

## Article

# Modernization of the Living Environment Space Using the Example of an Urban Array of Residential Buildings from the Soviet Period in Almaty

Kuralay Murzabayeva <sup>1,\*</sup>, Elena Lapshina <sup>2</sup> and Ainagul Tuyakayeva <sup>1</sup>

<sup>1</sup> Faculty of Architecture, KazLAACE (Kazakh Leading Academy of Architecture and Civil Engineering), Ryskulbekov St 28, Almaty 050043, Kazakhstan; tainagul@yandex.ru

<sup>2</sup> Department of Fundamentals of Architectural Design, Penza State University of Architecture and Civil Engineering, 440028 Penza, Russia; elenlaps@mail.ru

\* Correspondence: arhc-ledi@mail.ru

**Abstract:** This article explored the possibilities of modernizing the residential areas erected during the massive Soviet period building construction in Almaty city in the 1960's. There were proposals to improve the comfort of the living environment of citizens based on the modernization of mass residential development to improve socio-psychological, aesthetic, and ecological conditions. The comfort of the living environment has been achieved using several architectural and urban planning techniques for transforming the residential fund. By the authors it was demonstrated a certain approach to the reconstruction of residential buildings in mass series based on the principle of the trinity; the revival of the building idea by Edem, the development of the ideas of the Russian (Soviet) avant-gardes, underlying modernist solutions of architecture in mass residential series and the emphasis on the society in a deep perception of the centuries-old experience of organizing building areas in the natural and climatic conditions of Semirechye (Central Asia), folk traditions and modern requests. The study results are presented in the form of drawings and pictures of the re-planning areas of a residential building, the extension of the loggia and elevators, the superstructure of floors through the improvement of facade solutions, and also by the development of yard areas.

**Keywords:** residential environment; large-scale development; standard houses; reconstruction; landscaping; gardening



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## 1. Introduction

Kazakhstan's increasing sovereignty and modernized nation-building have led to the generation of considerable interest in the roots of cultural identity. The architectural research in the region has intensified due to the construction of the new capital, Nur-Sultan (formerly Astana), and the modern development of other cities in the Republic [1–9]. Along with the increased levels of new construction, a problem related to urban renewal in areas of large-scale housing development arose in the 1960s and 1970s, related to the construction of standard buildings, which is being addressed in many countries today [10–13], including in countries of the former Soviet Union. Approaches to solving this problem differ in different cities, due to the specifics of each situation. However, there are several general principles that guide designers when solving the said problem [14].

These problems have a common root in the period of large-scale housing construction after the devastating consequences of the Second World War. Today, many aspects of residential houses built in standard series, which were designed all at once to efficiently solve the problem of population resettlement, no longer meet modern requirements or are unable to provide the required level of comfort [11,13,14]. In cases where they can be demolished, given that they are dilapidated housing, renovation is carried out on the vacated plots, including the building of new residential housing. However, there are

residential buildings in the capital that cannot be demolished. These require reconstruction and the landscaping of residential yards.

Today, in the context of improving the planning structure of the city of Almaty and bringing it in line with modern requirements, transforming the urban environment of residential buildings from the Soviet period is an urgent task. At this stage, due to the lack of investors, large-scale demolition of obsolete buildings is not possible. Increasing the density of residential buildings has commenced via the selective demolition of old and the construction of new residential areas, as well as the dissemination of individual residential buildings or groups thereof. Under these conditions, the problem of the architectural renewal of large-scale residential buildings requires specific approaches. This article discusses possible solutions to this problem. The authors propose to, on the one hand, adhere to the newest building development technologies, apply (and upgrade) the principles of modernism in architecture, and, on the other hand, to revive the cultural traditions of the peoples inhabiting this territory.

## 2. Data Collection and Methodology

This study uses theoretical and empirical research methods. In the first part of the article, the theoretical (general) methods include analysis, synthesis, retrospection, and forecasting. This will involve the collection and analysis of archival data, the analysis of old maps and photographs, architectural mapping, and a large amount of historical research. In the second part, the empirical methods include questionnaires, monitoring, full-scale examinations with photo fixation, etc. Graphic proposals have been developed using Sketch-up 2019, AutoCAD 2013, and Corel Draw2021.

In addition, the historical development of folk dwellings was reviewed within the territory of Kazakhstan in general and in the city of Almaty in particular.

## 3. Conceptual Research Approach

Methods of solving the problem of the reconstruction of residential areas are currently being studied in different countries in Europe and Asia. We will here address the dwelling as a spatial archetype and consider its historical development in a global context. The concept of large-scale housing development, with the typical segmentation of middle-rise buildings, that arose at the dawn of techno-civilization was preceded by the concept of a national dwelling formation, determined by the national culture of a particular people and their territorial resources. Today, in response to the trends of housing globalization and depersonalization, interest in the national cultures of various peoples is increasing. Furthermore, a problem is emerging regarding preserving the archetypes of ethnic self-identification. In this regard, special attention should be paid to the issue of national identity from the standpoint of preserving, recreating, and further perpetuating the historical, cultural, architectural, and urban planning heritage of residential formations.

On the other hand, in the 20th century, a new era of avant-garde culture has developed, which has become the basis for the artistic and aesthetic approach to building new residential areas in modern cities, as well as forming the stylistic ethos of modernism, functionalism, constructivism, and minimalism in the architectural design of factory-made residential buildings. First of all, here, we should consider the role of the Russian avant-garde [15], as associated with the architectural school VKHUTEMAS (Russia) and a similar avant-garde school [16] that emerged in the Bauhaus (Germany).

In this study, to identify the key principles in the project of conceptually restructuring large-scale residential development in Almaty, the authors consider the above-indicated approaches in more detail.

### 3.1. The First Principle Is Garden with a Yard Area

The first principle of our desired reconstruction is connected with the revival of the idea of a dwelling as Eden.

Typically, when people are good, they are happy. In this context, they feel like they are in heaven. The Garden of Paradise, or Eden, is a consistently and universally sacred place for people in all countries. The garden is what people need for an invigorated life. The garden nourishes people with sun, air, and fruits, and shelters them with foliage and the crowns of trees from bad weather. The garden is a house, a shelter, a nourishing fruit source, and a stream of water, which will feed every tree and the gardener, too.

In the hot countries of Central Asia, gardens have traditionally been grown in the foothills of the Alatau or oases along rivers flowing from mountain spurs (Figure 1).



(a)



(b)

**Figure 1.** Apple orchards in the vicinity of Almaty. (a) <https://adrenalinicsilence.kz/portfolio-archive/yablonevye-sady> (accessed on 6 June 2022). (b) <https://www.nur.kz/society/1879643-gektary-ablonevyh-sadov-vyrubili-v-almatinskoj-oblasti-video/> (accessed on 8 July 2021).

In river basins and on river banks, it was possible to build a house that almost always contained its own garden. Gardens in the vicinity of the city of Almaty have always been filled with fragrant apple trees, and the very name of the city of Almaty is associated with this fruit—it is a combination of the words for apple and father. This image should be the main defining feature for the living environment of this city, providing not only comfort

for residents in green zones of residential courtyards, but also defining the symbol of the residential “house-garden” as a sacred place (paradise), a place of rest for any person.

