonian Academy of Arts, 2021).

3.2.3 Diversity instead of monofunctionality

Typical planning inevitably led to the uniform appearance of the panel areas, which at first seemed more uniform and boring. Spatial planning was based on the planning logic characteristic of the suburbs, where business and service functions are separated from the residential quarter. Although this is an easy-to-follow principle that characterises the original planning of the area, it forms a good soil for monofunctionality. Combining the overall look of the environment - uniform high panel walls and the unvaried urban environment, the result is a space that does not offer challenges and excitement of discovery.

In order to make monofunctional sites more attractive, they need to be integrated with enabling features. High-density areas offer space for spending time, but they are often oversized and lack human-scale implementations. Therefore, to achieve a lively environment, it is necessary to offer a diverse urban space that interacts with the user personally and offers many possibilities for discovery in various functions (Gehl, 2010). In this way, the diversity behind the panel walls is transferred to the public space, making the obscure courtyards lively and exciting.

According to the Tallinn 2035 Development Strategy, it has raised six strategic goals to achieve a lively and green city with consideration of sustainability. One of the objectives, called "Home that includes the street", considers the importance of spending time outside and integrating multi-purpose areas into residential quarters. This act will make the services more accessible and reduce transport usage. Moreover, the goal addresses the yards in Lasnamäe, Õismäe and Mustamäe, giving the promise of transforming these spaces into leisure areas (Tallinn 2035 Development Strategy, n.d.).

3.3 QUESTION OF PRESERVATION

Several different versions have been proposed for the future of panel areas. The Estonian Academy of Arts summarised the ideas proposed by the students and the visions of the city of Tallinn in the book City Unfinished: Urban Visions of Tallinn (2021). The replacement of residential premises with new and more economical buildings was considered by constructing new buildings for the residents in the vicinity of the old building. After the completion of the new building and the relocation of the residents, the old building will be demolished, where it will be possible to build a new one again (Estonian Academy of Arts, 2021).

However, according to the condition of the prefabricated buildings, it is possible to significantly improve the condition of the existing buildings and extend their life during the renovation works. A complete renovation can extend the life of apartment buildings by another 50 years, but this requires careful planning of new ventilation and technical systems and easy accessibility in the event of equipment ageing (Pihelo, 2020). Given that renovation is cheaper than constructing a new building, the aim should be to make existing buildings more energy-efficient and not demolish them prematurely. The panel districts are also historically significant areas that reflect the Soviet-era planning principles. Many generations have grown up in these districts, linked by emotional ties to the region. As many countries have already demolished a considerable amount of the panel buildings, they have erased an architectural trace from the history of their city.

3.4 CONSTRUCTION WASTE FLOWS

Although the renovation of apartment buildings is justified and necessary in cities with a growing population, there are many areas in Estonia where the population is decreasing. As a result, apartment buildings will remain empty and begin to collapse, a concern for local governments and the state. According to the assumption of Statistics Estonia, the population of Estonia will decrease by 2,7% by the year 2045, and population growth is expected in Tallinn and Tartu (Statistics Estonia, 2019). Although there are speculations about several options for uninhabited apartment buildings, including the pilot project (2019-2022) by the Ministry of Finance to explore possible solutions for empty apartment buildings, the demolition of valueless buildings is likely to be a fate (Idunurm & Kull, 2021).

Funded by the Ministry of the Environment, a summary of the future potential of the Estonian circular economy and measures (2021) was created, which draws an overview of the circular economy in the construction sector and the possibilities of recycling construction waste. As of 2019, only 0,7% of high-value construction and demolition waste was recycled. Construction waste, including plastics, glass, paperboard and a considerable number of metals are exported to other countries, which increases the ecological footprint through higher use of transit. However, concrete is crushed in Estonia and used as backfill or gravel, and wood waste is used as heating material. Although there are technologies that allow more waste to be recycled with the meaning of high quality, its implementation has so far been hampered by economic obstacles. (Idunurm & Kull, 2021).

However, there are examples in the world of how materials from demolished buildings can be successfully and prominently applied, giving them new life. The Lendager Group has developed a project in Denmark called the Resource Rows, which exploited the material potential of the demolished buildings to create a new sustainable residential quarter out of materials from abandoned buildings (Lendager, n.d.). Denmark has made a conscious move towards more sustainable and low-carbon solutions to achieve a fully circular approach in the construction sector by 2050 (Bekkering et al., 2021). Therefore, it is crucial to redefine the concept of waste, turning all materials, buildings and cities into resources that retain value (Lendager, n.d.).

The most distinctive part of The Resource Rows is the façade, which is made of brick modules from the local Carlsberg factory building and other old buildings in the immediate area. Since it has not been possible to dismantle the bricks individually since 1960 due to the strength of the cement, the brick modules were cut from the facades of the buildings and later reinforced with a steel frame. As a result, the new residential quarter got a facade with a unique design, reflecting the area’s history and the possibilities of upcycling (Lendager, n.d.). Returning to the problem of vacant apartment buildings, the previous case study is a clear example of recycling materials in demolished buildings. The same principle could be applied to Estonian new developments and reconstruction projects, reflecting the appreciation of materials and the extension of their service life.

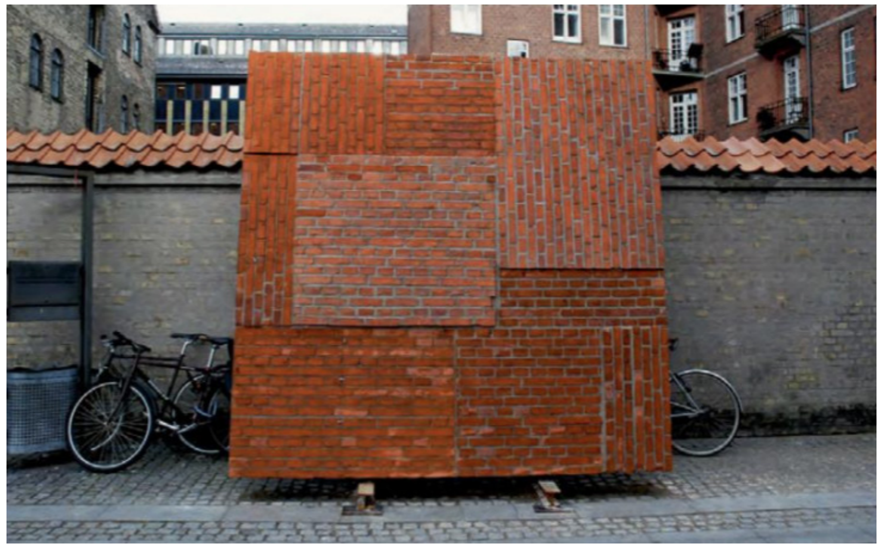

Figure 10: Brick module

Figure 9: Resource Rows by Lendager Group

Figure 11: Recycled brick modules

3.5 CASE STUDIES

Grand Parc Bordeaux (fig. 10) is the case of reconstructing 530 dwellings in three buildings by Lacaton and Vassal architects built in the early 1960s. The project's approach has been awarded the 2019 European Union Prize for Contemporary Architecture - Mies van der Rohe award. Considering Jury's opinion, the project with minimum means approached maximum effect by improving residents' quality of living situation without any demolishing and rebuilding, which is a considerable waste of energy (Archdaily, 2019).

The transformation project started when the demolition opportunity was excluded, and new, the improved design was built upon a principle that existing qualities should be maintained and missing amenities must be complemented. (Archdaily, 2019). The design process started with the inside out planning principle – the focus was on the quality of living space that led to the winter garden strategy. Considering these ideas, more space, daylight and views were improved by adding a 3.8 meters deep facade extension. A new part of the building works as a winter garden that makes every room wider and gives extra space and daylight. In addition to improved comfort of living, the energy performance of the building was elaborated as well. The extension acted as insulation for the building's façade, providing functional living space and improving the quality of existing apartments. In addition to the newly added structure, original small windows were replaced with floor-to-ceiling glass double-glazed sliding doors. To guarantee a habitable indoor climate, thermal curtains were added for extra insulation. A lightweight facade that consists of corrugated polycarbonate panels and glass in aluminium frames has reflective solar curtains for extra thermal comfort (EU Mies Award, n.d.).

In the case of the Panelak project in Slovakia (fig. 11), the panel building was revitalised with design changes and new features. At the end of the Soviet era, many people wanted to demolish the panel districts to erase history traces. However, the idea of demolition proved to be expensive and complicated, given the large number of people living in panel houses. In Bratislava alone, 130,000 people live in the panel districts (Douglass-Jaimes, 2016).

According to the original plan, the first floor of the building serviced mainly storage rooms, giving the non-existent integration to the street level. The architectural firm GutGut planned to open the first floor to the street, making the space program more versatile. The new program provided for the addition of a gym, sauna and café; the storage facilities were concentrated in a smaller area. The addition of a concrete module gave the commercial premises on the first floor of the building a terrace, marking the main entrance to the building (GutGut, 2016).

The plans for the apartments were completely revamped, offering a more diverse range of apartments. Balconies with a depth of two meters were added to the apartments to give residents a chance for more functional extra space than the typical prefabricated panel housing's small balconies. Four-bedroom penthouses were added to the roof level (GutGut, 2016).

This approach illustrates rethinking the old building that has seemingly lost its function. Given the new features that increase the value of the building, the apartment building becomes more desirable and gets a chance at a new life. However, it is much easier to realise named implementations when there are no living units on the first floor. Much more complex constructive changes should be made to revitalise the street level of prefabricated panel buildings in Estonia.

