5. Non-Capital Renovation—Urban Tissue Morphotypes and Evaluation of Potential of Intensive Development: Saint Petersburg as Case Study

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Theory: Extensive or Intensive Development?

The urbanization process has been accelerating throughout recent decades, with an increase in urban population and decrease in density, or urban sprawl (UN Habitat). Large Russian cities follow the same trajectory. The recent amount of housing construction beats the records of the late decades of the Soviet era, with most of development happening through the extension of boundaries of urbanized core toward non-urbanized periphery (Starikov 2019).

Causes of Extensive Development

Despite the common character of problems caused by such a format of spatial development in large cities across the globe, the causes of urban sprawl in Russian cities have specificity and are linked both to their Socialist legacy of urban planning and institutional governance and to contemporary neoliberal type of urban planning policy oriented toward a market context. Unlike the Soviet management system, which was also been oriented toward development of new territories, today's public administrations have little hold over the spatial development of cities. Mechanisms of governance in new development of inner territories are almost nonexistent, the public authorities are unable to stimulate the resale of land plots in the former industrial zones and

do not have appropriate tools for working with real estate owners. The situation is further aggravated by the ongoing crisis of housing and communal services, which generates even more derelict and precarious housing due to many years of insufficient investment into major repairs of dwellings (Sivaev 2018). An ever-increasing amount of resources is required for managing the built-up territories, while the demand for new housing is soaring due to several factors.

The first factor is a colossal inflow of population into large cities due to uneven development of the country in the aftermath of the collapse of the Soviet distributive model; this manifests itself in hyper-concentration of population and resources in large cities and a rapid exodus of population from small and middle-sized cities and towns (Golubchikov et al. 2013). The second factor is an increased demand for cheap, mass-produced commercial housing due to low income, unreliable institutions of commercial rent, and the inaccessibility of social housing for the majority of Russia's urbanized population. The third factor is the reinforcement of demand for housing by federal policies that require an increase in housing construction up to 120 million square meters per year by 2024, as stated in the Housing National Project. For the above-mentioned reasons, the allocation of these "square meters" within urbanized territories is determined not by the urban administration, but rather by market forces and the interests of real estate developers. For them, the development of vacant periphery is easier and more profitable, as land prices and the risks of conflict with other stakeholders are minimal there.

Problems of Extensive Development

As for typology, most objects developed on the periphery of cities are organized according to the "microregion" format of development, following in many ways the modernist practice of urban planning. At the same time, a neoliberal capitalist setting and limited control from government and civil institutions contribute to a larger scale of construction with an inadequate amount and quality of transport and social infrastructure (Chirkunov 2011). Despite the declarations on self-sufficiency of new districts as a key principle of integrated territorial development programs, the newly built peripheral microregions are, in fact, monofunctional, located far away from workplaces, and deficient in local workplaces, cultural facilities, sports facilities, and other services (Korolev 2018). This "dorm district" character of new microregions within the context of extensive development of a monocentric city aggravates transport issues, as

their residents are forced to make daily commutes. The remoteness and isolation of peripheral territories, as well as low connectivity of the road network and deficiency in public transport, increase the usage of private vehicles in new districts, with such consequences as transportation issues, environmental impact, and increase of municipal expenses for construction and maintenance of new roads and parking. Besides numerous social and infrastructural problems, extensive urban sprawl causes loss of agricultural land and natural landscapes and irreversible damage to ecosystems. At the same time, public and private investment into road and grid infrastructure is being rerouted from the existing urban tissue, which causes the degradation of the urban core due to lack of money for maintenance and reconstruction.

Intensive Development as an Alternative

Thus, extensive development of major Russian cities by construction of "dormitory" microregions is a socially, economically, and environmentally unsustainable model that increases inequality within the city, because the periphery fills with cheap mass housing, the city center undergoes gradual gentrification, and the semi-peripheral zone decays due to lack of investment (Badina and Golubchikov 2005). As the costs of this model become ever more visible against the backdrop of exhausted external territorial reserve for urban development, the search for a reasonable alternative is a question of growing importance.We see such an alternative in the urban planning concept of a compact city. This concept builds upon the idea of intensification of use of the already developed urban territories by means of their reorganization and transformation (Dielmann 2004). As practitioners in the field of urban planning, in this paper we would like to explore the spatial aspects of urban development and try to explore the following questions:

- Which spatial methods may be used to create favorable conditions for intensive development of already built up inland urban territories while at the same time preserving their values?
- What capacity for intensive development within this approach do the already developed urban territories have?

Urban Morphotypes as a Resource for Intensive Development

In order to start a conversation about intensive development of the already developed urban territories, we need to describe our understanding of these territories. We propose to use the concept of urban planning continuity employed by, among others, Kevin Lynch, who considered the urban environment as a sort of code that immobilizes "an image of time" in the circumstances of constant cultural, political, and social change (Lynch 1960). At each historical stage of urban evolution, urbanized territory has expanded to keep pace with its population's needs for housing and workplaces, while the type of space produced during this expansion was determined by the dominant social and political order of each distinct period (Lefebvre 1991). Such an expansion also determined the preservation of historical urban tissue containing permanent structural planning foundations that bore the features of previous stages of development (Veretennikov 2014). Thus we can, although in a somewhat conventional manner, describe the structure of urban tissue of a large Russian city as a set of different morphotypes that reflect the spatial and functional features of its urban environment at each historical period. Using the model of periodization of urban planning development proposed by Sementsov (2007), we mark out the following morphotypes: the historical city center (districts dominated by the prerevolutionary built environment), the "gray belt" (mostly non-residential territories of the historical industrial-residential rim), the "temporary city" (private housing sector, districts of individual or block housing), the "working settlements" ("garden cities"; the 2- to 4-story housing of urban districts of the Soviet preindustrial period between 1918 and 1957), "Stalin-era housing" (buildings along the main streets of the Soviet preindustrial period), "Khrushchev-era housing" (microregions of the first generation of mass housing series between 1958 and 1974), "Brezhnev-era housing" (microregions of the later generations of mass housing between 1975 and 1991), and the "post-Soviet districts" (districts and microregions built after 1991). In terms of the sustainability of decision-making and urban planning continuity, it is important to account for specificity of the environment of each morphotype. However, today we witness attempts of intensive development that do not take into account the uniqueness of each morphotype, thus generating a lot of problems.