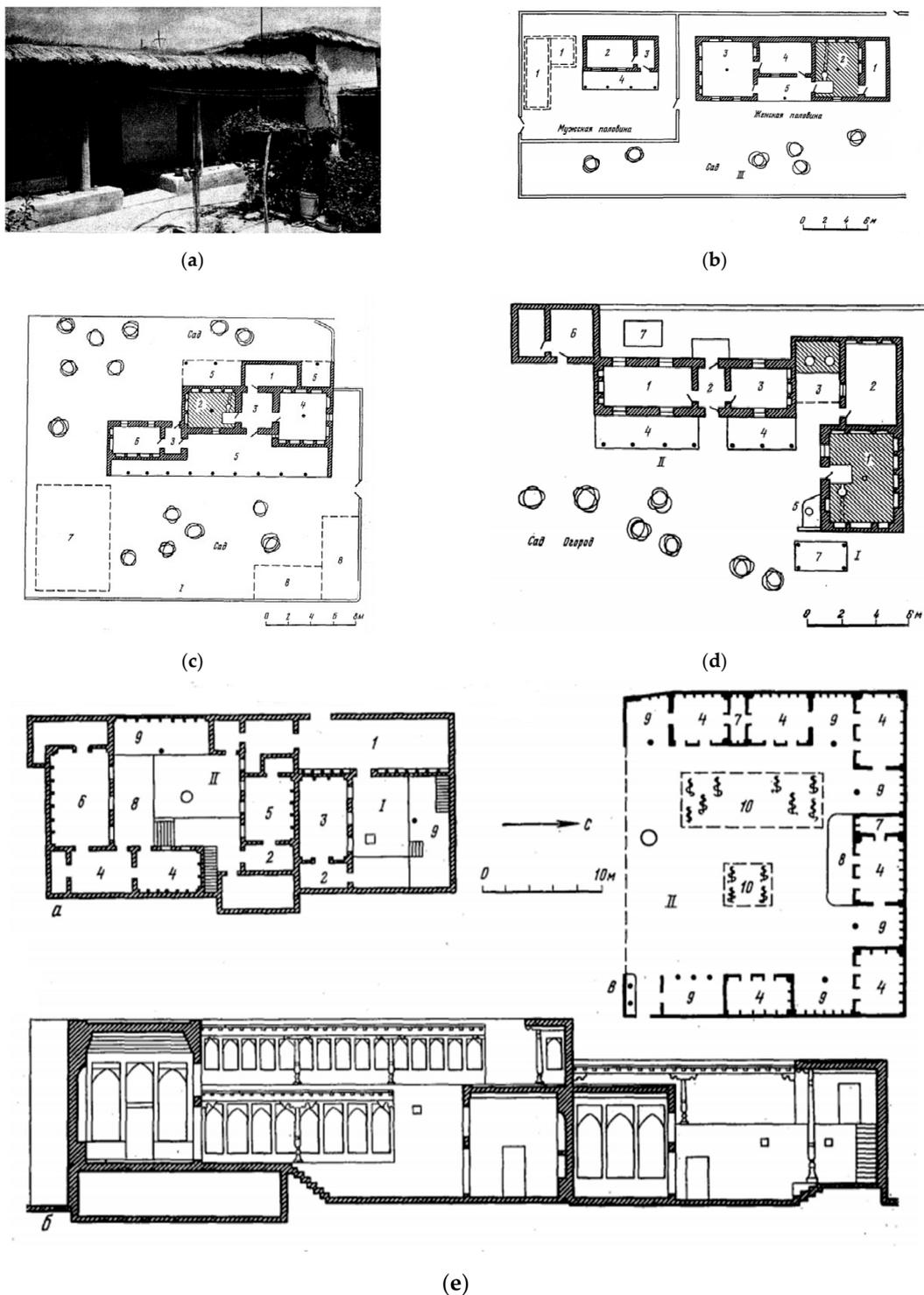
Route guides, ancient chronicles, and geographical writings note the presence of gardens in the medieval cities of South Kazakhstan. For example, the 10th-century Arab geographer Al-Maksidi notes the presence of gardens in the city of Taraz [17]. Here is what Academician N.I. Vavilov, who undertook an expedition to Asia in 1939, writes in his travel book “Five Continents”: “Alma-Ata literally means “the father of apples”. Around the city, at a great distance along the slopes of the mountains, there are thickets of wild apple trees, which make up whole forests here. Unlike small Caucasian wild apple trees, Kazakhstani wild apple is mainly represented by large-fruited varieties that differ little from cultivated varieties.” [18].

Furthermore, the monograph of K. Baipakov summarizes the findings of excavations and surveys of the area adjacent to the architectural complex Akyrtash, near the city of Taraz, dating back to the middle of the VIII century. A plan of the area is presented, and a hypothesis is put forward about the possible existence of a “quadrangular park garden” (250 × 250 m) [19].

Numerous items of specialist historical literature note that in the 10th century, as in previous periods, orchards, vineyards, vegetable gardens, and fields of crops were of great importance in the economy of the townspeople. Green areas of common use included small gardens near teahouses and on the corner of mosques, which were both utilitarian and decorative [20].

Returning to Almaty, the city of Verny (the pre-revolutionary name of Almaty) made an indelible impression on visitors who found one enormous garden. Here, an orchard grew near every single house, but there were also many quarters containing only one residential building and no other buildings at all; these territories were specially allocated as orchards. The most prized and prioritized of the fruit trees was the Oporto apple, which grows in several varieties here. By 1917, there were 22 square meters of city green per inhabitant [21].

Traditional folk dwellings have been studied by a number of researchers. In the historical cities of Central Asia, residential housing comprised a closed system with an inner courtyard. Located along the perimeter of the site, and joining with the end walls in one row, the rooms were arranged so that they were open to the courtyard and faced the street with a windowless back side. Whenever possible, running water was brought into the courtyard, which was landscaped, thus contributing to the improvement of the microclimate. The house did not always occupy the entire site area; the building would be built at right angles and gave into the garden (Figure 2). A fence prevented street dust from entering the courtyard and helped to create a microclimate. The yard acted as a thermal regulator, keeping the night air cool until midday. Watering in the evening moisturized and cooled the yard and was the simplest form of air conditioning. The temperature in the yard would have been lower than the outside temperature by 4–5 °C. The garden was planted with fruit trees, vineyards, and flower beds. Water reservoirs were arranged for drinking, household needs, and irrigation. The water reservoir would have been planted with trees—elm (*ulmus*), poplar, and plane trees. Their crowns covered the reservoir, preventing evaporation, while the roots strengthened the banks. Platforms (*sufa*) were built under the trees near the water. [22].



**Figure 2.** The traditional form of a rural house in the territory of Southern Kazakhstan is: (a) A house of traditional layout with an aivan, built in the village of Karnak in the 1930s. (b) The layout of traditional dwellings and estates of the late 19th to early 20th century for the wealthy strata of the population. (c) The plan of the judge's house and estate (treasury), built at the end of the 19th century. V. S. Karnak (s—z Atabaevsky) Turkestan district of the Shymkent region. (d) The plan of a house built during the Soviet period in the village of Ikan (Eski Ikan), the Turkestan district of the Shymkent region. Source: A. N. Zhilina, Traditional settlements and housing of the Uzbeks of Southern Kazakhstan, E.E. Nerazik and A.N. Zhilina "Housing of the peoples of Central Asia and Kazakhstan", Moscow: Nauka, 1982. (e) Perimeter yard construction: a, b—house in Bukhara (plan and section), c—house in Kitab (plan). (<https://www.academia.edu> (accessed on 8 July 2021)).

The main building unit of the city in the late Middle Ages was the quarter, a section of a street with houses giving into it. Lining the main streets and inside residential areas, the quarters, as a rule, were surrounded by blank walls, while each house had an individual exit to the intra-quarter street. In addition to the main streets, communication between the quarters was enabled via a network of narrow connecting lanes. The configurations and areas of the quarters could be different—there were rectangular ones, as well as trapezoidal and polygonal, with areas of up to 0.25 hectares. Despite the diversity of the general outlines of the quarters, there were some clear “red lines”, denoting well-planned houses, symmetrically accompanied by a “kosh” inside the quarters. These comprised paired ensembles of buildings, built on the same axis, with unloading platforms, or “pockets”, along the narrow streets. Each quarter included 6 to 15 housing estates [23].

Historically, Kazakhstan, and especially its southern part, has been most strongly influenced by the Central Asian region. Similar climatic conditions meant that many daily activities in the two regions were undertaken according to the same structure; therefore, the process of morphogenesis in this territory is considered by many authors as in unison with that of the entire Central Asian region [5].

L.S. Zaleskaya also studied how the traditional houses of the peoples of Central Asia were arranged (Figure 3). She describes the folk dwelling as follows: “The old Central Asian city with its narrow winding streets was rich in greenery, but it was located almost exclusively on estates—in courtyards, behind residential buildings, along ditches” [24]. The residential courtyard of a house in Central Asia would include a plot with an orchard, garden crops, and several ornamental plants. The old city, with its empty streets and richly landscaped courtyards, has been considered a characteristic of Central Asia for a long time. In the writings of travelers of the 18th and 19th centuries, we find detailed descriptions of gardens [25,26], surrounded by duvans (cob walls) with a water reservoir, a sufa (artificially raised platform made of ground excavated from the pool, used as a resting place), and an iwan. A large number of vined pergolas creates dense shadows. A carefully constructed area near the house and outbuildings would be surrounded by flowers. A small garden irrigated with a ditch would be planted with tomatoes, corn, and melons. Apricots, peaches, mulberry trees, almonds, pomegranates, apples, wild apricots, quince, pears, and fig trees would grow in the garden. The free space in the garden would be sown with alfalfa. There would have been no track layout; only the straight grooves of ditches divided the territory. The fruit garden would usually have been bordered by rows of decorative trees (Lombardy poplar, sycamore, purple osier [willow]). Purple osier would often be planted near a fence to create a dense hedge. The closer you got to the city center, the smaller the areas of the yards would become, with the gardens reduced to one decorative, wide-crown tree and a small bed with crops of corn and flowers. Almost universal to the yards were vined trellises and pumpkins growing up a pergola near a house wall. A high duvan would be richly ornamented, on the entrance side, with a complex pattern etched into the clay wall [24].

Ditches have long been an integral part of Almaty and are a distinctive local architectural element of the city. In 1874, a project to establish an irrigation system for the city streets began with installing a head ditch and a distributed network of ditches along the streets. The ditch system that existed before was replaced with a new head ditch. The new system could irrigate 20,000 hectares of the city’s territory. This system, however, had a much greater effect than just solving the utility needs of the city; ubiquitous gardening in the city began as a result of the unique microclimate created in urban quarters by streams of mountain air and the sanitation of the streets by the irrigation ditches, which permeated the entire city center and introduced the presence of nature in the city. This effect was enhanced by the network of water in ditches lined with rubble stone [21]. Older people affectionately recall this time, saying that the ditches used to “talk” and “sang” their song. The impression is very romantic: each ditch with its distinctive song, clean potable water, and Oporto apples that could float straight into the hands of an Almaty resident from the apple orchards.