Figure 12: The reconstruction of Grand Parc Bordeaux by Lacaton & Vassal

Figure 13: Panelak 's reconstruction by GutGut

4. SUSTAINABILITY IN ARCHITECTURE

4.1 CIRCULARITY IN ARCHITECTURE

4.1.1 Definition and origin

The circular economy (CE) implementation is becoming an increasingly important aspect in architecture and urban planning, given the consumption of raw materials and CO2 emissions in the construction and demolition. Considered the world's largest consumer of raw materials, the building industry is responsible for 37% of CO2 emissions annually, of which 17% are constituted by residential buildings (United Nations Environment Programme, 2021). Due to the imminent global environmental crisis, the European Union has agreed to become climate neutral by 2050 to achieve the goal of zero greenhouse gas emissions (European Commission, n.d.).

To achieve the aim of sustainability, the European Union set 17 sustainable development goals to be pursued for the benefit of the planet in 2015. The eleventh objective, sustainable cities and communities, focuses on the challenges of rapid urbanisation. The aim is to ensure adequate, safe and affordable housing for all. The twelfth target, responsible consumption and production, address CE's importance and rethinks business and production standpoints (United Nations, 2015).

According to the Global Status Report 2018, mainly used construction materials – concrete, steel, and aluminium- account for 23% of total global emissions that are implemented in the built environment (Architecture 2030, n.d.). Therefore, the implementation of circularity in the construction industry through biobased buildings is one of the critical solutions to fight against global challenges. Moreover, it revolves around traditional construction methods and guides to shape a more sustainable future with new technologies (Bekkering et al., 2021).

Circularity in architecture stands for the consideration of creating sustainable and resource-friendly living spaces through materials with the ability to reuse or deconstruct (European Parliament, 2015). Traditional construction practices have been implementing the linear economy principle as take-make-use-dispose, which have caused negative impacts through increasing carbon emissions, pressures on landfill and extensive pollution of the ecosystem. This has led to over-consumption globally, where natural resources are currently expended twice as much as produced (Arup, 2016).

The roots of resource wastefulness consideration go back to the 18th century when economist Thomas Malthus published an essay about population principles. He discussed that continuing population growth could reduce the world's capacity to ensure adequate food for all (Lacy et al., 2015). However, the industrial era with increasing urbanism and lack of environmental-friendly waste management gave impetus to discussions and goals for becoming more environmentally sustainable. Germany is considered an initiator of CE laws with the Closed Substance Cycle Waste Management Act, published in 1994 (Berg et al., 2018). The law obliges all producers to be responsible for environmentally sound waste management (German Law Archive, 1994). Japan and China took the following acts; however, China's waste-oriented recycling consideration led the country to the first one defining CE in waste and resource policy (Berg et al., 2018).

Contrasting the linear form of economy, known as cradle to grave, William McDonough and Michael Braungart developed the concept of cradle to cradle in the 1990s. The development created the consideration of the possibility of giving products a chance at a new life. In the case of the linear model, the value of the material starts to fall from the original until it becomes unusable and goes out of circulation. However, in the case of a CE, the material does not depart from circulation. Therefore, it gets a new value in the process of upcycling, where the original value increases, or downcycling, with a loss of initial worth. The definition of waste becomes meaningless by understanding the materials and buildings as valuable resources (McDonough & Braungart, 2002).

Cradle to cradle principle distinguishes two different material cycles: biological and technical. The biological cycle directs harmless products back to the biosphere as compost. A technical cycle is meant for a product that can be decomposed and recycled for a new product (EPEA, n.d.). It is substantial to point out that the cradle to cradle principle is not just about recycling opportunities for the material but draws attention to the whole process, which starts with product design. Bad design affects all cycle processes (McDonough & Braungart, 2002).

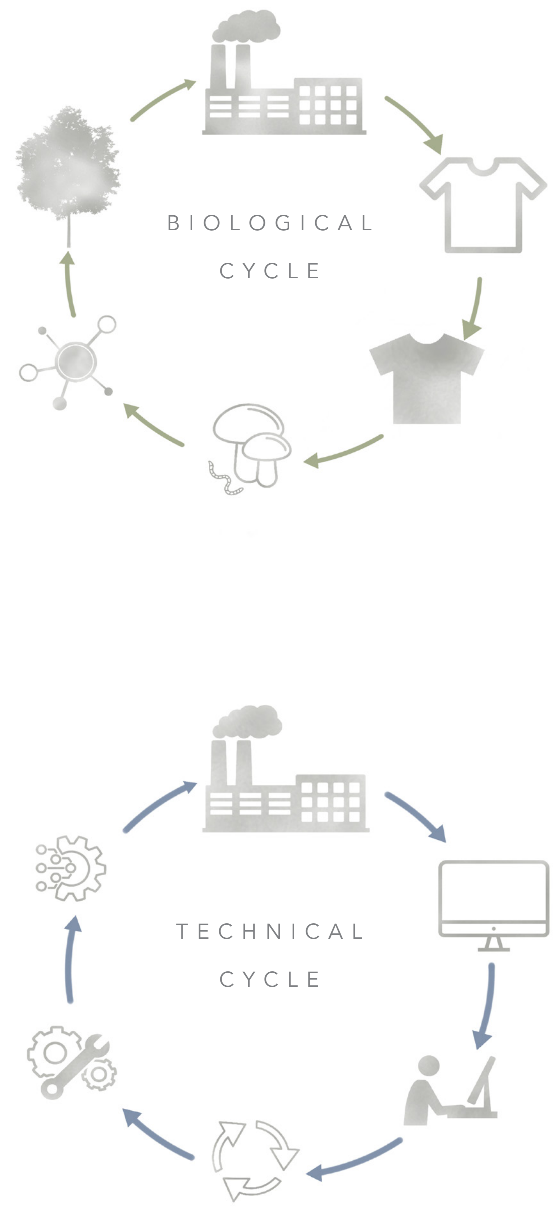

Figure 14: Author's illustration. Based on Cradle to Cradle principle

4.1.2 Early attempts of implementing circularity in architecture

Although concerns about mineral resources and the planet's capabilities have been under scrutiny for decades, which was reflected in the book The Limits to Growth by Meadows, Meadows, Randers and Behrens in 1972, which investigated population growth and its impact on raw materials stock, the European Union made an official statement to aspire towards climate neutrality in 2015 (Bekkering et al., 2021). While a more sustainable approach to projects has been addressed to some extent in the past, the awareness that has risen over the last decade has been most clearly reflected in architectural projects and thus in media coverage to show steps towards a more sustainable society.

Figure 15: Brummen Town Hall by Thomas Rau

Figure 16: Circular House by Arup

BRUMMEN TOWN HALL

Brummen Town Hall in the Netherlands (fig. 13), which opened in 2013, is one of the first projects designed to be demolished 20 years after construction. A new part of the building is built over the historic structure from the 19th century that was previously restored. Considering the changing boundaries of the district, the function as a town hall could lose its necessity. Therefore, the architect Thomas Rau developed a construction that could be decomposed and reused after 20 years. It illustrates a closed-loop system, where the product will be reused after it has lost its first purpose. The project used mainly materials, such as qualified timer elements that can be more possibly reused in subsequent projects. Concrete was avoided due to the difficulty of recycling (Ellen MacArthur Foundation, n.d.).

The frame of the building was constructed to dismantle it in the future quickly. Even if the materials have retained their quality during usage, the complex initial structure reduces the potential for further use. Brummen Town Hall's whole structure was mapped with the world's first material passport that stores information about the building's materials, products and components. Therefore, it provides a complete overview of the materials used in the building and facilitates their further use after dismantling (Ellen MacArthur Foundation, n.d.).

As an example of Brummen Town Hall, the building is already constructed with knowledge of future demolition. Although one of the principles of the CE is the operational planning, which allows for the most flexible long-term use possible for different functions, the approach to the project through material passport gives even more flexibility. Premises built for the current purpose do not have to be adaptable for other functions. However, the materials from which the environment is formed take on a new meaning

CIRCULAR BUILDING

Arup Group developed a prototype of a Circular Building for the 2016 London Design Festival to test CE in a built environment. The design concept was based on Stewart Brand's 6S model: it categorises site, structure, skin, services, space plan, and the stuff of the building under different usage time frames per unit (Rahla et al., 2021). According to the definition, the project's site is eternal – buildings can disappear or change, whereas the site stays still. Therefore, the prototype was built on the site for a month and then reconstructed. This project's aim supports the previous case study on applying a material passport and its use in a temporary facility.

As a building's structure, reclaimed steel was used with the possibility of returning it into the loop after deconstruction. Building's skin, the façade, was made of softwood with high durability to endure diverse use cycles. As part of services, a ventilation grid was put together using a 3D printer with recycled plastic. Therefore, it ensures convenient replacement of the parts if it is needed. The articulation of the space was created imaginatively to provide an opportunity for flexible use of space and rethinking. All used interior elements, the stuff, were based on the cradle-to-cradle principle – it was already used with an excellent opportunity to reuse or reproduce. Moreover, all used elements were mapped with a QR code that stored all the information of current usage and future uses to overview all the materials' lifecycles (Smith, 2016).

Figure 17: Stewart Brand's 6S model.
Author's illustration based on model

LIANDER OFFICES

Liander Offices, known as the headquarters of the energy grid company based in Duiven, the Netherlands, stands out as an energy-positive building. The building is the first renovation project in the Netherlands to receive a BREEAM-NL sustainability certificate (Ellen MacArthur Foundation, 2016). The redevelopment project, completed in 2015, involved merging several existing building volumes under one roof, thus making the area between the volumes an open public space. The distinguishing element of the common area is green-walls and greenhouses (Office Snapshots, 2015). Although more than 80% of the building uses recycled materials, it is characterised by energy production, producing more energy than the building itself consumes. Productivity is ensured by the heat storage of solar panels and an underground water tank (Rahla et al., 2021).

The new internal design of the building reflects the previous original structure in the form of recycled materials, which is constructed with the principle of reusing it in the future. For example, old wooden details were used in the interior of the building to avoid using new materials and thus provide a new way to recycle waste. The structure of the central part of the building, the connecting roof, was created on the principle of modules, making both the installation and the future deconstruction more convenient. The steel-modular construction material comes from the roller-coaster company, creating a completely circular steel roof by saving 30% steel compared to conventional construction (Ellen MacArthur Foundation, 2016).