Moscow Renovation as an Unsustainable Model of Intensive Development

Let us begin by considering the manner of intensive development that is actively implemented in Moscow and may be extended to other regions in the near future. The program of renovation of mass housing, initiated in 2017 by Sergey Sobyanin, mayor of Moscow, included the demolition of more than 5,000 residential buildings of mostly postwar series and their replacement by newer housing, which affected over a million people. The newer construction realized on the newly available territories is no different from that which is characteristic for the peripheral areas—that is, microregions of high-rise residential buildings. Such a solution indeed allows intensifying the use of the built-up urban core and making use of the existing transportation, power distribution, and social infrastructures; the investments are allocated to their reconstruction rather than the creation of new ones. Still, despite the declared advantages, the urban renovation program has provoked controversy in the expert community and has led to the rise of the most intense urban resistance movement in Moscow's recent history. Criticism of such a form of intense development includes many aspects, including economic, social, and environmental concerns.

Firstly, such a model of urban renovation is far from flexible—it does not provide conditions for further autonomous development of the territory and its ability to change, but simply assumes a complete replacement of one morphotype by another one. Secondly, such a change is in contradiction with the principle of urban planning continuity, as it implies complete destruction of an entire morphotype of an already established urban environment, completely negating its architectural, historical, and social value. Besides that, criticism is also aimed at the economic aspects of the project: their large scale of construction, high cost of demolition, and the necessary relocation of residents of the affected buildings mean that such a program cannot be implemented at the expense of private investors and requires considerable investments drawn from municipal budgets—which is practically impossible anywhere except Moscow. Finally, the "Moscow renovation" generated an intense social conflict, as many residents of the buildings subject to demolition refused to be relocated but were faced with the fact that even property rights did not guarantee immunity from demolition. Thus, Moscow's model of intense development of inner urban territories proved to be unsustainable, as it is not designed for full par-

ticipation of all stakeholders and destructive for the environment and communities already established within the morphotype.

Renovation Outside the Capital: Our Proposals

We assume that the implementation of an intensive model of development within the content of Russian cities requires a more nuanced and precise approach that would take into account all the complexity and diversity of the environment within cities, be economically realistic and well-founded, and essentially be a result of cooperation among all stakeholders that opens opportunities for further autonomous development of the territories in question. While considering the existing urban tissue as a set of morphotypes, we aim at demonstrating the potential for intense development that each of them has, as well as spatial methods suitable for realizing such potential. Our approach is based upon the model of intensive development and developed individually for each morphotype of the already existing urban tissue so that it accounts for their particular features and prevents them from losing their valuable environmental qualities. In our opinion, the right way to transform the established urban tissue consists not in demolishing the existing built environment and replacing it with a new one, but in extending the planning structure into the under-formed parcels of territories, construction on inefficiently used plots, and densification of the existing built environment. In our study, we have used the DBR (design-based research) method applied to real urban locations in order to explore spatial solutions that enable intense development within the morphotypes of the existing urban environment, as well as to approximately estimate their development capacity. In the next chapters, we will describe our methodology, research process, and results in more detail.

Methodology: Developing Research Principles and Methods

Principles

Before moving on directly to DBR methodology, it is necessary to formulate the principles that should, in our opinion, guide the intensive development of urban inner territories. Our position is based on the acknowledgement of the importance of urban planning continuity and is also close to Gutnov's statement (1984) regarding the necessity of preserving stable and sustainable elements of urban structure. We are also endorsing Chirkunov's concept (2011) of the compact city and Yablonskaya's position (2011) regarding the necessity for regeneration of the urban environment according to the principles of self-organization and authenticity. Thus, we consider that the treatment of already developed territories requires not only their densification, but also fixing the existing deficiencies of their environment, alongside the preservation of their valuable features and specificity, as well as providing conditions for flexible self-development. From these foundations, we have deduced the following principles of research that would allow us to design the necessary spatial tools during the planning stage:

1. Supporting small-scale development. The densification and increasing of spatial diversity of developed territories is to be implemented through local projects to add additional stories and extensions, as well as small objects of new typologies. In order for these tools to become widely used, a system of support for small-scale development may be required. Homeowners themselves should become agents of transformation of their surroundings.
2. Privatization of territories within districts. A lot of territories within the formed districts neither have clear legal status nor belong to specific owners. This abundance of "gray zones" may slow down the necessary transformation. An inventory of land plots is required in order to rationally distribute them between different kinds of users. There should not be such a thing as "no man's land" within the morphotypes in question.
3. Demarcation of land plots under the existing buildings, with a perspective toward further development. Such a demarcation should be done in a manner that opens opportunities for development of the existing real estate. Public spaces should be demarcated with clear boundaries, functions, and characteristics. The remaining plots may be allocated for private use, which would reduce maintenance costs for municipalities. The NIMBY

phenomena can be averted by empowering beneficiaries to induce demand for small-scale development. This process also contributes to formation of communities of responsible real estate owners.

4. Construction and rehabilitation of streets conceived as public spaces. In order to create a fully formed spatial structure within which functional land plots can be defined, streets must be rehabilitated as fully formed public space. Each demarcated space must have access to commonly used land and facilities. Increasing the overall length of streets improves the connectivity of spaces and creates new opportunities for small businesses.
5. Creation of a connected and intuitively "readable" structure of boulevards, gardens, and parks. Besides the streetscape, an integrated system of public spaces should be formed. Public spaces must function as a whole system of interesting places of different scales, and the transition between these spaces should be free from obstacles. A clear system of public spaces can also contribute to solving the non-authorized parking problem. Parking lots should be inventoried, and predictable parking policy roles should be established.