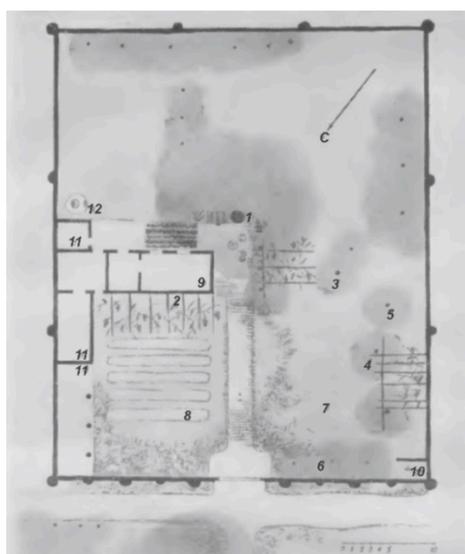
(a)



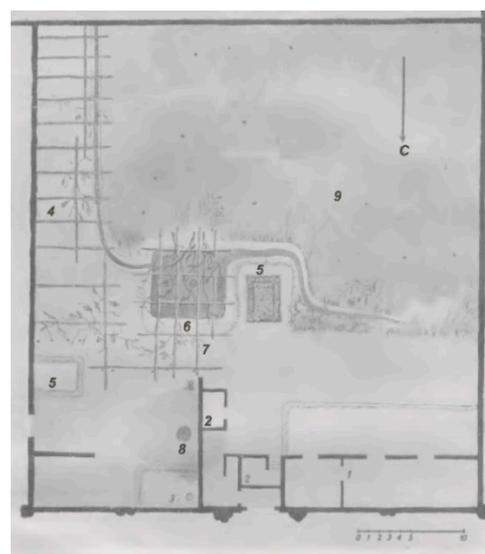
(b)



(c)



(d)



(e)

1—karagach  
2—vine  
3—here  
4—apple tree  
5—pear  
6—quince

7—clover  
8—potatoes  
9—residential premises  
10—restroom  
11—service buildings  
12—oven

1—residential premises  
2—services  
3—oven  
4—premises for livestock  
5—ufa

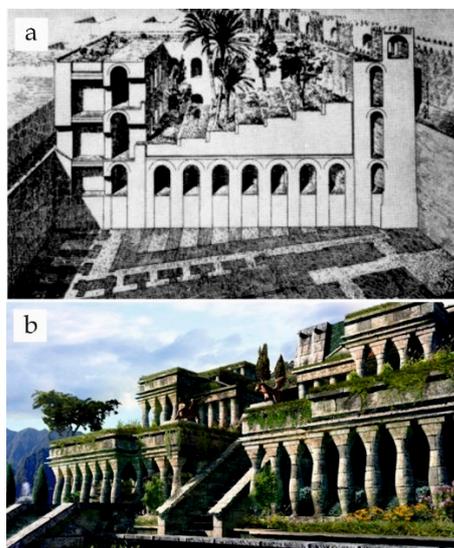
6—house  
7—pergola with vineyard  
8—mulberry tree  
9—orchard

**Figure 3.** Traditional folk dwelling in Central Asia (according to Zelenskaya L.S.): (a) elm tree, (b) vineyard on the 2nd floor of a house (Kokand city), (c) vineyard on the 2nd floor of a house (Samarkand city), (d) Nuridinov Nabi house plan (Samarkand, Penjikentskaya St.), (e) plan of a country house on Khiva St., Samarkand. (<https://docviewer.yandex.kz> (accessed on 8 July 2021)).

We propose to recreate this atmosphere of green landscaped corners, acting as gardens of paradise in residential courtyards in Almaty. “With our prodigious store of knowledge, we have it within our power to create on this earth a veritable garden paradise” [27].

To begin, we should look into the past, at how the idea of Eden, the paradise on Earth, emerged and how it has been implemented.

The history of garden creation goes back millennia. Special regard is given to the myth of the World Mountain and the World Tree, designating and distinguishing the sacred center of the world [28,29]. One example of the gardens of the Ancient World is the legendary Hanging Gardens of Babylon, ranked as one of the seven wonders of the world (Figure 4).



**Figure 4.** Hanging Gardens of Semiramis (graphic reconstruction); (a) <https://present5.com/arxitektura-dvurechya-mesopotamiya-1-v-tys-do-n/> (accessed on 8 July 2020); (b) <http://ancient-buildings.ru/architektura-drevnego-vostoka/gde-nachodilis-visyachie-sadi.html> (accessed on 1 June 2022).

These were not only a myth but existed in the culture of Mesopotamia [30]. In 1900, an archaeological expedition led by the German scientist R. Koldewey discovered fragments of the foundation of the Tower of Babel and the walls of the city of Babylon. The remains of terraces of a four-tiered tower were found in the ruins. The archaeological reconstruction made it possible to establish that the terrace platforms were made of boulders covered with a layer of rush and filled with an ancient analog of asphalt. Then there was a layer of bricks, lead plates, and a further layer of fertile soil. The levels were connected by stairs and supported by colonnades. From an observer's point of view, the structure was impressive—it would have seemed like a mirage, a green garden in the middle of a desert. This is the description given by the ancient Greek historian Herodotus [31,32], which existed in the 5th century BC in the Gardens of Babylon.

The dry, hot climate would have contributed to the walling of Central Asian gardens in the 11–15th centuries. The Central Asian garden scheme of “perimeter wall–garden–central pavilion”, seen in Iranian cities of the 16–17th centuries, developed into the “perimeter building–garden” scheme. This was more enclosed and more efficient in urban environments. Courtyard gardens and garden tectonization limit dust transfer and solar radiation and contribute to the creation of a stable temperature and humidity regime. The idea of the four rivers of paradise was embodied in the rational establishment of irrigation ditches, an idea that gave rise to the name chor-bag—four gardens. The chor-bag was a compact interior space and a specific type of architectural garden in Central Asia (Figure 5) [33].



The shape of the city is a circle. The area of the city is 5000 acres, and the area of the agricultural belt is 1000 acres (so the total area of the city is 6000 acres). The city is crossed by six boulevards (120 feet wide) that divide the city into six equal sectors. The central square—the intersection of the boulevards—is a 5.5-acre circle (also a garden) surrounded by public buildings: the town hall, library, museum, hospital, etc.

The central sector is surrounded by a glass gallery—a public park of 145 acres (with sports venues). The Crystal Palace is also a part of the park and is covered. Exhibitions and trade events are held here. At a distance from the center, concentric rings of buildings expand (each is surrounded by additional land—this is not compact planning) [36].

Howard's scheme grew out of his criticisms of contemporary industrial cities, which grew uncontrollably, displayed unsanitary conditions, and were a generally chaotic and inhuman spatial entity. It is especially interesting for us that his scheme envisages a park in the very center of the city, i.e., a green zone. This is encircled by residential buildings—low-rise buildings with private plots that are also greened.

It should be noted that attempts to introduce traditional gardens into residential building schemes in the cities of Central Asia were made during the Soviet period. This concept formed the basis for the planning of microdistricts—the standard territory of microdistrict gardens was reduced, and this reduction was compensated for by an increase in private gardens. Since the 1950s, the integration of gardening into the structuring of new cities has been implemented by reducing the areas of planned planted units, placing them in urban development spaces, furnishing them with greater regularity and expressiveness, and reviving the concepts of courtyards and linear historical types of gardens. Here, these linear types were used similarly to the linear bazaars, acting as the “ridge” of the planning structure of a new city. The establishment of the first quarters of the new city of Navoi (architects A. Korotkov, I. Orlov, N. Simonov, V. Ivanov, et al.) showed that private garden spaces could be greened most effectively. As such, the standard areas of microdistrict gardens were reduced, and the areas of green spaces within the residential estates that made up the microdistrict were increased. An interesting example of this type of gardening can be seen in the Palace of Culture city “Farhad”, the courtyard of which was planned in the strict style of a traditional chor-bag garden [33].

Thus, the idea of a garden city, combined with the image of the Hanging Gardens of Babylon and the desire to revive the traditions of the folk dwellings of Central Asia, which necessarily contained gardens, comprise the basis for our landscaping project aiming to reconstruct the residential courtyards of mass developments in the city of Almaty. This is united with the desire to revive significant historical symbols and folk traditions that have been forgotten today, along with the related folk crafts and customs that are decaying, as this historical forgetfulness has also affected the cultivation of apple orchards in the vicinity of Almaty [37,38].