This project is a good illustration of the ability to use materials using roller coaster constructions, which were given a completely new purpose through the Liander Offices project. Moreover, it leads to the consideration of what resources can be reused by redefining them in the form of a new function.

As previously addressed projects showed, the sustainability in architecture stands on three main optimisation principles – fewer materials take less energy; therefore, the production of CO_2 is smaller (Ellen MacArthur Foundation, 2016). Architecture is seen as the material depot, an intermediate stop before the next chapter of use, not an application for the latter purpose. Therefore, it is vital to have an overview of all used components for their current condition and planning for future implementation.

Material passport is the common keyword considering the circularity projects confirmed by its application in previously named projects. It is a characterisation tool that gives an identity to each material through the database, where all the products are findable by the keywords. This approach helps to improve recycling with more possible ways of upcycling rather than downcycling. Moreover, the building's dismantling becomes much easier in the future, giving the availability to use the mapped materials for a new purpose (Bekkering et al., 2021). Given the ever-evolving age of technology, this is undoubtedly a new challenge for cooperation between the architectural and information technology sectors.

Figure 18: Liander Offices by Fokkema and Partners

4.1.3 Circularity in contemporary architecture

According to an increasing contribution to preventing an environmental crisis, the European Commission released 2020 a guide of Circular Economy – Principles for Building Design to achieve climate-neutral goals and develop sustainable designs. This document summarises the main keywords to be considered for construction and reconstruction. Durability as a first concern needs to pay attention to building and elemental service life planning with a focus on the design life of fundamental building elements. In addition, this aspect considers the elements' maintenance and replacement cycles as a part of CE. The second, adaptability, focuses on providing a cost-effective and convenient means of possible replacement and repair of the elements. The third aspect is a waste reduction with a high potential for reuse (European Commission, 2020).

While previously implemented projects were mainly building-based, the CE is increasingly linked to the overall urban planning level. Although the construction sector is responsible for a large share of CO2 emissions, it is also essential to consider building users' needs and consumption patterns. Moreover, it is essential to note that the growing population also needs more food to consume, leading to a high cost for the food industry and food waste to the environment. According to the EU, the world's food production demand will double by 2050 (European Union, n.d.). Therefore, it is vital to create a harmony between circular architecture and urban space that offers food growing opportunities.

TAISUGAR VILLAGE

Taisugar Circular Village in Taiwan by Bio-architecture Formosana, completed in 2021, represents the residential project combined with the elements of CE in the living environment. The means of circularity has expanded from a building-based solution to the surrounding environment, with a strong emphasis on the possibility of growing food. The government initiated a plan to develop an intelligent ecosystem urban space that works in harmony with nature and considers residents' communities through a green life system. The village is built upon a principle of three "Circular Blocks" with mainly studio apartments, 429 rental units. The other buildings serve the functions as a living room of the village, called C-House; the kitchen, named E-House; and a garden for food production, called a C-Farm (Taisugar circular, n.d.). A diverse living environment offers a possibility of producing the food locally, creating an extra function to the traditional residential area.

Although the complex of buildings stands out in terms of the possibility of growing food, the construction of the buildings has taken into account sustainable building materials and energy production. For example, the structure of an E-house is constructed with hardwood from the old local buildings and railway tracks were found for new use as a fence for the peripheral area. New materials were picked out considering the reduction of carbon emissions; therefore, the CLT and recycled LED glass insulation to ensure thermal comfort. Steel was used instead of concrete to give construction material the possibility for further life cycles, given its ease of disassembly and the plethora of possible future features (Taisugar circular, n.d.).

Even though the project's location differs from the Scandinavian weather conditions, it illustrates the combination of circularity based on architecture and food production. A sustainable living environment is not only defined in terms of architecture and building materials; it also combines a lifestyle and daily habits. Therefore, a similar concept can be applied almost anywhere.

Figure 19: Taisugar Village by Bio-architecure Formosana

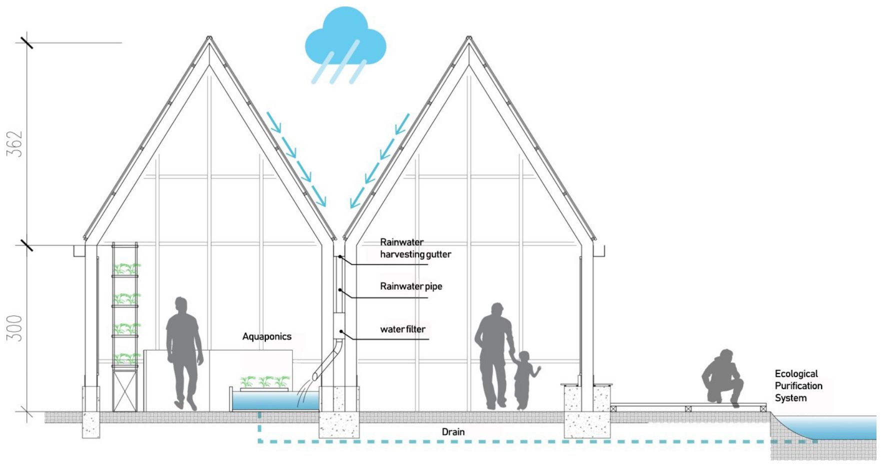

Figure 20: Circularity principles of the quarter

SCHOONSCHIP RESIDENTIAL

Schoonschip residential development stands out as a sustainable floating living quarter in Amsterdam, offering 144 inhabitants a self-sufficient living environment. The project's master plan by Space & Matter has been underway for over a decade since 2008 and got finalised in 2021. The residential area is given a variety of dwellings designed by different offices that follow the master plan's overall framework and design principles. The revitalised site used to serve industrial activity before the sustainable transformation. Today, it consists of 45 housing platforms connected with a jetty; each unit is considered sustainable for energy production and waste management (The most sustainable, n.d.).

The circular community's primary goal is to achieve the local loop closure and have the least possible impact on the environment, particularly on the canal. To accomplish the idea of circularity, the area combines local energy production with solar panels and heat pump systems, the operation of an indoor climate network and the extraction of energy and nutrients from wastewater (The most sustainable, n.d.). A private smart-grid energy system provides supply and demand optimisation locally with the help of intelligent technology software. Therefore, it helps the community be as self-sufficient as possible using sustainable energy resources (Smart-grid, n.d.).

Figure 21: Schoonschip Amsterdam by Space & Matter

According to the project's location, monitoring and systematising water consumption are mandatory to minimise its environmental impact. Hence, the community considers different ways to reuse, clean or collect the water. For instance, rainwater is collected for watering the plants and flushing systems in toilets; showers have a recirculation system that starts to pump the water in a closed hygienic system after long-term use of water. Wastewater is divided into separated systems called grey and black water, whereas black water goes through the distillation processor that transforms the products into biogas. It can be used to produce both electricity and its by-product fertiliser (Solutions, n.d.).

Many wooden materials have been used in the construction of the buildings; thereby, the frames of the houses are made of timber. Bio-composite materials, such as wood fibre, were used to provide thermal insulation. This project is well illustrated because it is not always possible to create a living environment with fully sustainable materials. For example, due to the location, it is unavoidable to use other than concrete as the foundation of the plot. However, recycled concrete was used as much as possible (Method, n.d.).

The project's integrity is reflected in many aspects that are possible as a result of a long work process. Developed over a decade, the project involved a large team, including future residents. It, therefore, took into account many activities related to everyday life to make them as environmentally friendly as possible. Compared to the previously discussed case studies, the Schoonschip project reflects a comprehensive outcome that focuses on smart solutions for the future operation of the community.

REGEN VILLAGES

The possibilities of applying technology to create a sustainable and circular living environment are increasingly interconnected. The conceptual project of ReGen Villages in Sweden is a cooperation project of a future residential area by White Arkitekter and Silicon Valley-based ReGen Villages that combines high-technology knowledge and resilient circular community principles. All neighbourhood systems are controlled by artificial intelligence and the operating system, bringing computer game ideas into reality through the connection between nature and technology (White Arkitekter, 2020). Given the details of the project, it needs both financial funding and significant IT development before it can be realised. Therefore, the project that was announced in 2020 has not had any realisations yet.

The project aims to integrate 250-300 housings with energy production, waste management and the idea of food production in the area size of 250 000 square metres. A circular community would be built on a principle to answer all the Global Goals for Sustainable Development challenges. It considers ecological food production, sustainable energy development and storage, recycling of water and waste and energy-positive homes. All the elements would be managed by artificial intelligence, similar to smart-home systems,

Figure 22: ReGen Villages in Sweden by White Arkitekter

which consider the local climate and conditions and make the necessary adjustments. Food production creates a closed-loop system that integrates vertical farming and aquaponics, while solar panels and biogas produced from local waste are responsible for energy production (White Arkitekter, 2020).

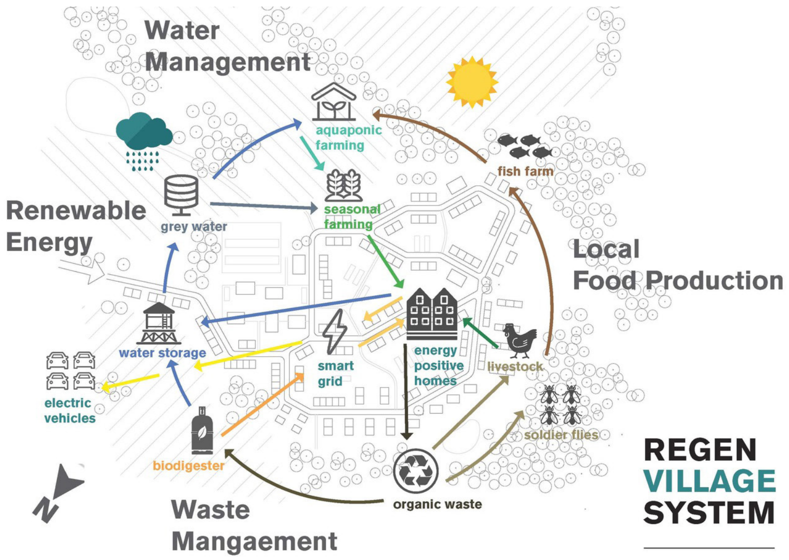

Figure 23: Scheme of circular village based on ReGen

4.1.4 Future prospects

Given the previously discussed case studies and the goals set by large corporations, the future is moving towards an increasingly sustainable and resource-efficient society. The circular economy is essential in reducing waste and developing more innovative solutions. Projects involving residential areas and communities are increasingly being worked on. Although the building-based circular economy is essential, it is even more vital to expand it to more significant regions and quarters; therefore, carefully thought-out solutions have a more visible effect on society.