Methodology

In order to apply these principles to real territories of urban morphotypes in our own design-based research, we have developed the following methodology. On one hand, we have used the Research by Design (RbD) approach, which includes a certain sequence of phases of research, such as pre-project analysis of the territory and context research, the design itself, and theoretical analysis of the results of the design (Roggema 2017). On the other hand, during the design stage we have applied a widely used Massing Study approach, which implies an estimation of capacity characteristics of the territory concerned through placement of architectural volumes according to existing spatial and legal norms (Donath 2008)—in our case, according to the principles formulated above. The key feature of our methodology consists in looking for answers to the research question directly in the project phase of the research—that is, looking for spatial tools for work with the morphotypes of built environment at the designing stage; such tools would allow an intensive development of territories according to the principles formulated above.

1. Case study
   (a) Selecting the case
   (b) Defining boundaries of the already developed urbanized territories
   (c) Demarcating morphotypes of built environment within boundaries of urbanized territories
   (d) Selecting pilot territories in each morphotype to be redesigned

2. Pre-project analysis of pilot territories
   (a) Field studies, gathering data
   (b) Data analysis, defining values and deficiencies
   (c) Calculating present values of indicators

3. Developing test projects for selected pilot territories
   (a) Searching for spatial tools of intensive development
   (b) Massing study—evaluating capacity characteristics by placing building volumes according to chosen tools
   (c) Calculating new values of indicators

4. Post-project analysis
   (a) Extrapolating the infill capacity resource of each morphotype to all developed urbanized territory of the case city and evaluating the intensive development potential
   (b) Discussing results and defining conditions of applicability of the discovered spatial solutions

Data

In order to define the boundaries of research and the urban environment morphotypes and to calculate indicators, several GIS tools provided by the Committee of Urban Planning and Architecture of the Government of Saint Petersburg were used. The data included: buildings and structures (by year of construction), water bodies, road network, boundaries of commonly used territories and linear objects, commonly used green infrastructure and protected green areas, land-survey plots (and their respective types of allowed usage), and territorial planning projects for Saint Petersburg. Data derived from OpenStreetMap (OSM) and the "Reform of Housing and Communal Services" digital platform have also been used for calculation of respective indicators.

OSM data has been used regarding the following parameters: buildings and structures, water bodies, pedestrian crossings and road networks in the Oblast of Leningrad, and commercial and social objects and services. The "Reform of Housing and Communal Services" platform has been used to obtain the data regarding the residential buildings of Saint Petersburg and the Oblast of Leningrad.

Indicative Parameters

In order to characterize the environment and the built-up structure of each of the morphotypes, it is necessary to choose parameters for evaluation of the intensity of development, infill potential, and efficiency of use of territory. These parameters have been used according to the Spacematrix urban form description model (Berghauser Pont and Olsson 2017):

1. Public / private ratio: the percentage ratio of public and private spaces, which characterizes the structure and efficiency of use of urban areas.
2. FSI: floor space ratio, an indicator of density of territorial development. Calculated as a ratio of total floor-by-floor surface of buildings to the surface area of the plot.
3. GSI: ground space ratio. An indicator of density of construction. Calculated as a ratio of total surface covered with buildings to the surface area of the plot.
4. Height index: an average number of stories of buildings on the plot.
5. OSR: open space ratio. The amount of unbuilt surface on the territory. Calculated as a ratio of total surface of non-built territory to the total surface area of the plot.
6. Road network density: an indicator of territorial connectivity and structure. Calculated as a ratio of total length of streets to the surface area of the plot.
7. Parks: an indicator of publicly accessible green spaces. Calculated as a ratio of total surface of publicly accessible green spaces to the total surface area of the plot.

These parameters will be used to evaluate the present state of each morphotype. Next, the evaluation will be repeated after modifying the structure and adding new volumes to the existing urban tissue. After that, a comparison be-

tween the initial and modified values of indicators will allow us to make conclusions about the intensification of development and the existing capacity of each territory.

Empirical Experience: Design Study of Tools and Potential of Intensive Development

Case Study: Saint Petersburg

Saint Petersburg, the second largest Russian city, has exhibited positive dynamics of population growth for at least the last ten consecutive years; this growth is caused both by an ever-increasing number of immigrants and by natural population growth. The growing urban population is mostly provided with housing in the extensively developed peripheral territories—located for the most part in former agricultural lands, which erodes the green belt surrounding the city (see fig. 1). New areas of residential construction have already been established at the periphery of Saint Petersburg, such as Murino, Devyatkino, Parnas, Kudrovo, Shushary, the "Baltic Pearl," Koltushi, Bugry, Zanevskoe, the Solnechny Gorod residential complex, and Lensovetovsky. Most of these are built along the radial highways and characterized by their singular function, high density and average number of stories of housing, a deficiency in social infrastructure and everyday services, and traffic problems upon arrival to Saint Petersburg and in daily commutes to the city center because much of the new high-rise housing lacks any new workplaces (Babenko 2013). Besides that, many satellite towns of Saint Petersburg are also expanding: Vsevolozhsk (Yuzhny microregion), Pushkin (Slavyanka and Pushgorod residential complexes, District 9), Kolpino (Novaya Izhora), Novogorelovo, Sertolovo (Zolotye Kupola residential complex, Novoye Sertolovo microdistrict). New housing commissioning rates in the Oblast of Leningrad are nearly as high as in Saint Petersburg: in 2018, 2.64 million square meters have been commissioned in the Oblast of Leningrad, compared to 3.2 million square meters in Saint Petersburg itself, according to the information provided by the Government of Saint Petersburg in 2018. The increase of construction activity in the satellites of Saint Petersburg also continues: integrated territorial development projects are scheduled for realization on the sites of Planetograd (1.5 million sq. m.) and Yuzhny satellite town (4 million sq. m.).