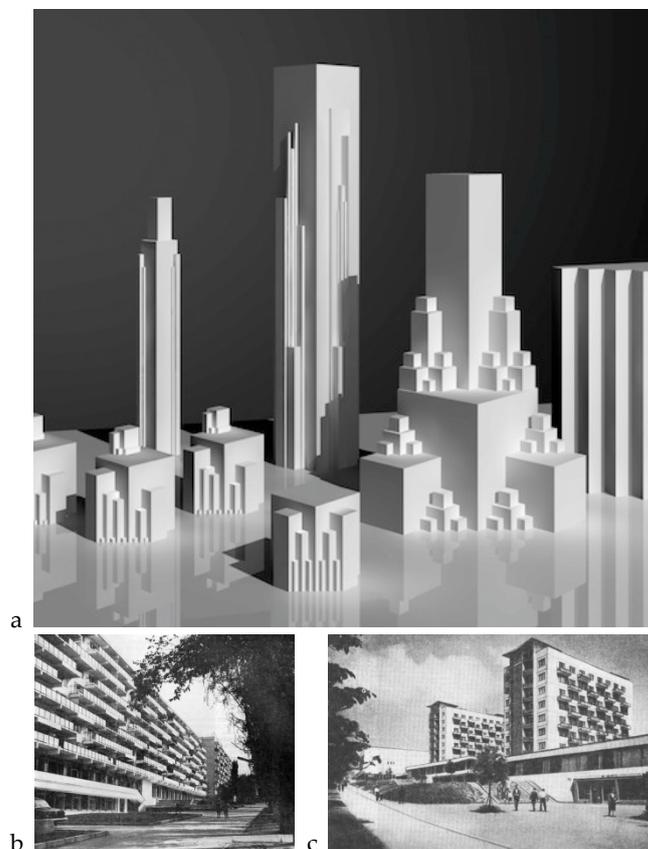
### *3.2. The Second Principle Is an Avant-Garde as a History Development of the Typical Series of Buildings*

The second principle dictating our reconstruction of a large-scale dwelling from the Soviet period is associated with developing the ideas of the Russian (Soviet) avant-garde.

To address the composition of a group of residential houses under reconstruction, we must review the history of the design of typical series from the Soviet period in more detail.

The creation of typical residential buildings in the Soviet period is based on the history of Russian (Soviet) avant-garde architecture [39–41]. This economical housing, with simple, even lapidary forms, is in line with the famous architectons of K. Malevich [42,43], combined with El Lissitzky's prouns and planitas [44,45]. At the beginning of the 20th century, the latest forms of architecture and art, in general, were being developed under the VKHUTEMAS [46–50] and the Bauhaus [50]. The motto put forward by one of the leaders of the Russian avant-garde, Vladimir Tatlin, was “Neither the old nor the new, but the necessary” [41].

Malevich's plane suprematism resulted in volumetric–spatial compositions called architectons (Figure 7a). These served as the prototype for new architectural forms, including residential buildings built in the 20th century (Figure 7b,c).

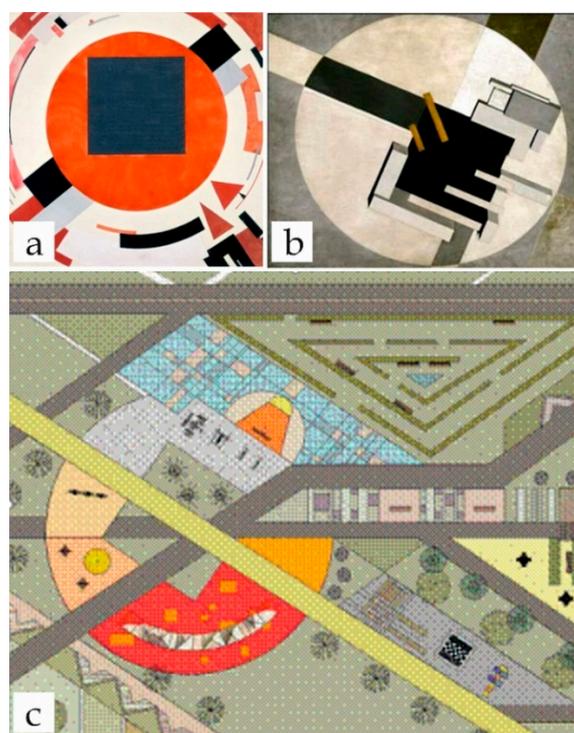


**Figure 7.** (a) Malevich's architectons. <https://thecharnelhouse.org/2012/11/22/the-arkhitektons-and-planets-of-kazimir-malevich> (accessed on 8 June 2022); (b) Alma-Ata. Residential buildings on Lenin Avenue. Architects N. Ripinsky, T. Basenov, A. Petrov, etc.; (c) Vilnius. Žirmunai. Microdistrict D-18. Architects B. Kasperaviciene, B. Kruminis. 1967. Type of development [http://ussr.totalarch.com/general\\_history\\_architecture/1955\\_1970/house\\_social](http://ussr.totalarch.com/general_history_architecture/1955_1970/house_social) (accessed on 8 June 2022).

A new form of 20th-century architecture was also proposed by El Lissitzky. His prou— the new assertion project—was created to visualize the emergence of plane suprematism in architecture. It was proposed as the central formative idea of residential space landscaping and was intended to determine geometric solutions for territorial planning (Figure 8).

The first post-war standard series, with economical apartments, were developed under an all-Union competition announced by the USSR State Construction Committee and the Union of Architects in 1956. In the 1960s, similar standard series oriented towards industrial production were designed, but this time not for the single-room family accommodation in houses, but for apartment-based family accommodation [51,52]. However, earlier projects also aimed at organizing a new way of life in the USSR. In 1925, a project to design apartments for a worker's family was commenced by Nikolai Ladovsky, one of the leaders of the VKHUTEMAS. Sectional residential buildings soon appeared in Russia as a form of urban building with expensive, comfortable apartments. In the 19th century, these mostly manifested as medium-rise tenement buildings. In the 1930s, the construction of sectional residential buildings began in urban areas free from buildings, which were workers' settlements. Residential buildings quickly became city-forming elements of neighborhoods and residential areas, and in the 1940s, the typical low-rise construction of houses with two or three floors was widely introduced. Cities began to "sprawl" geographically, and soon, this type of large city development was recognized as inexpedient.

It was decided to construct multi-apartment residential buildings with four to five floors, which were the most convenient at that time. From 1920–1930, research was carried out to design, develop and construct economical residential buildings, which helped determine the compositions and areas of rooms in apartments and the availability of building utilities. There was a clear intent to reduce the areas of rooms and apartments in general. Thus, a two-room apartment for a worker's family (arch. N.A. Ladovsky, 1925), with a total area of 28 m<sup>2</sup>, consisted of: two living rooms (one less than 8 m<sup>2</sup>—non-walk-through; the second slightly less than 10 m<sup>2</sup>—walk-through); a front hall—2 m<sup>2</sup>; a kitchen—about 4 m<sup>2</sup>, and a toilet. The development of an economical layout for apartments with a small living area also determined corresponding planning solutions, as well as the composition and nomenclature of the premises, their relative positions in the apartment structure, and their parameters. In the late 1930s, the USSR Academy of Architecture created an experimental design for new apartments with small living spaces [52].



**Figure 8.** About El Lissitzky. (a) Planetary suprematism <http://www.art-drawing.ru/images/comments/el-lisitskij-proun.jpg> (accessed on 6 June 2022); (b,c) The concept of the master plan of the city <http://cscb.su/n/031001/031001039.htm> (accessed on 8 June 2022).

The typification and industrialization of construction have always been a main focus of one of the major representatives of the Russian avant-garde, M. Ginsburg. He tried to establish a theory of Soviet architecture in the second half of the 1930s and showed that the introduction of new technologies into construction could not but affect the compositional structure of a building, given the development of a new artistic language in architecture [53]. One of Ginsburg's major works on housing construction dates back to the war years, when Ginsburg headed the Bureau of Typification at the USSR Academy of Architecture. Realizing that in the post-war years, large-scale housing construction would be necessary, Ginsburg developed in advance a number of fundamental requirements related to mass housing construction under standardized projects, with the specifics of the post-war period factored in. In 1943–1944, he designed a series of typical low-rise buildings for the southern regions.

Through the work of the State Planning Committee and Giprogor, some proposals were developed that later had great importance for housing construction in the country. Firstly, it became clear that the creation of one type of building with a rigid social structure does not

solve the housing problem; a system of typical residential buildings is required, which must take into account the diversity of everyday lives and needs, but all of them should also stimulate the transition to a new way of life. Secondly, this work established a new approach to technical and constructive issues. In this transitional period, Ginsburg considered it permissible to build a vast number of dwellings with a short depreciation period, using lightweight structures. Thirdly, searching for new forms of socialist settlement led Ginsburg to consider the development of network services for the population, approaching the issue as not only concerning a service system for a given residential estate but as related to the possibility of a single service network for residents of all populated areas. Fourthly, these settlement issues led to interesting conclusions about the nature of residential areas. Ginsburg believed that large areas of low-rise or high-rise buildings should be surrounded by greenery and be dispersed freely [54].

Since the mid-1950s, the main goals of housing design and construction have been speed, mass character, cheapness per square meter, and industrialism. Buildings had to be quickly assembled on-site from factory-made parts. These goals have transformed the concept of residential architecture. The search for artistic aesthetics and decorative elements faded into the background, while the technology of manufacturing building elements, the speed of construction, and efficiency came to the forefront. It was during these years that the main solutions for large-scale small-sized economical housing were established, resulting in hundreds of characterless residential quarters, each similar to the other and devoid of any individuality and architectural expressiveness.

New standards for housing were developed, and the minimum permissible sizes of living rooms, kitchens, and combined bathrooms were introduced. All this made it possible to unify and reduce the costs of construction. On 1 January 1955, the USSR State Construction Committee introduced building codes and regulations (SNIps), which were approved for mandatory application by all ministries, departments, and Councils of Ministers of the Union republics. SNIps became the main working documents for designers and builders. In 1962, by decision of the Government, the SNIps were revised and reissued. They applied to all types of construction. Subsequently, the SNIps were repeatedly revised, changed, and supplemented, and today, new regulatory documents are used—sets of rules (SP). Since the mid-1950s, active theoretical research has been carried out on standard design, with the search for new methods of developing standard series of large-scale housing taking precedence.