4.2 BIODIVERSITY IN ARCHITECTURE

4.2.1 Definition and importance

Global warming and the number of greenhouse gases have significantly impacted the planet's species richness and nature conservation. Cities are expanding at the expense of the surrounding natural environment, making the environment more artificial and creating an established natural balance. The European Union and the United Nations have developed several different agendas, such as the European Green Deal (2019) and the Sustainable Development Goals (2015), focusing on preserving natural resources and becoming climate neutral. As the construction sector has been responsible for many CO_2 emissions, it is vital to integrate biodiversity into architecture and the urban environment.

Biodiversity stands for a variety of species that are living on Earth. It brings together all wildlife parts, such as plants, animals, bacteria, fungi and humans (National Geographic, n.d.). Therefore, biodiversity in urbanism is the intertwining of nature and artificial environments. By the year 2050, 68% of the population will live in urban areas, leading to the loss of natural species (United Nations, 2018). However, recent research has shown that cities allow for the development of species richness. For example, some plant and animal species are more productive in urban areas and have larger populations than in rural areas (Spotswood et al., 2021). In addition to preserving species richness, biodiversity brings more life to urban space and brings the artificial environment into harmony with nature, giving back the environment attributed by humans.

One of the sub-objectives of the European Green Deal, issued by the European Commission, is the Biodiversity Strategy for 2030, which aims to protect nature and species diversity more widely. The goal focuses on reducing the spread of forest fires, the effects of climate change, food availability, and controlling the spread of communicable diseases. In order to achieve the set goals, the network of nature reserves will be expanded, and a restoration program will be conducted to re-establish areas with degraded ecosystems into sustainable environments (European Commission, 2020).

4.2.2 Green facades and vertical farming

Although green spaces and parks play an essential role in ensuring biodiversity, the problem of declining green spaces is emerging in ever-expanding cities. The natural green areas are exchanged for concrete districts, which store a large amount of heat energy, thus transforming into urban heat islands (Cuce, 2016). The problem of heat islands is also an increasingly common phenomenon in Estonia, especially in high-density residential quarters. Surfaces without high landscaping absorb and then radiate heat, causing overheating problems. Overheating is most common in prefabricated residential areas in Tallinn, especially in Lasnamäe around Laagna Road (Oidermaa, 2021). However, big cities increasingly integrate nature into architecture and biodiversity with facades through green walls.

Green walls that can be implemented with climbing plants or a double-skin system create considerable benefits to the building's thermal envelope and increase local biodiversity. As a green infrastructure, it impacts a building's internal temperature reduction, energy consumption and surrounding perceptible temperature, preventing the surfaces of the building from overheating. The most common typologies are implemented directly on a façade or by creating a double skin with a support structure. A more complex system, a living wall, requires pre-grown plants in special modules attached to the façade. Although this solution is visually compelling, it requires much financing compared to the traditional approach with climbing plants. However, considering the façade temperature reduction, the living wall system is the most effective one, creating an approximately 5-degree difference compared to the bare wall, whereas direct and indirect reduced 1,2 and 2,7 degrees (Cuce, 2016).

The growing world population raises the question of food production. Urban sprawl is increasingly taking up potential rural land, leading to the problem of food production due to the loss of arable land. In order to reduce the global footprint, transport costs, including food supply, must also be minimised. Linking agriculture to the urban environment would significantly reduce transport costs and contribute to the diversification of urban space. Moreover, it makes more functional surfaces that are not used with total capacity before, such as roof surfaces (Thomaier et al., 2014).

Vertical farming is a greenhouse built height, taking up significantly less space than traditional rural farming. In general, vertical farming is divided between the categories of horizontal shelf-based growing platforms and crops growing on a vertical surface. For convenient plant growth, irrigation systems are generally installed, which provide the necessary amount of water and nutrients for the crops. Units with controlled conditions for growing plants require higher energy consumption. For example, glasshouses use less energy to provide sufficient light for plants than enclosed spaces, where the need for light must be met through LED panels. Although integrated vertical agriculture takes up much less space than a traditional approach, urban areas are expensive due to high demand. To solve this, it should be integrated into existing buildings, ensuring the economy of the solution (Beacham et al., 2019).

GREENBELLY

GreenBelly is an urban gardening approach that implements blind walls to create vertical crop-growing surfaces. The system is built up considering sustainable solutions, gathering the rainwater to ensure adequate watering and local organic waste for compost. The greenhouse construction is based on a modular system that is easy to install and adapt to the project's site. Residues of material, such as wood and scaffolding, have been used as modules. In addition to local food production and the enrichment of the local people's table, the modular system also acts as a sound barrier. It protects the façade from overheating, making it an additional functional layer to improve the building's technical performance (GreenBelly, n.d.).

As this project involves the creation of new functions and responsibilities, it raises the question of greenhouse management. The proposal has discovered many different ways of managing the system. Firstly, it could be managed by local people, who are in charge of selling and keeping everything in order. At the same time, the modules can fulfil the purpose of the rental space, allowing residents to grow their garden products. The project also highlighted the cultivation of products for educational purposes, helping the homeless, and belonging to a private company engaged in the food trade (GreenBelly, n.d.).

Given the typology of panel districts, where each building has at least two blind walls, a similar principle could be applied to diversify areas. It would also allow apartment dwellers to engage in organic farming, which many residents would like to do. Although these systems are not yet widespread, this is undoubtedly one of the likely outcomes for the future agricultural sector.

Figure 24: Greenbelly vertical greenhouse

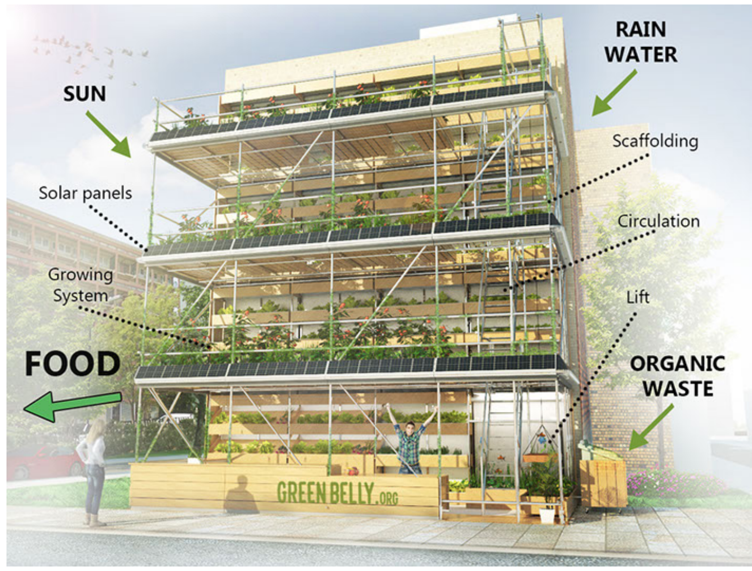

Figure 25: The scheme of vertical greenhouse

5. SUMMARY

Typologies of modern urban planning found an application in many Soviet-era residential areas in the form of standardised panel houses. The neighbourhood that once was a symbol of innovation, in today's context, an obsolete suburbia that needs immediate intervention in terms of energy efficiency and more liveable urban space. This master's thesis investigated the transformation of an Soviet-era residential quarter into a circular block utilizing only environmentally friendly and recyclable materials.

Applying standardisation in building construction helped building new residential quarters at an unprecedented speed. Large, prefabricated panel buildings defined an innovative approach to constructing residential areas. Single-family apartments were an unattainable dream for many, which were issued under special conditions. A modern home was where everything necessary for everyday activities was available, but it favoured a social lifestyle, spending free time outside the home. However, many planned ideals were not realised due to economics, so the quarters became monotonous sleeping areas. There was no well-thought-out functional social urban space. Le Corbusier's ideal of the 1930s had turned into a cold monofunctional production-centric solution, an opposite of the concept of a human-friendly urban space as we understand it today.

Lasnamäe was the most significant area built in Tallinn at the end of the Soviet era. Le Corbusier's planning typologies were most clearly materialized here, deliberately separating high-speed transport from residential quarters. Considering the rapid growth of car use in this century, the dominance of cars prevails both in Lasnamäe and in other panel districts, which defines the surrounding space as a monotonous parking area.

The share of prefabricated houses in the Tallinn housing stock is quite significant, which leads to the consideration of renovation. The necessity of the topic became apparent 50 years after the first large-panel buildings were erected. It has been established that the effective renovation of thermal envelope prevents moisture from entering the load-bearing structure and therefore prolongs the life expectancy of buildings. In addition to the solutions of outdated building envelope structures, the quality of the indoor climate in non-reconstructed apartments is deficient, which was not considered during the design. In addition to the surrounding environment, it also affects the residents' quality of life and comfort. The topicality of the renovation is made critical by the goal set by the European Union to achieve climate neutrality by 2050. Therefore, a large part of the housing stock built in the last century needs renovation.