Against the backdrop of extensive development, Saint Petersburg is facing numerous challenges related to aging of housing of inner urban territories (Sivaev 2018), as well as to a lack of social infrastructure and low transport accessibility. Resources and the attention of the urban administration are dedicated to solving problems caused by urban sprawl, whereas the existing developed territories suffer from degradation of utility infrastructure, housing, and the urban environment. As a result, the city is facing a double problem: peripheral outskirts with an ever-increasing demand in investment, and inner city territories that undergo degradation. In our opinion, what Saint Petersburg really needs is an exploration of approaches to implement the compact city model and testing of new spatial solutions to the placement of new housing within its inner territories, as well as creating conditions for intensive development.

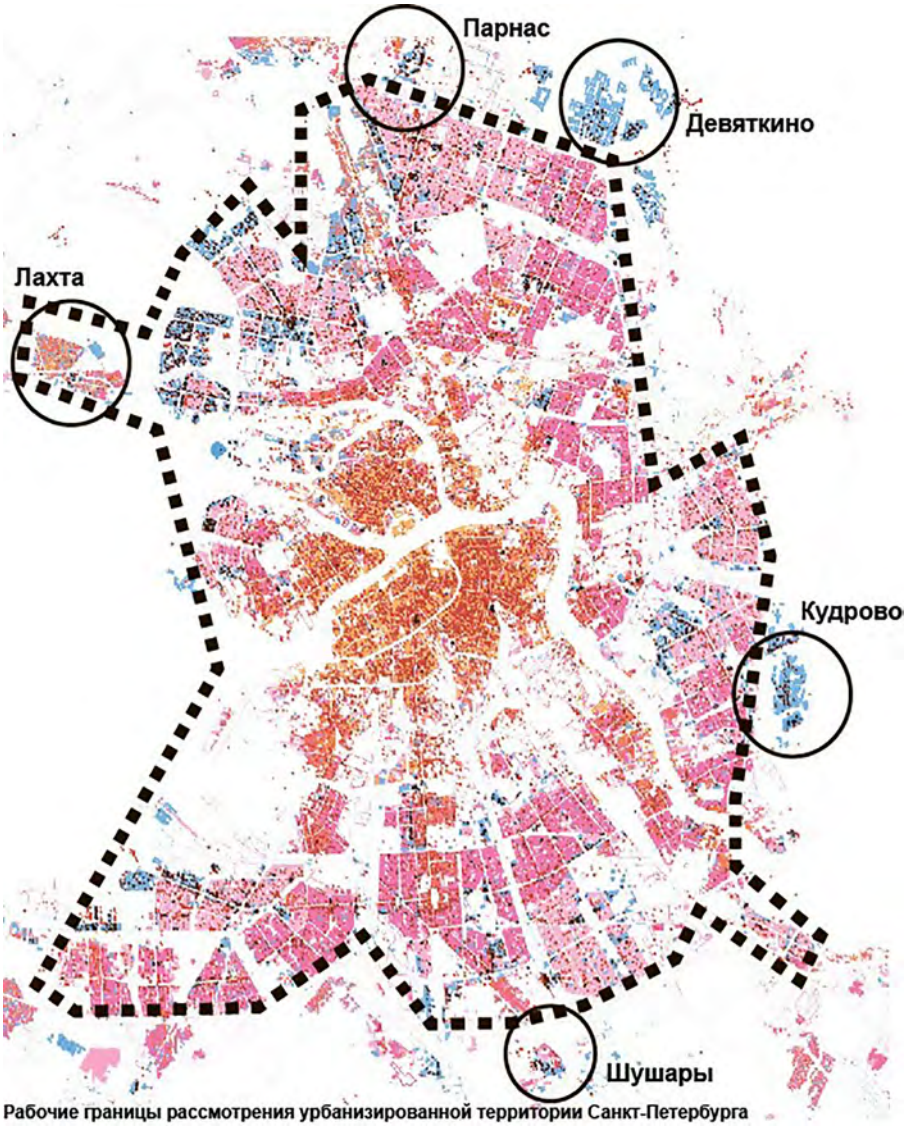
Defining Boundaries of Already Developed Urbanized Areas

In order to further evaluate the potential of an already developed urbanized area in terms of capacity for intensive development, it is essential to define its boundaries in a precise manner. In European urban planning practice, boundaries of urbanized territories are defined according to continuity of dense development and high connectivity of urban tissue (Монастырская 2017). In order to define boundaries of highly connected, dense, and continuous urban tissue, we have used GIS tools in order to combine three spatial layers: historical strata of urban tissue (years of construction and historical districts of the city); density of services; and environmental barriers (industrialized territories, railroads, water bodies, and expansive green areas). The boundaries thus defined do not include several exclaves of high-density development, such as Devyatkino, Kudrovo, Lakhta, and Shushary. Barrier territories on this map are whitened in order to better show the relatively continuous fragments of urban tissue.