The 1960s–1980s marked a new stage in housing development. During this period, work was carried out to align types of families with types of apartments. We see proposals regarding the range of apartments available both in that period and in the long term. In general, design and construction during this period involved a limited number of types of houses and apartments, with little variation in living spaces and utilities. The rejection of promising monolithic housing construction approaches, and the raised enthusiasm for prefabricated panel construction, are still apparent today. As a result, various types of residential buildings were actively introduced, both in the Russian Federation and in the territories of the Union republics. At this time, the principle of the serial design was employed, leading to the establishment of complex series. As such, in the 1960–1980s, the 1-439, 1-447 and 1-464 series, along with their various modifications (1-439A-5 (7, 12, 37, 38, 40, 41, 42, 44), 1-447c-4/5 (5/60, 12A, 12/61, 17, 36, 37, 38, 39, 40, 43, 44, 46, 47), 1-464A-1к (2, 2к, 3, 14, 16, 30, 54), etc.), were employed in large cities. In general, despite the seemingly huge variety of series, the main disadvantages of these types of residential buildings include the uniformity of their volumetric planning solutions, as well as the lack of modern utilities in the apartments, residential buildings, and adjoining buildings. These buildings are characterized by a typical set of one-, two-, three- and four-room apartments. Depending on the series, some differences can be noted in the layouts of the apartments, but they are too insignificant to affect the overall function or planning structure [52].

### 3.3. The Third Principle Is Creating a Comfortable Area

Large-scale residential development in standard series was carried out from the 1960s to the 1970s in various cities and countries. Today, at the beginning of the 21st century, it seems to have exhausted its resources in terms of both functional planning solutions and constructive and engineering aspects. In addition, modernization of architectural appearance is required. Specialists from different countries have looked into how the renovation and reconstruction of such residential areas can be enacted.

A detailed study was carried out by Maria Melnikova. She studied typical series of residential buildings in Russia, Germany, and the Baltic countries. Melnikova M. reviewed the possibilities of upgrading the large-scale developments in residential areas of various cities in these countries [13] (Figure 9a–d). She particularly studied the social prerequisites for reconstructing residential buildings in specified periods. It was recognized that four- to five-story panel houses do not only comprise a huge amount of living space in modern cities. They also help develop a unique community of townspeople (society) who need a more comfortable living environment and who, at the same time, do not want to alter their place of residence by moving to the outskirts of the city.

The German architect Stefan Forster radically changed the internal and external environments of five-story buildings, expelling any negative sentiment and significantly improving the dwellers' lifestyles (Figure 9e–h) [55]. In a European city, where history must always be considered, the typology of existing buildings demands building different buildings. Residents of each house received small gardens, or "green rooms", as the author called them—their own comfortable private spaces sectioned off from the street by a low fence. The idea was to change the image of the area to that of a traditional German city—a garden.

The reconstruction of residential five-story buildings in Moscow was carried out over several years at the beginning of the 21st century by the architect A. Krotov (Figures 10 and 11). A. Krotov's famous sentiments, such as "Reconstruction of five-story buildings is a solution to a national problem!" and "To rethink the ancestral ideals without rejecting achievements, without destroying the physical environment that has already created—this is the main task facing architects nowadays" are becoming more relevant now than ever.

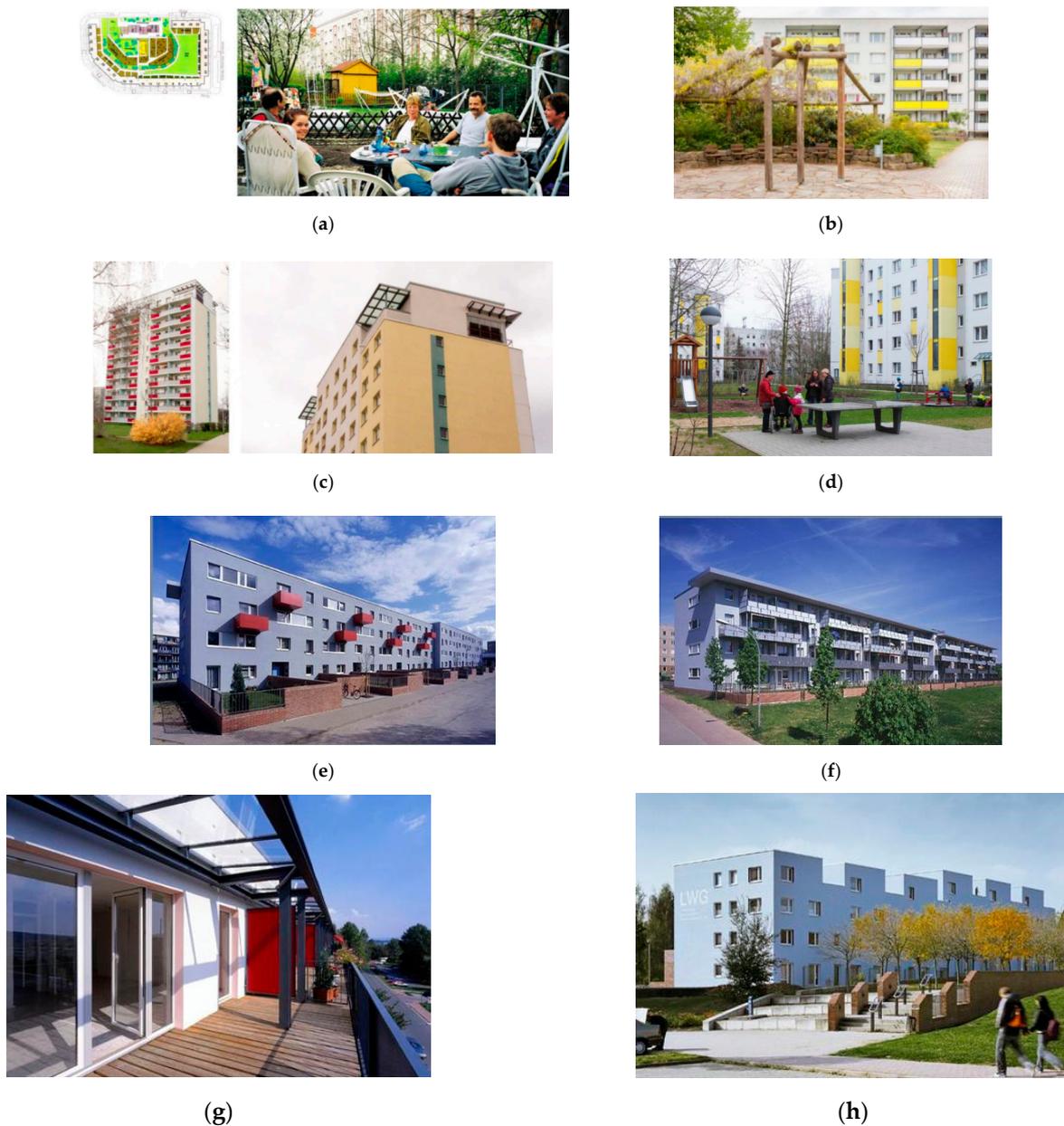
His studies of these problems led to the conclusion that reconstruction is more economical, and in every sense more profitable, than renovation (i.e., the demolition of old buildings and the construction of new modern housing on vacated territories) [56].

We have established a design solution for reconstructing a standard, large-scale series of residential buildings from the Soviet period, exemplified by the reconstruction of five-story buildings in Moscow (Figures 10 and 11). At this stage of reconstruction, a re-planning of apartments was proposed to create comfort; a superstructure of floors and enclosing constructions, pylons, and monolithic frames were built, and an elevator and ventilated facade were installed [56].

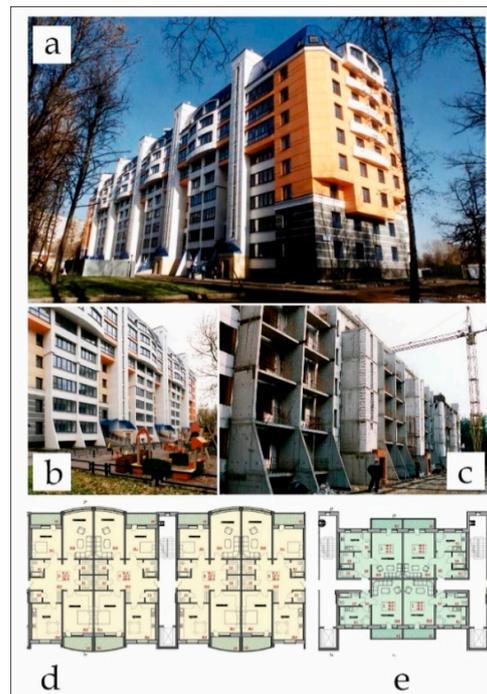
Alexei Krotov applied various reconstruction modes to five-story buildings. For example, he proposed inserting new houses into existing housing groups for the temporary accommodation of dwellers. He also proposed another method of reconstruction that did not involve resettling the dwellers from their apartments.

A similar method was described by Melnikova concerning reconstruction in the cities of Germany [13].