The expansion of cities will inevitably turn former suburbs into parts of the city, making residential areas more multifunctional. The construction of new residential areas aims at creating a diverse urban space where residents can feel safe. Therefore, it is essential to integrate new solutions into previously created residential areas, thus making the city a more cohesive whole. Considering the large share of panel districts in the cityscape of Tallinn, it is crucial to diversify the monofunctional environment there and create better coherence with the rest of the urban environment.

Although there have been speculations about the fate of the panel districts, including the gradual demolition of buildings and the replacement of new energy-efficient buildings, the potential of the existing housing stock to be renovated must be borne in mind. Demolishing an old and building a new one is many times more expensive than improving the construction conditions of the old building. Modern ventilation and insulation options for structures extend the service life of structures for many years. Renovation of panel buildings also challenges for developing new technologies and sustainable opportunities.

The decreasing population of the counties directly affects the existing housing stock, which is depleting as a result. The emptying of apartment buildings is likely to lead to their demolition, directly affecting the management of demolition waste. Based on the report commissioned by the Ministry of the Environment, it appears that so far, the financial aspect has hindered the larger-scale recycling of waste generated by the construction sector in Estonia. As of 2019, only 0.7% of construction waste was recycled. Although the demolition of old buildings may be inevitable, ,the resulting waste can be minimized by finding a new use.

Accordingly, implementing the circular economy in the construction sector is extremely important. The European Commission's guide in 2020 considers the principles of circular economy that must be implemented in the buildings. In addition to the aspects of sustainability and reusability of constructive components, attention must be paid to the consumption habits of the population. Therefore, organic farming plays an essential role in many circular economic solutions, allowing residents to grow their food. Linking food production to the urban environment diversifies the area, reduces transit costs and makes maximum use of courtyards, roofs and facades.

Although the approach to the circular economy is a crucial issue today, it is an evolving and opportunity-seeking field. Sustainability and the circular economy are increasingly being applied to new housing estates. Many of them are in the development phase and, therefore, in the conceptual design phase, but there are few examples of the revitalisation of existing areas given these principles. Therefore, during the development of this project solution, a symbiosis had to be created of the renovation of prefabricated houses and the principles of circular residential areas to revitalise a monofunctional living environment.

Figure 26: View to Varraku and Virbi street corner. Author's illustration

PROJECT'S PROPOSAL

6. PROJECT'S LOCATION

The project is located in Lasnamäe district, which is the largest prefabricated panel district in Tallinn built in 1980s. Laagna district was the first district in this area, built in 1979-1982. The characteristics of the location is the 50 meters wide Laagna Road that divides area into two. It is the inner-city highway that provides a fast connection between city center and suburban areas.

The selection of the location was initially proposed by Tallinn Architecture Biennale 2022 vision contest's circumstances. The location is selected randomly considering the repetitive typology of standard planning principles and the potential of the current courtyards. However, the design proposals can be applicable in similar locations.

Chosen area is near Varraku and Virbi streets. Arbu street is a inner-quarter street that serves the connection to the building's entrances. Laagna Road is approximately 6 meters lower than the residential quarter, providing a distance from traffic noises.
.

Figure 27: Situation scheme. Author's illustration

6.1 Surrounding environment

All the buildings in considered area are 9-storey high. It causes a high-density that is visible by the amount of cars in the courtyards. The courtyards are quite spacious, however the dominance of cars are giving the artificial environment feeling, although the existing greenery has grown quite large over the years. There are only few places to spend time outside, all the diversity is gathered inside the buildings. Outdoor seems dull and monofunctional, serving the parking area for cars without any consideration of local residents.

The facades of the buildings are renovated approximately a decade ago with a very modest and traditional looking. From the distance, it seems that all the buildings do look the same.

6.2 Concerns of current situation

One of the main issues is car domination in the courtyards which makes the public space expressionless and uniform. Strictly defined car and pedestrian streets are making a barrier and do not give the idea of home yard. This problem could be resolved with bigger parking house near the residential area, underground parking lot in the courtyard or more scattered parking sports over all the area with no strictly defined ground, combined with greenery, shelters with solar panels and small scale implementations. However, the idea of underground parking lot does not support the principles of preserving the existing environment and sustainability.

Current courtyards have only 3 main aspects – car domination, green areas and a few playgrounds. The second concern is a lack of public space amenities, areas to spend some time and get fresh air. Considering the Figure 25, the problem of lacking public spaces is obvious. It is a self-made, spontaneous use of space with old chairs. Place under a balcony creates a shelter that shields the extra sunlight or a rainfall.

Figure 28: Typical existing seating area.
Author's photo

Figure 29: Self-made seating spots.
Author's photo

Figure 30: Lack of enjoyable public space.
Author's photo

Figure 31: Typical facade of prefabricated housings in Lasnamäe.
Author's photo

Figure 32: Street corner of Varraku and Virbi.
Author's photo

To understand the density and amount of housing units in this area, I've made a quick calculation according to the plans of the buildings. There are 36 apartments per one entrance, which means the total for 5 buildings is 756 apartments. According to that, it is quite difficult to follow the contemporary parking norms in this area. However, there is no law to do that in existing residential areas; therefore, the goal for this approach is to preserve the existing parking spots with more scattered principle. That allows the new interventions with pavilions, shops, offices and other amenities.

Figure 33: Main car roads.
Author's illustration

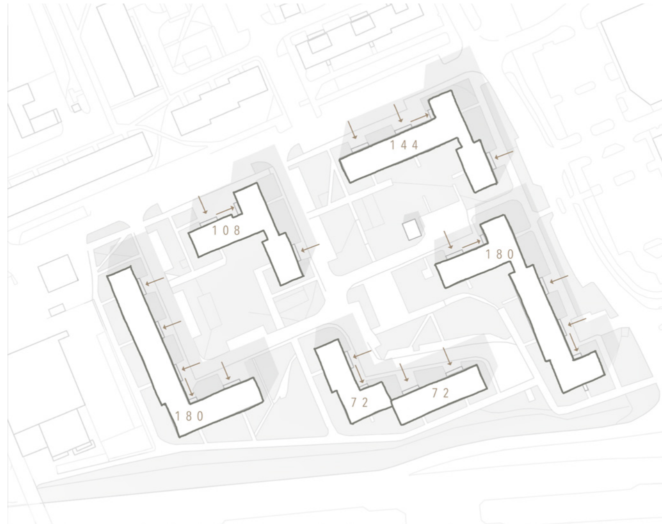

Figure 34: 756 apartments per 5 housings.
Author's illustration

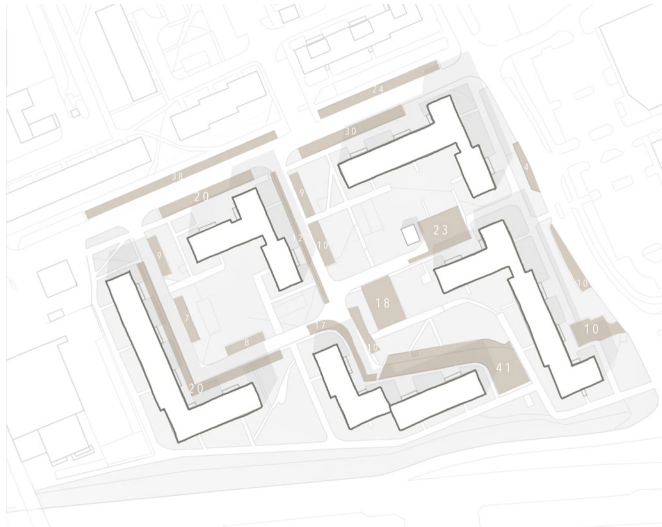

Figure 35: 340 parking spots per 5 housings.
Author's illustration

7. DESIGN PROPOSAL PRINCIPLES

The development of the approach takes into account all lacking aspects in courtyards with mixing them together with small scale buildings. The aim is to create more scattered parking spots near the buildings considering the fact that cars can't disappear over the night. It is a space between buildings that puts car dependency on the background and gives the opportunity for the locals to feel free without any certain boundaries. Intentional common path for cars and pedestrians is provided as a opportunity to feel free without any certain boundaries.

For existing building intervention, the goal is to bring the nature diversity to the plain walls to create the connection between prefabricated panel buildings and new more diverse environment. The circularity principles are considered with the materials, such as timber, recycled brick modules, green facades and gabion walls.

This intervention connects the considerations of circualrity principles, as well as enjoyable urban space. The combination provides sustainable yet more interesting urban space.