Defining Built Environment Morphotypes

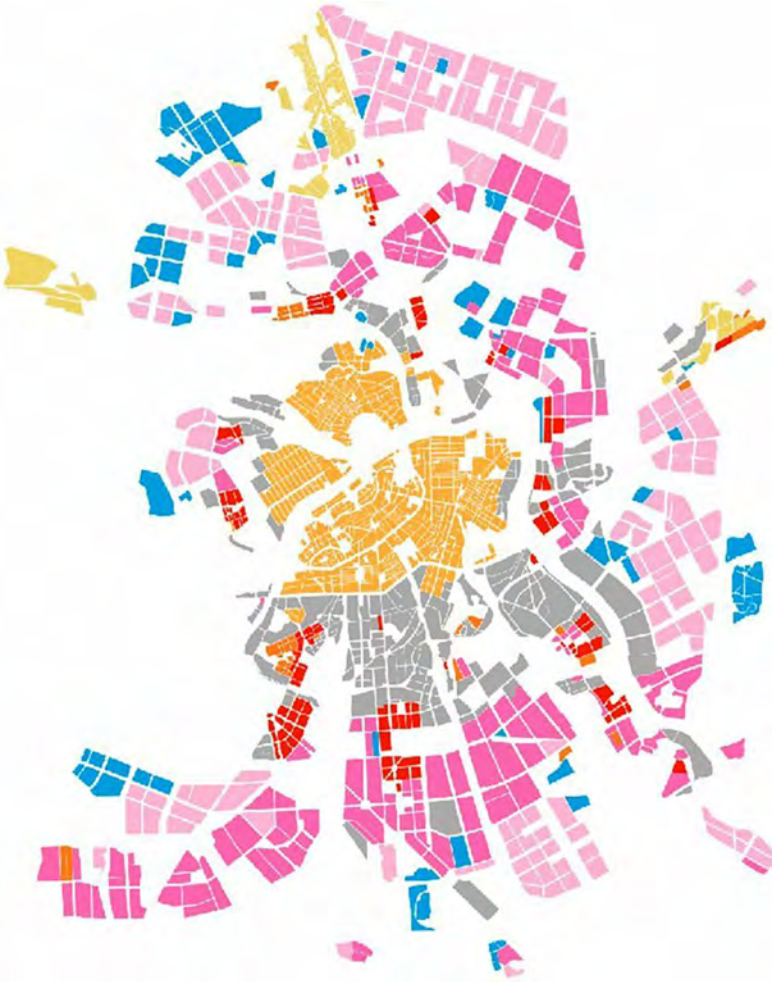
According to the model of study of urbanized territory of the city as of a set of morphotypes that reflect the spatial and functional features of urban environment at each historical period (see section 1.4 of the present paper), the territory of Saint Petersburg has been divided in the following manner (see fig. 1):

Figure 1a: Boundaries of developed urbanized territory of Saint Petersburg.



Source: Authors.

Figure 1b: Morphotypes of urbanized territories of Saint Petersburg (map).



Source: Authors.

Figure 1c: Morphotypes of urbanized territories of Saint Petersburg.

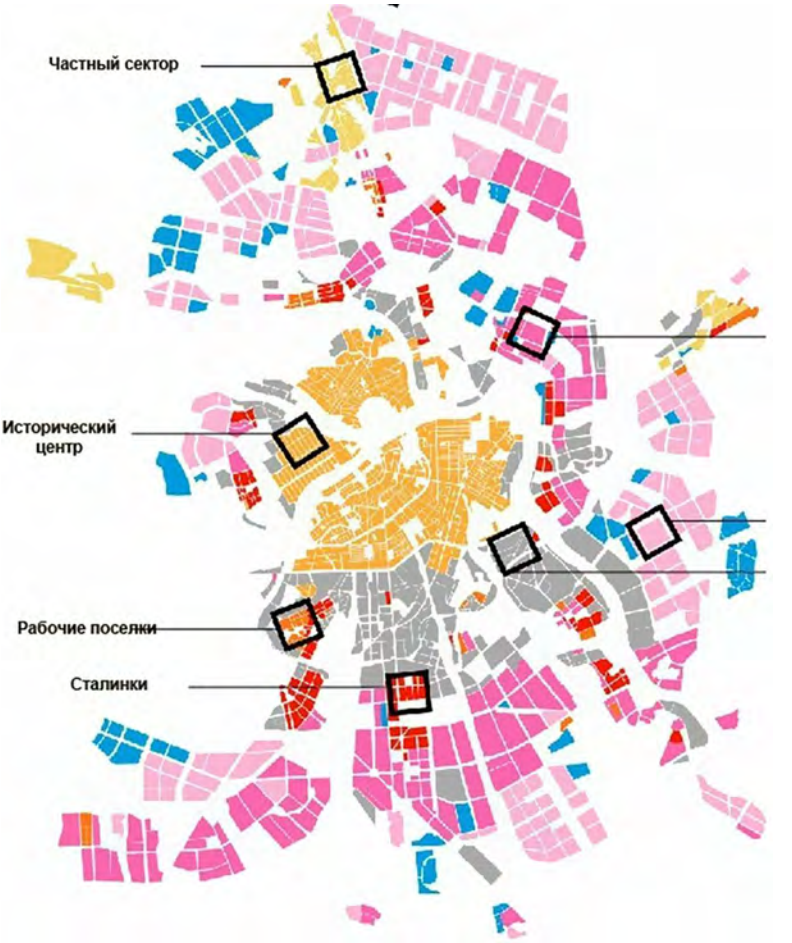
Source: Authors.

Allocation of territories has been implemented with GIS tools by means of aggregation of data related to years of construction and function of buildings within districts as units of planning structure. Morphotypes have been assigned to each district according to the prevalent built environment in terms of age or specific functional and environmental features (such as industrial objects for the "gray belt" morphotype or private housing for the "temporary city" morphotype). The scheme that reflects the distribution of urban territory between different morphotypes shows a ring-like structure that has formed as a result of consecutive waves of city expansion (see fig. 1).

Selection of pilot territories for design research within each morphotype:

For design purposes, several characteristic examples for each of the morphotypes have been selected (see fig. 2).

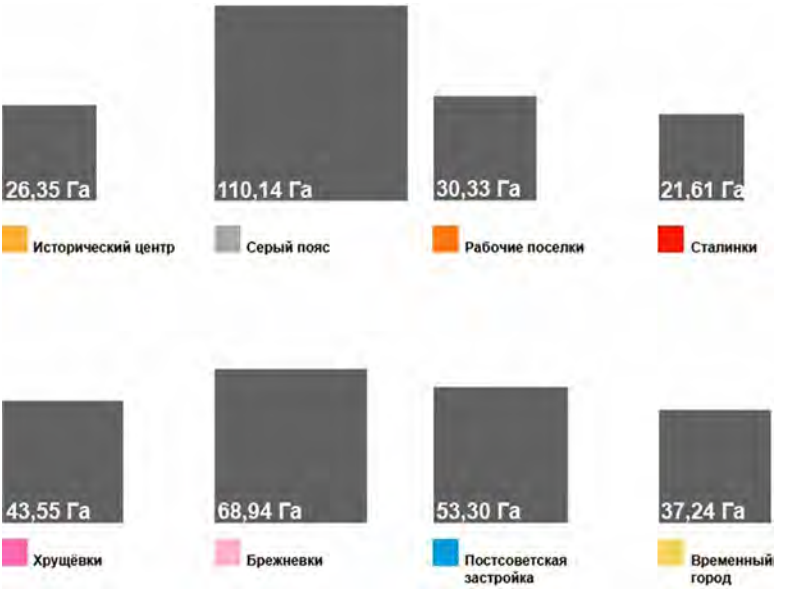
Figure 2a: Pilot territories of each morphotype, located on the city map.