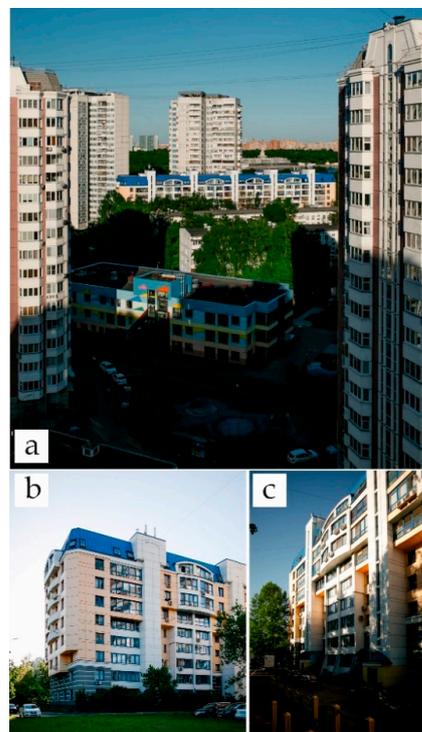
The solution to designing a residential yard is here considered via the example of the city of Izhevsk (Figure 12). A conceptual solution is shown that defines functional zoning as well as transport and pedestrian connections. The landscaping of property in the vicinity of the Palace of Pioneers, "Zvezdny", was achieved using conceptual associations: a round square with a monument in the center embodies the heliocentric system of the Order of the Revolution—the sun is represented by benches; flower beds and stairs are the orbits of the planets; lanterns are stars; the lighting built into the coating resembles a photograph of the starry sky taken with a long camera exposure; the playground represents the lunar surface; the smooth shape of the ice rink resembles the image of the icy dwarf planet Pluto, with the famous spherical willow representing hope for extra-terrestrial life, etc. [57].



**Figure 9.** (a) Garden plots centered on the courtyard of a residential building. (b) Landscaping example for a residential courtyard within the Lobeda area, Jena—landscaping example where a tree is used, and creating green space is the main landscaping element. (c) Additional stories within the Lobeda area, Jena. Similar projects were implemented from 1990–2000. (d) Social ties between residents are a key safety factor. Wuhletal cooperative courtyard. Source: M. Melnikova “Not just panel buildings”. (e,f,h) Projects for the reconstruction of buildings by the German architect Stefan Forster. (g) Open terraces instead of the former balconies. Source: (<https://archi.ru/russia/6176/shtefan-forster-znatok-pyatietazhek> (accessed on 19 January 2022)).



**Figure 10.** Reconstruction of a house with a superstructure of floors according to project A. Krotov: (a,b) The general view of the house after reconstruction. (c) The reconstruction process. (d,e) Variants of planning solutions, with the organization of a staircase–elevator hall and a change in the apartment. (<https://www.akrotov.ru> (accessed on 15 January 2022)).



**Figure 11.** Reconstruction of a house with the superstructure of floors according to project A. Krotov: (a) The house after reconstruction in the neighborhood environment. (b,c) The house is given an individual appearance by the architectural and planning techniques proposed by the author, reviving the residential environment. (<https://www.akrotov.ru> (accessed on 15 January 2022)).



**Figure 12.** Improvement of a residential yard in Izhevsk (project) (<http://tehne.com/event/novosti/vse-proekty-konkursa-koncepciy-blagoustroystva-territorii-prilegayushchey-k-mfk-rivera-zhknol-v-izhevsk/> (accessed on 8 June 2022)).

In the example of the reconstruction of five-story residential buildings of typical series from different countries, it is proposed to create a comfortable area for residents by the re-planning, superstructure of floors is proposed, as is underground parking. Based on the history of the development of the idea of the Russian avant-garde to create a composite living environment in the yard area, and to create a green recreation for residents, the idea of a garden city was used. Thus, the three principles we have identified can form the basis of a conceptual solution to reconstruct a large-scale residential development from the Soviet period in Almaty.

#### 4. Place and Subject of Research

We can view the townspeople not only as independent or active consumers but also as architectural space-shapers (MP Nazarova).

The location of the research is the city of Almaty.

The research target is microdistrict (MCR) No. 1 within the large-scale residential development from the Soviet period. The subject of the research is the reconstruction of the residential environment and which methods are the most acceptable and recommendable for microdistrict No. 1 in the city of Almaty, specifically for landscaping a residential yard in this microdistrict.

The residential areas studied in this work are located in a residential area to the west of the historic district of the city. It includes microdistricts No. 1–12, and 12a, containing panel four-story standard houses of the 1K3-464ДC and 1K3-464AC series.

The residential area studied by the authors was built in the 1960s and has a mixed population. It includes older people who were born and grew up there, migrants who bought affordable housing in recent decades, and tenants who arrived later and rent apartments. The last two groups are mostly represented by students and residents working in various enterprises in the city. The socio-demographic composition of the residential area's population, as well as its architectural and spatial environment, were studied via a questionnaire survey of the residents, and on-site surveys and photographic recordings of residential buildings and courtyards were taken.

#### 5. Analysis

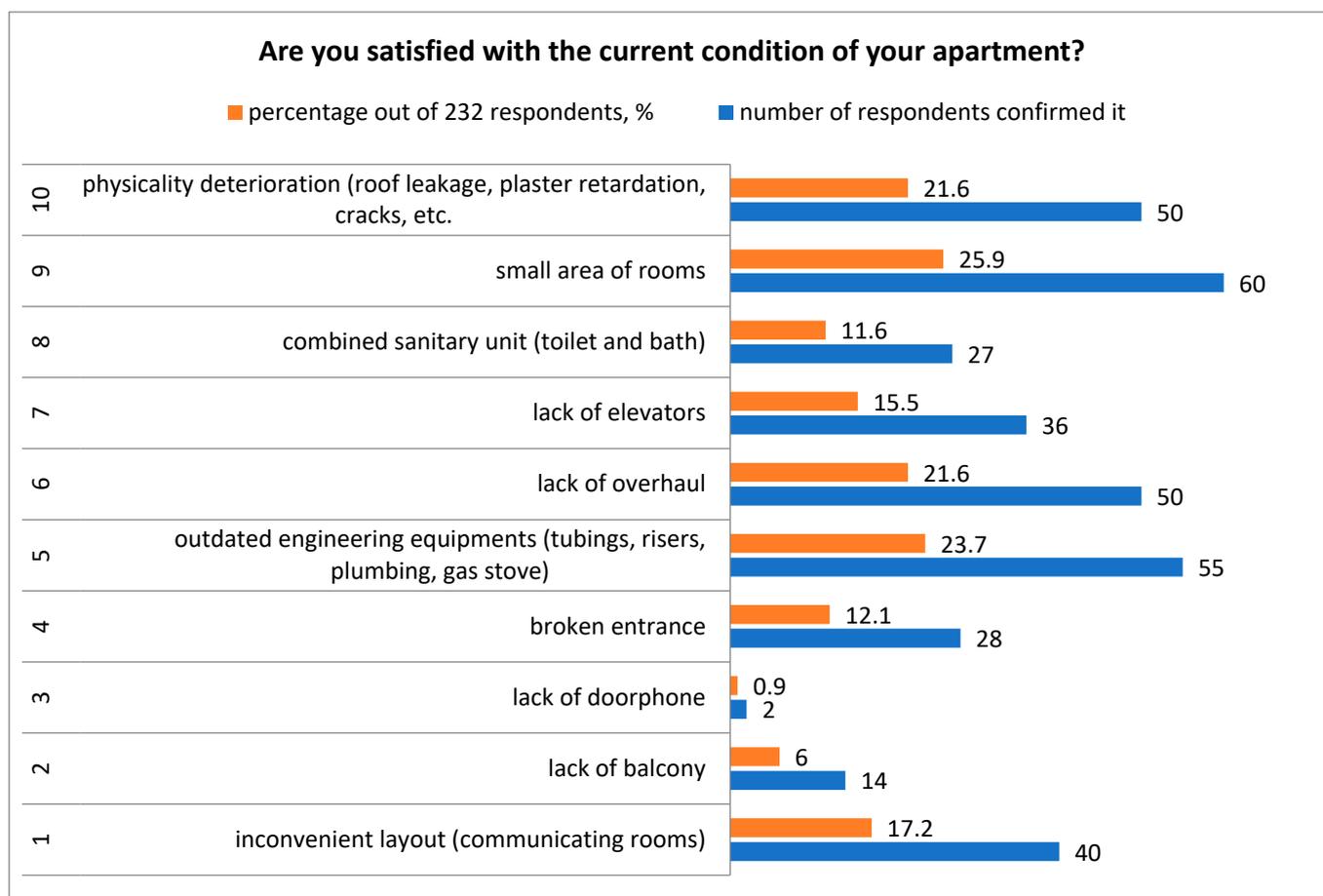
##### 5.1. Socio-Demographic Characteristics

Architectural space refers to an environment for human activities, which is designed in accordance with social necessity, technical capabilities, and human aesthetic ideals. We can talk about citizens as an independent and active entity, involved not only in consumption but also in the formation of architectural space [58].