Figure 36: Existing facades.
Author's illustration

Figure 37: New implementations.
Author's illustration

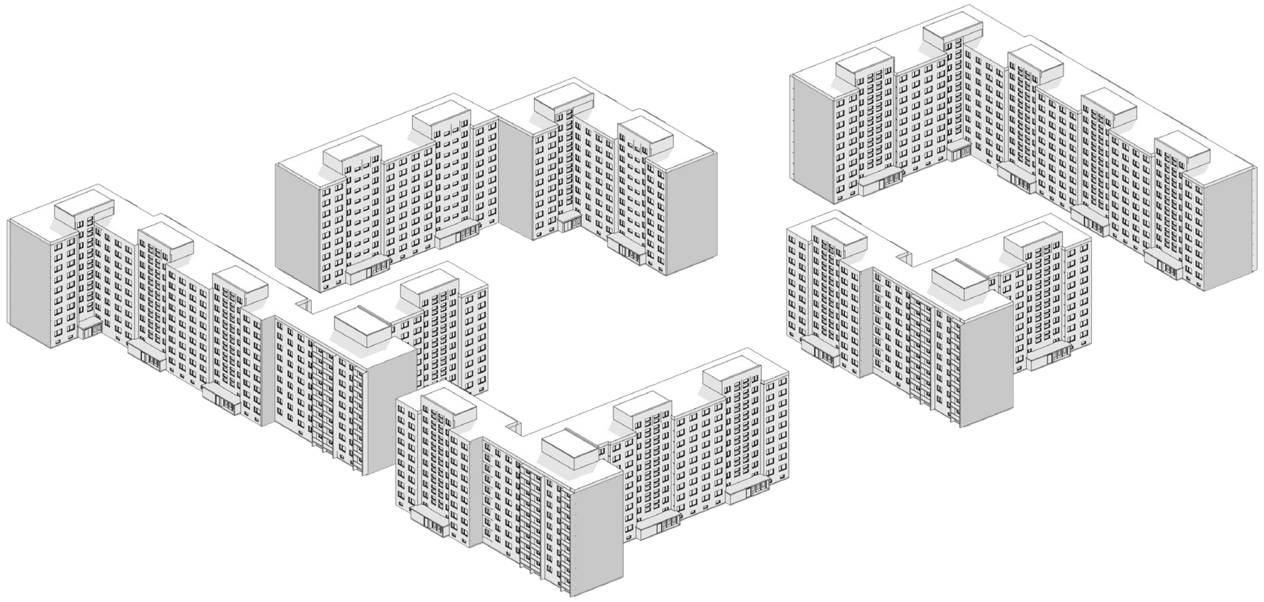

Figure 38: Monofunctional urban space.
Author's illustration

Figure 39: New exciting diverse urban space.
Author's illustration

Figure 40: View to the street facades from Varraku street. Author's illustration

8. SITE PLAN

Figure 41: Site plan.
Author's illustration

Figure 42: New diverse courtyard. Author's illustration

9. BUILDING'S INTERVENTIONS

9.1 First floor implementations

To create multifunctional space with new amenities , the new interventions affected the building's ground floors. New interventions are serving the idea of commercial premises and more noticeable entrances. Some of the first floor's apartments got a private yard, that is provided by the elevation of the ground with landfill. Considering the overall bad conditions of the panel housing's balconies, new timber balconies are planned as well.

The aim of the building's interventions is to provide more interesting living space with improved thermal envelope. The existing apartment plans are not took into consideration to change, considering that the apartments of Lasnamäe are having the better design than the previous prefabricated apartment buildings.

However, some of the existing apartments got affected by the new interventions. Therefore, to not lose any of the existing apartments, the new ones are proposed to the rooftop level.

Considering the same planning typology, the interventions are shown based on one building. Same typologies can be implemented in the other buildings in this area as well.

Figure 43: Similar typology locations in the quarter. Author's illustration

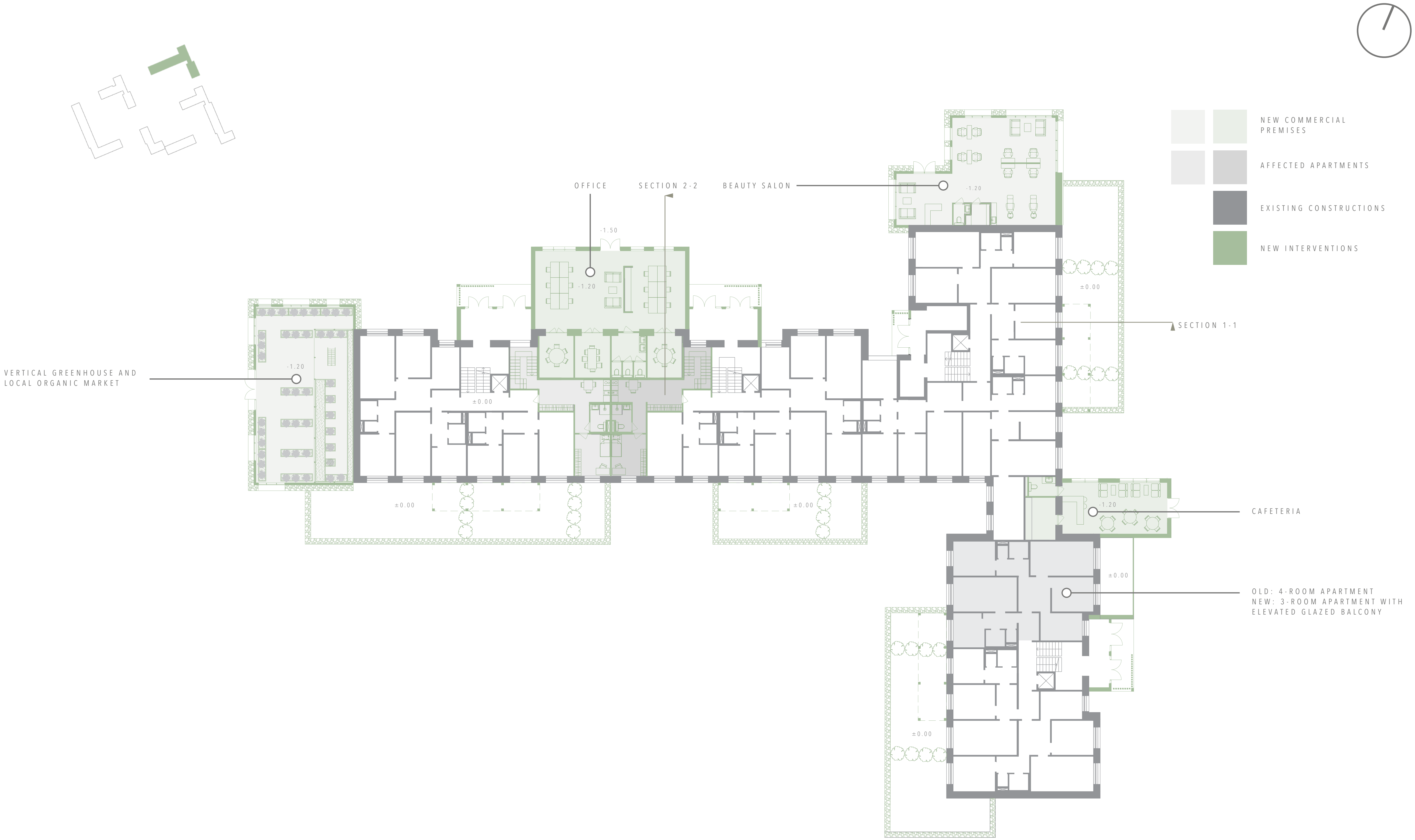

Figure 44: First floor's interventions. Author's illustration

9.1.1 Detail sections

Figure 45: Section 1-1. Author's illustration

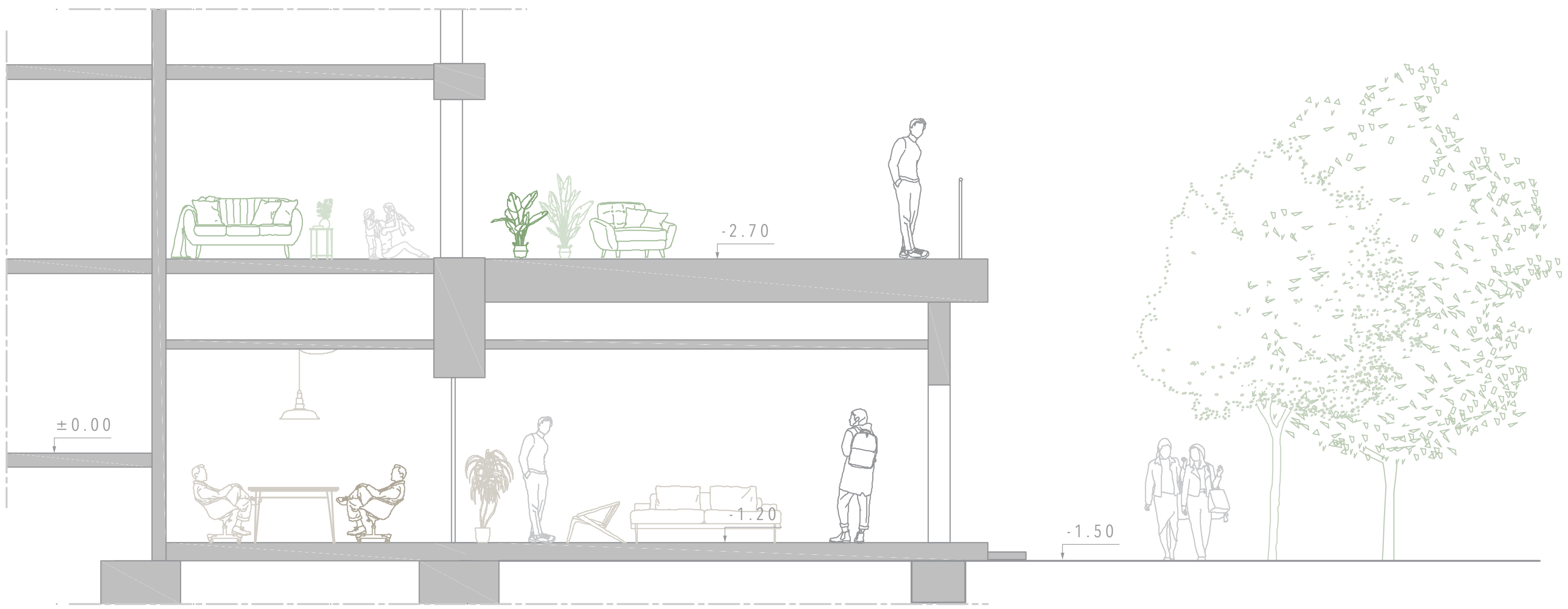

Figure 46: Section 2-2. Author's illustration

Figure 47: View to the courtyard from the balcony. Author's illustration

9.2 Rooftop implementations

The aim of the rooftop apartments is to provide more diversity in aparment-level as well as in the surrounding environment. Some of them are designed to compensate the loss or change of first floor's apartments. The apartment plans are considering the existing canalisation shaft, therefore some of the apartments are not following the traditional aparment logic. However, the idea was to provide something different from the existing apartments on a plan level.

The surrounding area is used as a rooftop garden, where to spend time more privately or to have a own planting box.