Source: Authors.

The main selection criteria was homogeneity of the tissue: the built environment of a pilot territory should reflect, as fully as possible, the type of environment proper to the morphotype. The test plot size was defined according to typical dimensions of planning elements of morphotypes.

Figure 2b: Comparative sizes of pilot territories of each morphotype.



Source: Authors.

Pre-Project Analysis of Pilot Territories

In summer 2018, field studies have been conducted in order to gather understanding of specific features of pilot land plots in each of the eight morphotypes. Based on field and theoretical research, each morphotype has been assigned values to be preserved and issues to be solved. Also, values of indicator parameters have been calculated for each of the pilot zones.

Khrushchev-Era Housing:

Khrushchev-era housing encompasses the microregions of the first generation of massive housing series (1958–1974). Typical prefabricated block housing developments that happened on a wide scale from the late 1950s to early 1980s, commonly referred to as "Khrushchev-era housing," or "Khrushchevka," can be found in any city across Russia. In Saint Petersburg, Khrushchev-era housing districts occupy 15 percent of the surface area of the urban core. For our study purposes, the Polyustrovo district has been chosen, located at the intersection of Prospect Metallistov and Piskarovskiy Prospect. Functionalist architecture has influenced the approach to territorial planning; thus a number of specific features of Khrushchev-era development have formed. Among them are the typological monotony, a lack of distinctive features, and the zoning and hierarchy of spaces. The stigmatization of these territories caused by these numerous issues led to the situation where the dominant mode of redevelopment took the form of complete demolition of the existing buildings with subsequent redevelopment of the newly available plots. However, such an approach is tremendously difficult, costly, and is only possible as a large-scale, publicly operated project. Moreover, researchers have found that the consequences of demolition for the affected territory include the loss of confidence of inhabitants and the destruction of local communities and of positive characteristics of the place. Nevertheless, wide availability of this morphotype in the urbanized area enables the production of a significant amount of "surplus" square meters, all the while preserving the existing buildings and positive features of the environment—and this effect can be achieved by the proposed model of renovation in the framework of intensive development of urban core territories. Key identified values are: greening of intra-microregion territories and the presence of established communities. Key identified problems are: total permeability; lack of division between public and private spaces, transitional character of courtyards as sources of conflicts; rundown local amenities due to lack of shared responsibility for maintenance of courtyard spaces between homeowners and the municipality; monotonous character of built environment—all the facades have the same look, which makes the territory difficult to navigate; and a virtually complete absence of commercial fronts and necessary services. Indicative parameter values are: overall surface of the morphotype in the city = 4,160 ha; surface of the pilot zone = 43.55 ha; 45% private space / 55% public domain; FSI = 0.57; GSI = 0.14; height index = 4.53; OSR = 1.52; street grid density = 0.08; and parks = 6.17.

Brezhnev-Era Housing:

Microregions of the later generations of mass-produced housing (1975–1991) comprise the most widely distributed type of built environment in the Soviet Union. It is widely considered that Brezhnev-era housing includes all buildings constructed between the mid-1960s and late 1980s. Residential buildings mostly took the form of 9- to 12-storey-high housing organized into microregions. Such a morphology is widely present, taking up to 16 percent of the urban core area. For research purposes, a territory of the microregion adjacent to Prospekt Bolshevikov subway station has been chosen. This morphotype is characterized by diverse typologies of development, an absence of structured spaces and visible boundaries between public and private domains, and, therefore, a low-quality urban environment. The total surface of territories built up with Brezhnev-era houses is enormous, as this morphotype is one of the dominant ones on the territory of the urban core of Saint Petersburg. This factor alone makes these territories highly attractive for redevelopment. Moreover, the microregion structure is characterized by abundant underused spaces and empty lots. This opens wide opportunities for new construction, which is already happening in these territories. However, this usually takes form of high-rise infill development, which exacerbates the problems of Brezhnev-era housing instead of solving them. Key identified values are: good greening of territories inside microregions; a presence of dominants; and diversity of planning schemes within microregions. Key identified problems are similar to Khrushchev housing: total permeability; no distinction between public and private spaces; transitory character of courtyards, which generates conflicts; degradation of public amenities due to lack of shared responsibility between homeowners and municipalities; monotony of built environment—all facades have similar exteriors which makes the territory difficult to navigate; and numerous empty lots. Indicative parameter values are: overall surface of the morphotype in the city = 4,313 ha; surface of the pilot zone = 68.94 ha; 47% private space / 53% public domain; FSI = 1.23; GSI = 0.14; height index = 9.34; OSR = 0.70; street grid density = 0.05; and parks = 9.38.