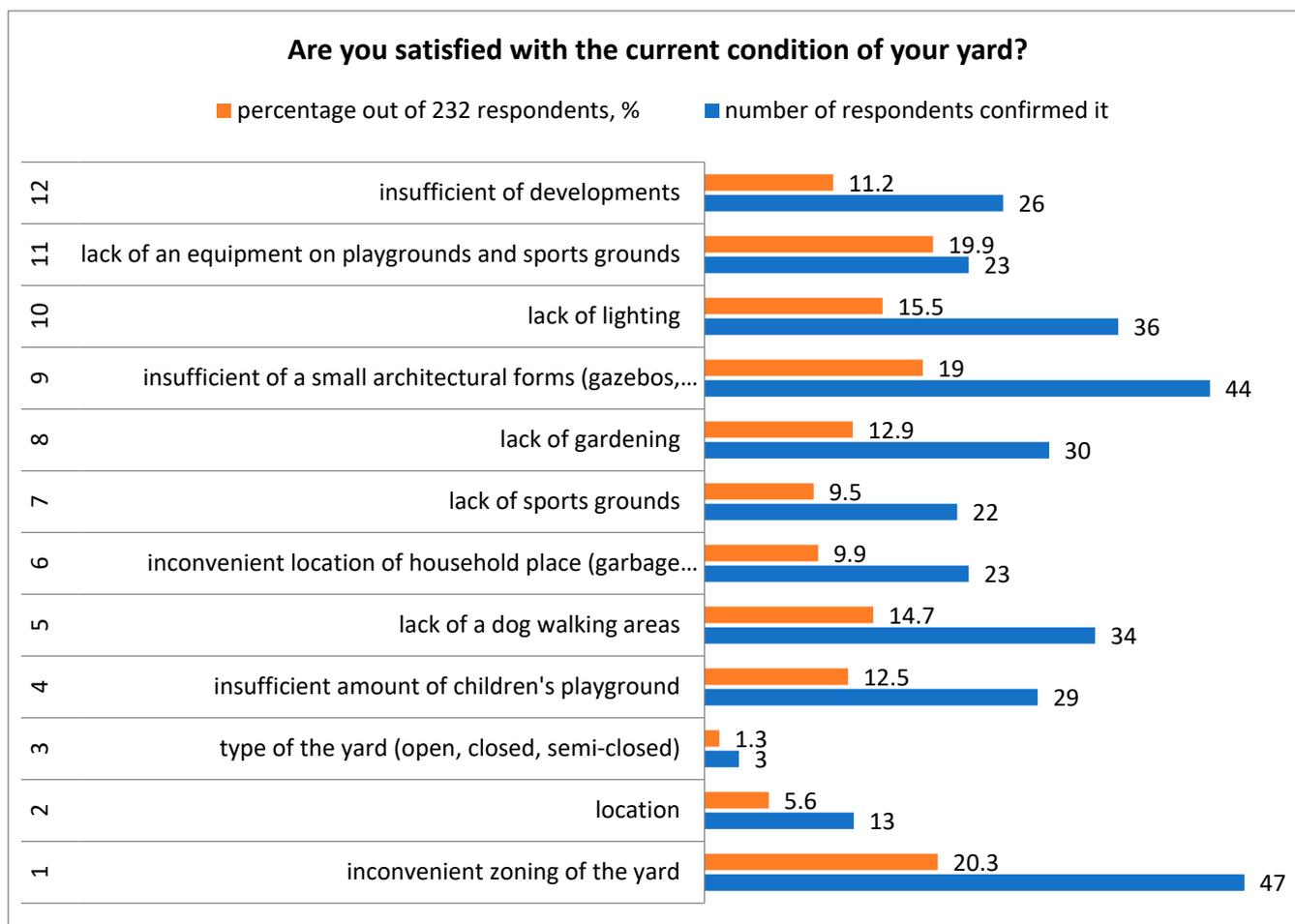
According to data from the Almaty city administration's polling stations (2021), 89,961 people live in microdistricts No. 1–12 and 12a, of which 65,259 are adults and 20,702

children; that is, 72.6% are adults and 27.4% are children. Among the adult population, the number of people aged 18–29 is 12,074, or 13.4%. The number of residents over 65 years old is 11,100, or 12.4% of the total number of residents. Children of preschool and school-age (up to 18 years old) constitute 23% or 20,702 people.

During our on-site surveying of the reconstructed territory, the interests of groups of residents were identified (Figures 13 and 14), which can be grouped in the following areas: chess, amateur performance, sports, gardening, children’s creativity, animal lovers (dogs and cats), etc. These interests and activities were related to certain places in the territory under consideration, in the form of amateur chess players playing on benches, children’s drawings on asphalt and plein-air paintings near the entrance area to an art school, gardens well-tended by residents, walking “dog lovers”, etc.



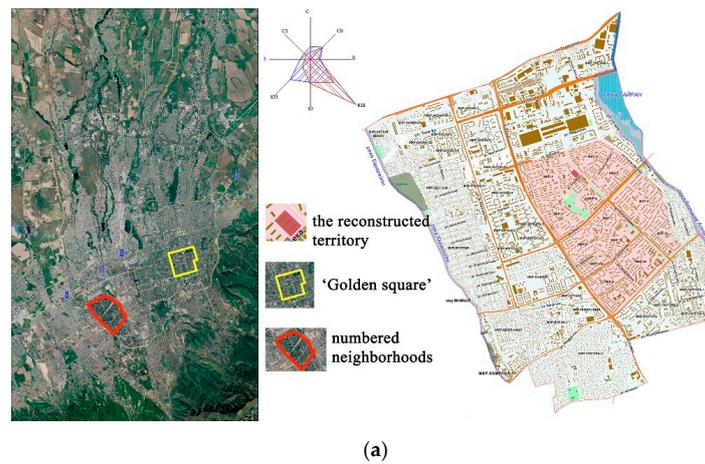
**Figure 13.** The results of the social survey (Author’s material).



**Figure 14.** The results of the social survey (Author’s material).

### 5.2. Current Position—Baseline

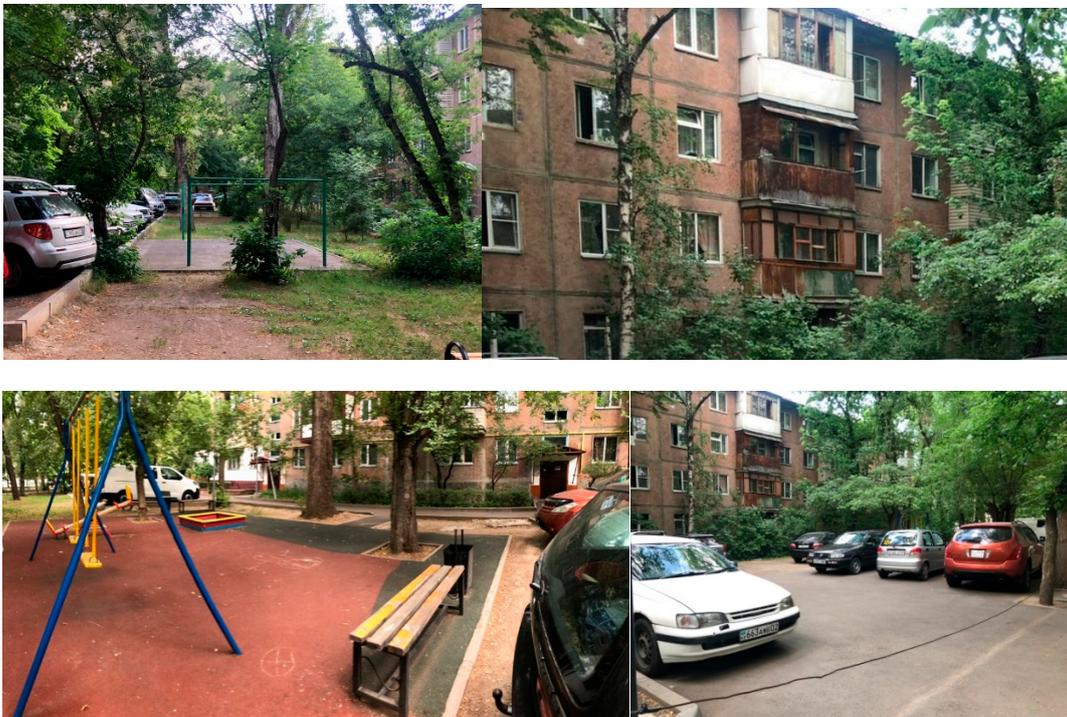
The reconstructed territory is located in the Auezov district, in the western part of Almaty, at the intersection of Altynsarin street and Ulugbek street, in microdistrict №1 (Figure 15) The site is bordered on the north-eastern side by the main street of the district, Altynsarin, on the south-eastern side by the residential street Ulugbek, and on the other sides by four-story residential buildings. At present, these residential buildings are at the limit of their design lives. The on-site survey revealed that the territory suffers from a number of problems, as described in Table 1.