Figure 48: Similar typology locations in the quarter. Author's illustration

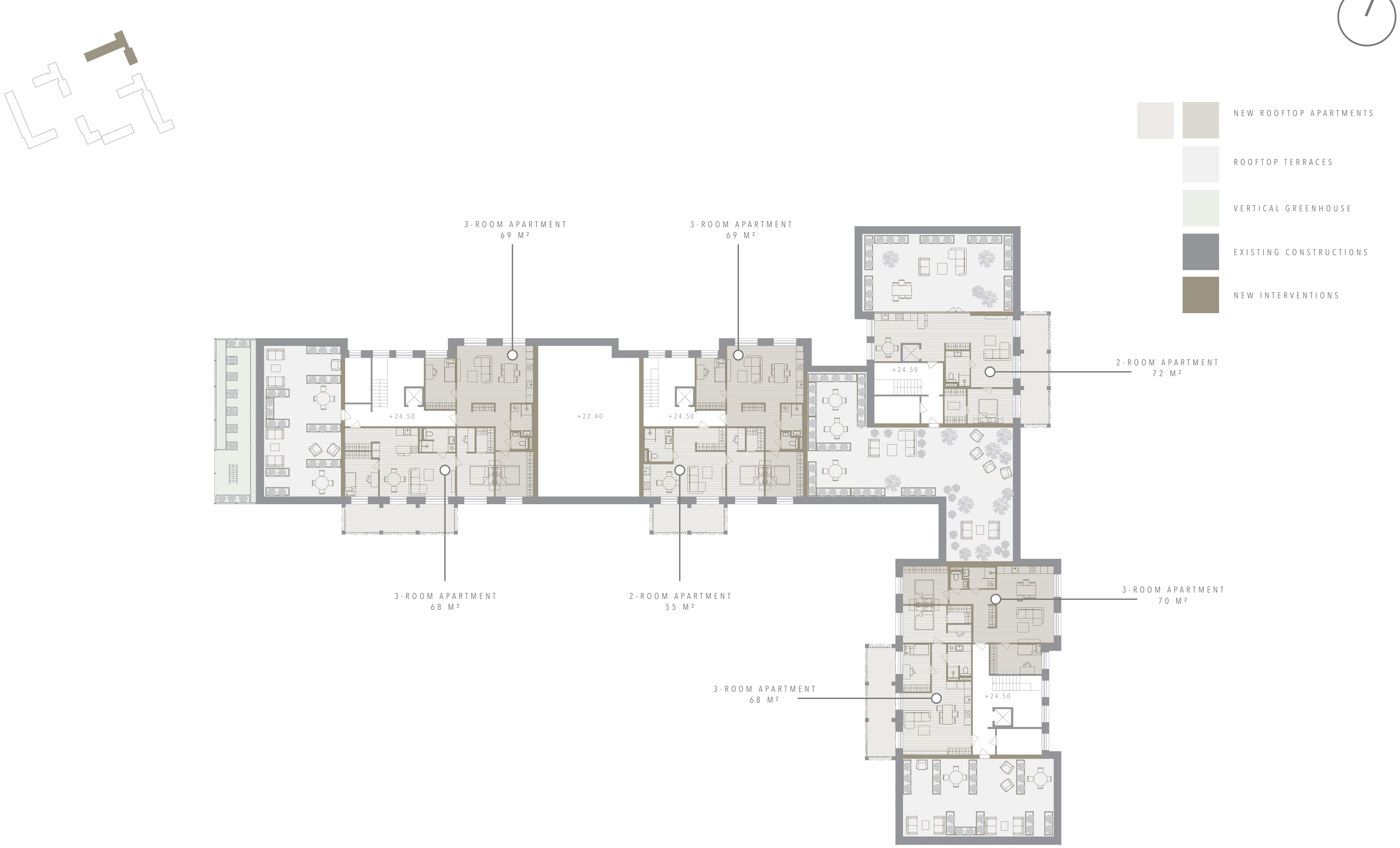

Figure 49: Rooftop interventions. Author's illustration

10. IMPLEMENTATIONS OF CIRCULARITY

The residential quarter is following quite different circularity principles. One of the main ideas was to find a function to the plain walls. Therefore, the idea of vertical greenhouse was implemented.

Vertical farming works on a circular economy principle: food waste generated in the apartments is collected in a container, for example in the basement of a residential building. The biogas tank, which can be used as an energy source for the building, produces fertilizer as a by-product. The fertilizer is piped to the façade of the building where the crops are grown. When the crops ripen, they are harvested by a green-wall robot attached to the facade. The products can be sold on the local market or consumed by residents.

The facade materials are chosen by the idea of sustainability circuarity. One of the combinations are recycled brick modules with a support frame and gabion blocks. Brick modules can be allocated from the old buildings that are going to be demolished. The outcome would be diverese and interesting with the history that tells a story about the material.

Gabion blocks are mainly used for a elevated private gardens to give the residents a privacy from the street noise. Thick blocks are giving a dimention and diversity with showing the very raw materials from the environment.

As other new facade materials, timber and food products are mainly used for a resilient and warm outcome. The new balconies are constructed from high durability CLT, to ensure the fire safety.

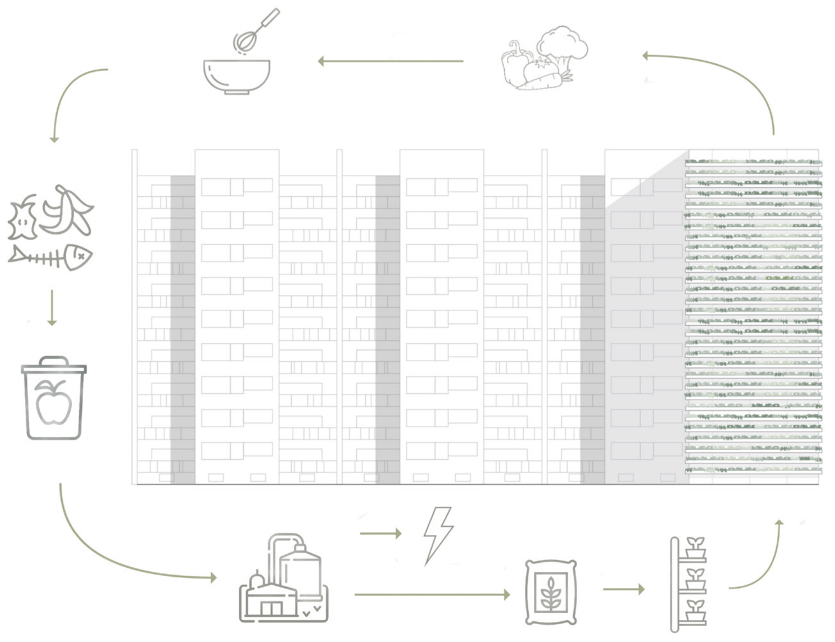

Figure 50: Building-based circularity. Author's illustration

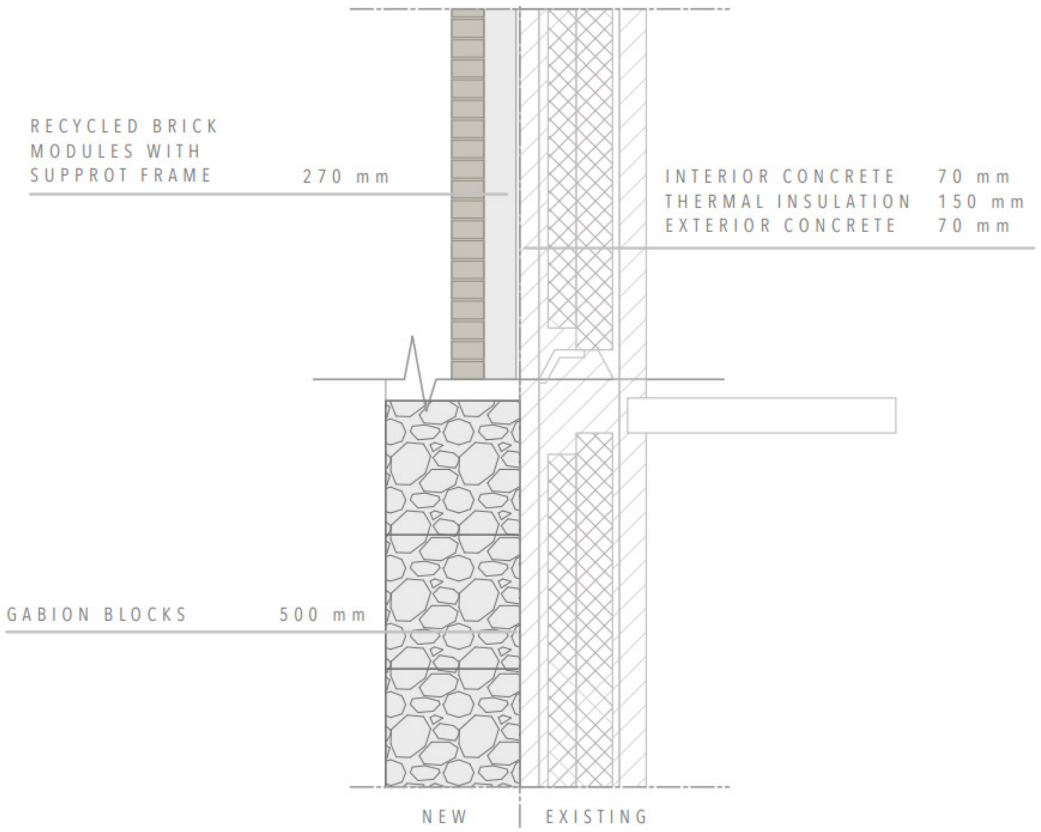

Figure 51: Section of external wall. Author's illustration

Figure 52: Courtyard. Author's illustration

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LIST OF FIGURES

APPENDICES

Appendix 1: Poster 1

Appendix 2: Poster 2

SITE PLAN

1:500

MONOFUNCTIONAL URBAN SPACE VS. IMPLEMENTATIONS OF DIVERSITY

EXISTING BUILDING VS. NEW IMPLEMENTATIONS

III

Appendix 3: Poster 3

IV

Appendix 4: Poster 4

Appendix 5: Poster 5

Appendix 6: Poster 6

The concrete panel facades serve as manifests of industrial age and effectiveness of production. With the knowledge of today, and in the light of sustainability, they read as manifests of accelerated resources consumption and as denial of diversity of life. However, behind every panel and window there is a household and individual, with his or her own lifestyle and habits.