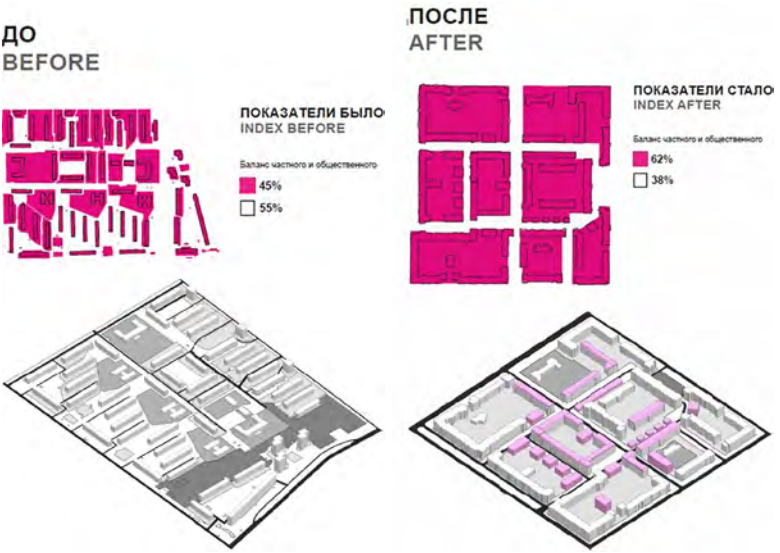
Development of Test Projects for Pilot Areas

Drawing from the initial declared principles, as well as values and problems detected during the research, we have developed separate renovation projects

for each pilot area which take into account re-demarcation and restructuring as well as the construction of new streets and infill development. During the planning, appropriate spatial tools were chosen in order to preserve and reinforce the values of each morphotype, as well as to solve the characteristic problems of territories. Based on the massing study conducted for each territory, new values of indicative parameters have been calculated. Chosen spatial solutions for intensive development of each morphotype, illustrations of design solutions, and new values of indicative parameters, which allow estimation of the modifications applied to the respective territories, are presented below.

Khrushchev-Era Housing:

Figure 3: Test project for renovation of Khrushchev-era housing morphotype.



Source: Authors.

Tools used:

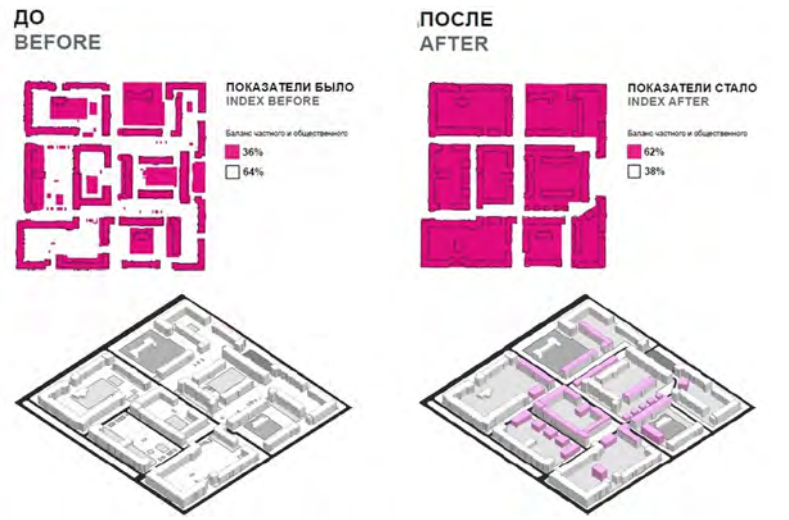
1. Fractioning of district structure: tracing new transit streets
2. Division of space between houses into courtyard spaces and streetscapes; privatization and enclosure of courtyards

3. Creation of fully functional parks and publicly accessible boulevards
4. New development along the front of transit streets
5. Increasing the height of buildings
6. Construction of multistory rental parking garages along the main streets. Multistory above-ground parking with active ground floors (including shops, gyms, etc.), unlike underground parking garages, can further be easily transformed into public buildings. At the present stage, they can serve as an efficient component of parking solutions.
7. Narrowing the corridors of thoroughfares and construction along the new front
8. Placement of "beacon" buildings as landmarks in key locations of microregions

Indicative parameter values: 56% private space / 44% public domain; FSI = 0.86; GSI = 0.22; height index = 4.11; OSR = 0.91; street grid density = 0.17; parks = 10.61

Brezhnev-Era Housing:

Figure 4: Test project for renovation of Brezhnev-era housing morphotype.



Source: Authors.

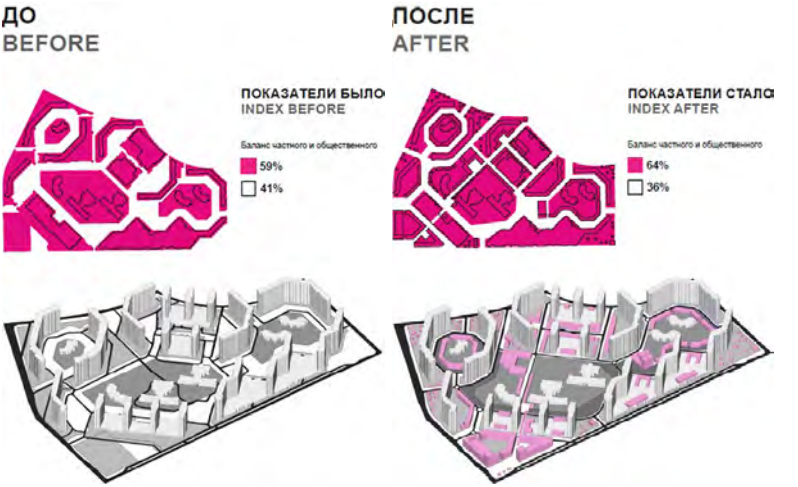
Tools used:

1. Transition from microregions into districts: tracing new transit streets
2. Creation of unified system of squares and boulevards within the new groups of districts; transformation of a "park town" into a "town of streets and squares." Reduction of the area of open spaces must be compensated by improving the quality and accessibility of preserved and newly created parks, boulevards, and squares.
3. Connecting the elements of green network into unified system by active greening of streets
4. Working at four levels of scale: superblock (microregion), group of blocks, block, plot
5. Forming fully functional parks and publicly used boulevards; each group of blocks has its own public space
6. Division of spaces between buildings into courtyard spaces and streetscapes; privatization and enclosure of courtyards
7. Creation of districts with two fronts: Brezhnev-era housing + low-rise development
8. Creation of "Brezhnev-era housing + low-rise development" districts by developing the front edges of the district
9. Increasing building height
10. Construction of multistory rental parking garages along the main streets
11. Optimization and "straightening" of street grid within the microregion; improving permeability, visibility and intuitive "readability" of the streets within the "super-block"
12. Densification of street front along the thoroughfares with temporary pavilions located at the "unusable" plot. In order to render the new streets more efficient, opportunities for development along the setback boundaries should be used as much as possible.

Indicative parameter values: 60% private space / 40% public domain; FSI = 1.71; GSI = 0.24; height index = 7.62; OSR = 0.45; street grid density = 0.17; park = 2.00

Post-Soviet Development:

Figure 5: Test project for renovation of Post-Soviet development housing morphotype.



Source: Authors.

Tools used:

1. Division of space between houses into courtyard spaces and streetscapes
2. Optimization and "straightening" of the street grid within the microregion
3. Densification of "unusable" areas with small-scale typologies
4. Humanizing the scale of courtyards by integrating rows of the low scale block housing. Rows of block housing not only reduce the scale of the visual space of playgrounds and surrounding streets making perception of the space more comfortable, but also create new formats of housing and spatial cells for new businesses.
5. Landscaping tools for humanizing the scale of the environment. If new development cannot be used to "reduce" the scale of space between buildings, landscaping tools (such as artificial landforms and trees) can be used.
6. Integration of "beacon" buildings as landmarks in key locations across the microregions
7. Creation of human-scale street corridors along the way from subways to parks

8. Functional diversification or development of non-residential functions
9. Creation of high-density, multifunctional development nodes adjacent to subway stations

Indicative parameter values: 64% private space / 36% public domain; FSI = 3.09; GSI = 0.26; height index = 13.74; OSR = 0.24; street grid density = 0.15; parks = 3.34

Post-Project Analysis

The extrapolation of infill development potential values calculated during the project onto the entire urbanized territory of Saint Petersburg allows us to estimate an approximate potential of intensive development according to our model. These calculations show that about seventy million square meters of new residential and non-residential floor area can be integrated into the existing urbanized territories of the city. This number outstrips by far the need for new residential, business, and social development for many years ahead and proves the viability of developing Saint Petersburg according to the intensive development model, rather than extensive expansion. Three quarters of this capacity can be implemented by densification of territories occupied by three morphotypes—the gray belt and Khrushchev- and Brezhnev-era housing—as these morphotypes provide maximum infill development capacity. Thus, for example, microregions of Khrushchev-era development alone can accommodate about 17 million square meters of more new development. It is important to note that such a volume of new development can be produced with very limited amounts of demolition while preserving the values of each of morphotype and solving problems specific to each.

Limitations

The morphotype method can be successfully applied for approximate estimation of infill development potential of already developed territories. It has, however, a number of limitations that do not allow it to be used as a universal method for calculating additional capacity of the territory. Thus the method only works best in the case of fragments of "clean" and homogenous development, while urban planners mostly have to deal with mixed development that consists of buildings of different ages and typologies. Another limitation

is related to the fact that the spatial tools developed in the framework of the present research are based on a number of principles that reflect our position regarding the quality of urban space, yet urban planning principles adopted by different cities can differ from the ones adopted as a foundation of the present research. Also, this research only accounts for spatial characteristics of different types of developed environments, while the choice of planning solutions in practice can be also determined by a number of highly unpredictable factors, such as sanitary and environmental conditions, local regulations and restrictions, architectural and urban planning traditions, specific preferences of residents, et cetera. Any practical projects of infill development of any type of built environment should account for such a diversity of factors; our model can only serve as a tool for the estimation of maximal capacity for supplementary surfaces that does not diminish valuable features of urban space.

Conclusion

In the framework of this research, we have demonstrated a conceptual model of intensive development of already developed urbanized territories that can serve as an alternative to widespread models of extensive development and the "Moscow renovation project." Drawing from the principles of urban planning continuity and the concept of compact city, we have proposed a way of approaching already developed urbanized territories as a set of well-established morphotypes of urban tissue that reflect the historical and functional layers of urban evolution and have specific environmental features. By using the design-based research method, we have developed a number of spatial tools that can create conditions for the implementation of a compact model of urban development, while the estimation of infill development capacity has shown the presence of an enormous resource of urban tissue eligible for infill development. As urban planning practitioners we have proved that, while using these tools, it is possible to satisfy the needs for new real estate for many years to come while preserving the diversity of environments and preventing urban sprawl. The flexibility of our model is an advantage compared to the "Moscow renovation project," as it aims at self-organization and sustainable development of territories driven mostly by the efforts of owners of real estate and small-scale development, rather than by large corporations operating within integrated territorial development projects.

However, while our research focuses exclusively on spatial methods, we consider it important to note that the policy of intensification of inner territories cannot be implemented without legal end economic initiative, by working with urban communities and introducing changes to urban planning regulation mechanisms. Our concept may be used as a foundation for strategies of the spatial development of cities and serve as a tool for evaluating the capacity of inner urban territories for intensive development, but strategic planning should also include the participation of a wide range of stakeholders in the process of deliberation, ensuring their ability to voice their concerns and to influence the decision-making process. Whether the city must grow extensively or intensify the development of inner territories should be openly discussed at the level of urban development strategy. Only upon reaching consensus regarding the urban development policy can details be discussed, such as choosing priority hotspots for investment or defining territories with stricter protection or limitation of development. Strategic visions and principles should be legalized by adopting territorial planning documents, rules, and local norms. An infill development plan or matrices of optimal density for residential development of the city, stages, and rates of growth should determine key performance indicators of achieving strategic goals or provide more details to specific chapters of strategies.

In this paper, we have tried to demonstrate the dangers related to extensive urban development and propose spatial methods that can be used to implement the model of intensive development of urbanized territories, and we have also shown the potential of such a model. Besides spatial methods, however, social, economic, and political methods of transition from an extensive to a compact and intensive development paradigm should be explored. These methods include urban planning regulations, land use policy, economic stimuli and restrictions, and loan and mortgage policy, as well as policies regarding social and rental housing.

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