Vertical farming works on a circular economy principle: food waste generated in the apartments is collected in a container, for example in the basement of a residential building. The biogas tank, which can be used as an energy source for the building, produces fertilizer as a by-product. The fertilizer is piped to the façade of the building where the crops are grown. When the crops ripen, they are harvested by a green-wall robot attached to the facade. The products can be sold on the local market or consumed by residents.

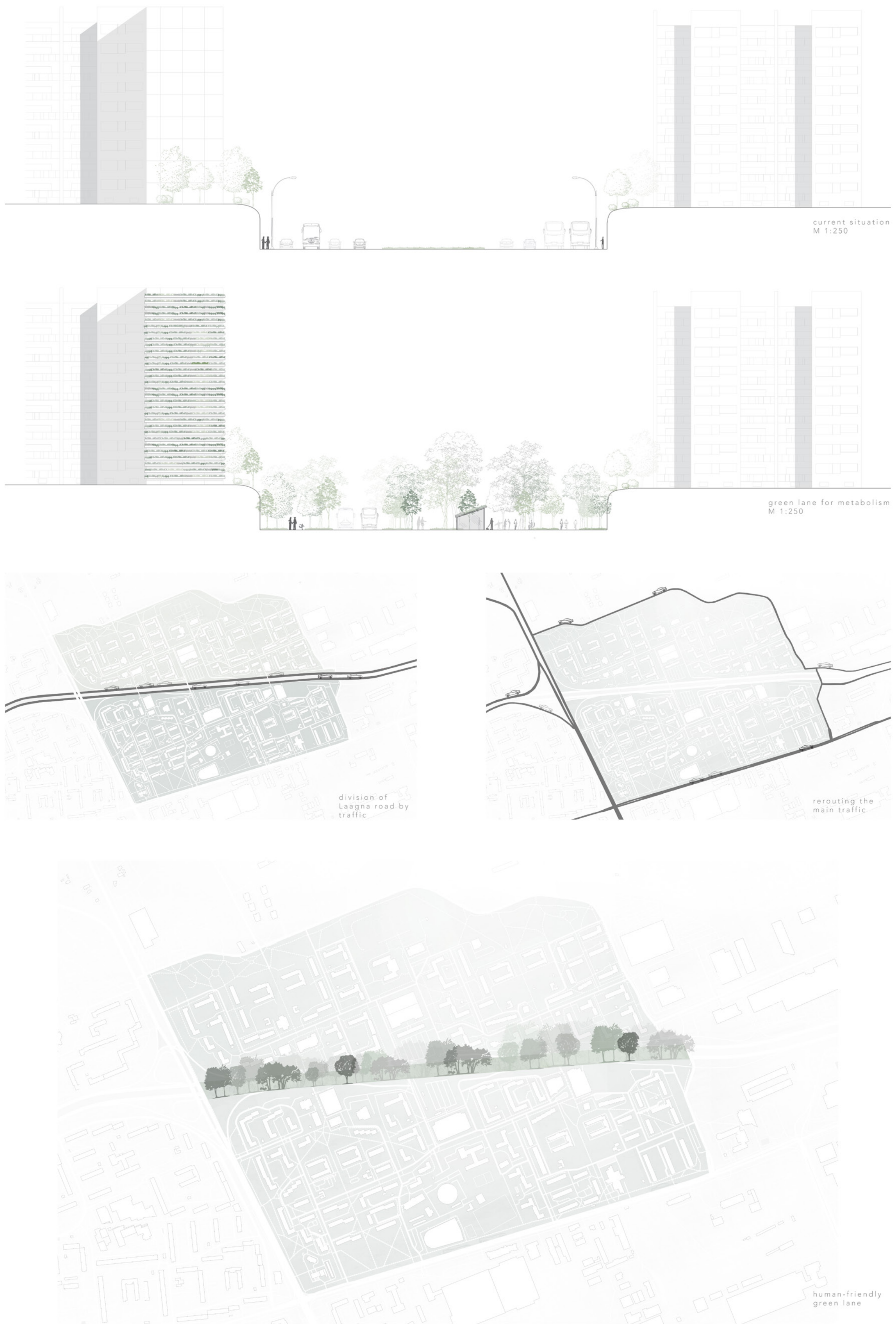
Laagna Road with its six lanes is not only an overdimensioned transport investment – it is a self-made problem, a barrier that forcefully divides the area in two. It manifests car-dependent life style and the era of soil-sealing. The artificial environment, created with machines to machines, lacks human dimension.

This proposal transforms car-centric roads into a green corridor to serve pedestrians, public transport and circularity, offering the chance to give a second life to materials and goods that no longer serve their first owner. This is fundamental for circularity: to postpone the moment when a material or a product is defined as waste. Following the example of the High Line in New York, an utilitarian infrastructural investment is converted here into a new kind of urban space that is spatially rich, promoting diversity and responsibility. Residents will have the opportunity to leave items on the open market, where it will be given a new lease of life, thereby reducing waste generation.

The car transport will be diverted around the Laagna quarter. Two lanes of public transport will be maintained in the canal, for biomethane buses, which (with the current Estonian grid electricity) has the lowest greenhouse gas emissions as a mode of transportation.

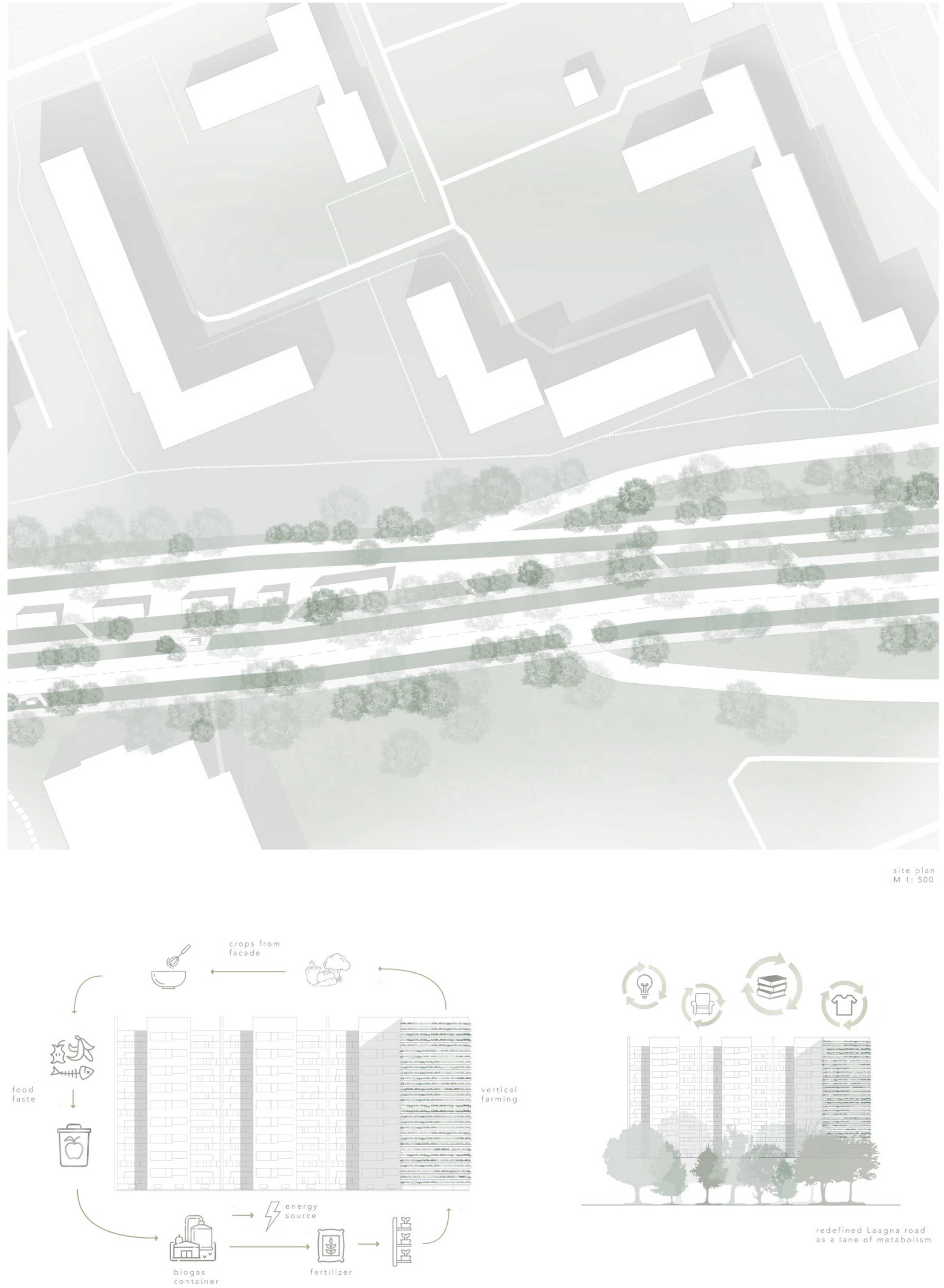
Appendix 7: Tallinn Architecture Biennale vision competition summary text

Appendix 8: Tallinn Architecture Biennale vision competition render



LANE OF METABOLISM

Appendix 9: Tallinn Architecture Biennale vision competition poster 1



LANE OF METABOLISM

Appendix 10: Tallinn Architecture Biennale vision competition poster 2