(a)



(b)



(c)

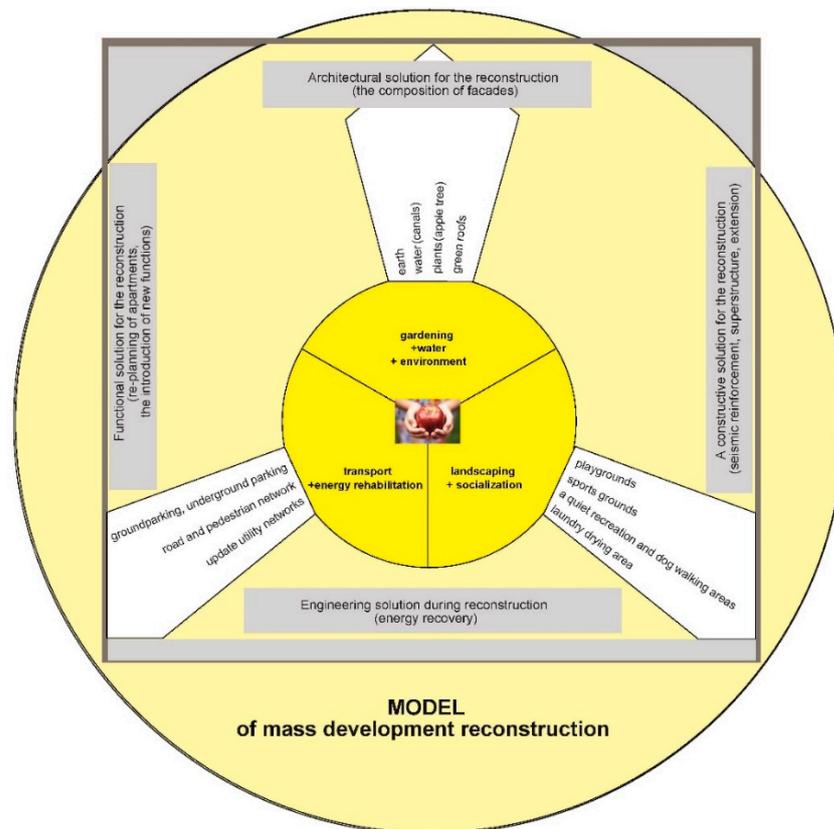
**Figure 15.** Initial data on the reconstructed territory—a fragment of microdistrict №1 in Almaty: (a) Situational scheme. (b) Reference plan. (c) Photos of courtyard spaces (Author's material).

**Table 1.** Pre-project analysis.

Housing Stock	Residential Environment
Disadvantages	
small dimensions of kitchens and bathrooms	lack of elements for yard improvement
layout costs—walk-through rooms	limited types of landscaping (several old large trees)
physical condition of houses: the need for major repairs	lack of parking spaces
accumulated disrepair—wear of window and door locks, roofs, “broken” entrances and basements, etc.	walk-through yard spaces
monotony and dullness of facades	the absence of compositionally closed (i.e., proportionate to a person and, therefore, comfortable) spaces
lack of harmonious solutions and colors, etc.	openness of the yard space to transit along Altynsarin St.
absence of sun protection devices on the facades of buildings	monotony (primitivism) of planning solutions for yard spaces
absence of wheelchair access and elevator	lack of well-thought-out compositional solutions for the organization of the yard territory
no intercoms	absence of MAF and water inclusions; limited area of courtyards; lack of active and passive recreation areas
obsolete types of engineering equipment	sports and children’s playgrounds, dog-walking grounds, front gardens, etc.
Advantages	
orientation of houses in the cardinal directions	the connection of yard spaces with the boulevard along Altynsarina Street
good insulation	location near Sary Arka Market and cinema
average number of floors (four to five floors)	accessibility-availability of a public transport stop nearby
optimal density of the housing stock	transport links to different parts of the city
optimal distances between houses	the proximity of the OGC node is two stops to the metro line (to Abai Avenue);
established neighborly relations	Proximity to (within a 30-min walk/up to 10–15 min by public transport) Grand Park shopping center, Armada shopping center, Goldmarket shopping center
relatively homogeneous composition of the population by income level	availability of landscaping (about 25% of the territory)

The functional planning analysis performed on the adjacent territories showed that there are primary (grocery store, pharmacy) and periodic service providers (Sary Arka market and cinema, restaurants, cafes, beauty salons, shoe repair shops, bank branches, notaries, clothing stores) in close proximity. There is a comprehensive school (500 m) and a kindergarten (300 m) within the local radius. The analysis revealed the need for some functional places, such as places of employment, co-working spaces, rental space for shopping facilities, hotels, catering, etc.

Our conceptual reconstruction project considers several aspects that have been included in the models presented by other authors (Figure 16).



**Figure 16.** Model of reconstruction of mass residential development in Almaty (Author’s material).

### I. Architectural planning solutions for residential buildings.

The reconstruction of residential buildings includes:

- Architectural and aesthetic solutions (architectural compositions using modernized and new architectural elements—loggias, elevators, pediments, entrance groups; two-sided attics and two-level apartments on the upper level; sun protection; silhouette alterations [roofs; improved color compositions]);
- Functional solutions (change of apartments—redevelopment of apartments, introduction of service functions on the ground floors [leisure, co-working, trade, walkable roof for recreation, etc.]);
- Engineering and technical solutions (energy-efficient remediation—reducing energy consumption, upgrading engineering systems, collecting rainwater, recuperation, introduction of devices of alternative energy sources, etc.);
- Constructive and technical solutions (super structuring of floors and volume extension, use of underground space, new finishings, and heat-insulating materials)).

### II. Landscaping and gardening of residential yards.

The yard space landscaping suggestions include:

- Environmental solutions (using innovative technologies for landscaping and watering; increasing open spaces (without asphalt); ensuring continuity of the landscaping system);
- Improvement of the road network and modernization of utilities (organization of parking in the underground space of the courtyard; temporary eco-parking above ground; collection of rainwater and vertical planning; laying of bike paths);
- Landscaping and socialization (organization of active and passive zones, taking into account the ages and interests of residents—playgrounds and sports venues, quiet recreation spaces, utility areas [for walking dogs, drying clothes]; front gardens; installing small architectural forms in courtyards; barrier-free environments, etc.).

### 5.3. Analysis Results

To rethink past ideals without rejecting our achievements or destroying the already present material environment is currently the main goal of architects (A.V. Krotov).

Reconstructing five-story buildings solves a nationwide problem (A. V. Krotov).

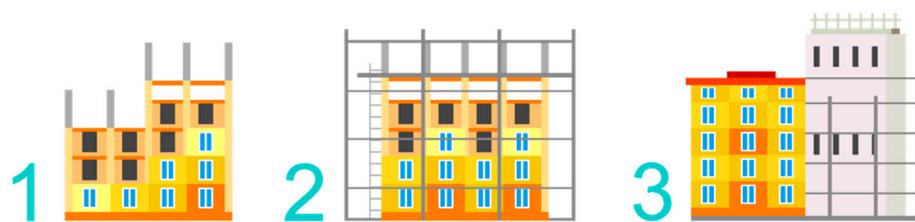
The design solution for the reconstruction of residential buildings—a typical series of large-scale developments from the Soviet period—proposed by the authors for the city of Almaty is based on the example of the reconstruction of five-story buildings in Moscow (according to A.V. Krotov) (Figure 17), but adapted to local climatic conditions (seismic, contrasting daily and seasonal temperature drops, etc.). The reconstruction approach is differentiated into three types: the superstructure of a low-rise attic, the superstructure and construction of a building on separate foundations, and the extension of individual residential sections.



**Figure 17.** Reconstruction of mass residential development (projects of A.V. Krotov’s workshop) <https://www.akrotov.ru> (accessed on 15 January 2022).

The superstructuring of a low-rise attic has several advantages: the simplicity and relatively low cost of construction (20–50% cheaper than usual), the possibility of establishing a high-quality overhaul, and installing elevators due to the installment of a superstructure up to one to two floors, and the option to carry out work without, or with only partial, resettlement of residents. The disadvantages of this reconstruction method are the relatively small area of the superstructure, which occupies two to three additional floors, and the existing apartments undergo almost no changes (Figure 18(1)).

The establishment of a superstructure and the construction of a building on separate foundations have many benefits: the total area can be doubled; the area of all existing apartments is increased; the economic efficiency of reconstruction can be optimized, especially on expensive urban land plots. The long-time taken to obtain permits is the only drawback of this type of reconstruction (Figure 18(2)).



**Figure 18.** Three types of reconstruction (according to A.V. Krotov): (1) the superstructure of a low-rise attic, (2) superstructure, building on separate foundations, (3) the extension of separate residential sections. (<https://www.akrotov.ru> (accessed on 15 January 2022)).

The extension of individual residential sections offers the greatest increase in area, wide architectural and urban planning opportunities, the possibility of combining various reconstruction methods with a superstructure for a group of houses, and the possibility of phased reconstruction, with the resettlement of residents within the reconstructed group. This method applies to a group of houses, or in cases when there is the option of densifying buildings that are practically exhausted, a long project implementation period, and significant financial resources (Figure 18(3)).

Reconstruction is beneficial to all participants. For residents, there is the option to stay in the same district while improving their living conditions by increasing their living area (on average by 20–30 sq.m) and an opportunity to purchase additional housing in the built-up part of the same house; furthermore, the overall solidity of the residential building increases, and the market value of each apartment increases by an average of 40%. On the other hand, shareholders can purchase apartments in the built-up part of the same house for approximately half the market value, and developers can make savings when purchasing land and enjoy a greater availability of urban infrastructure and communication.

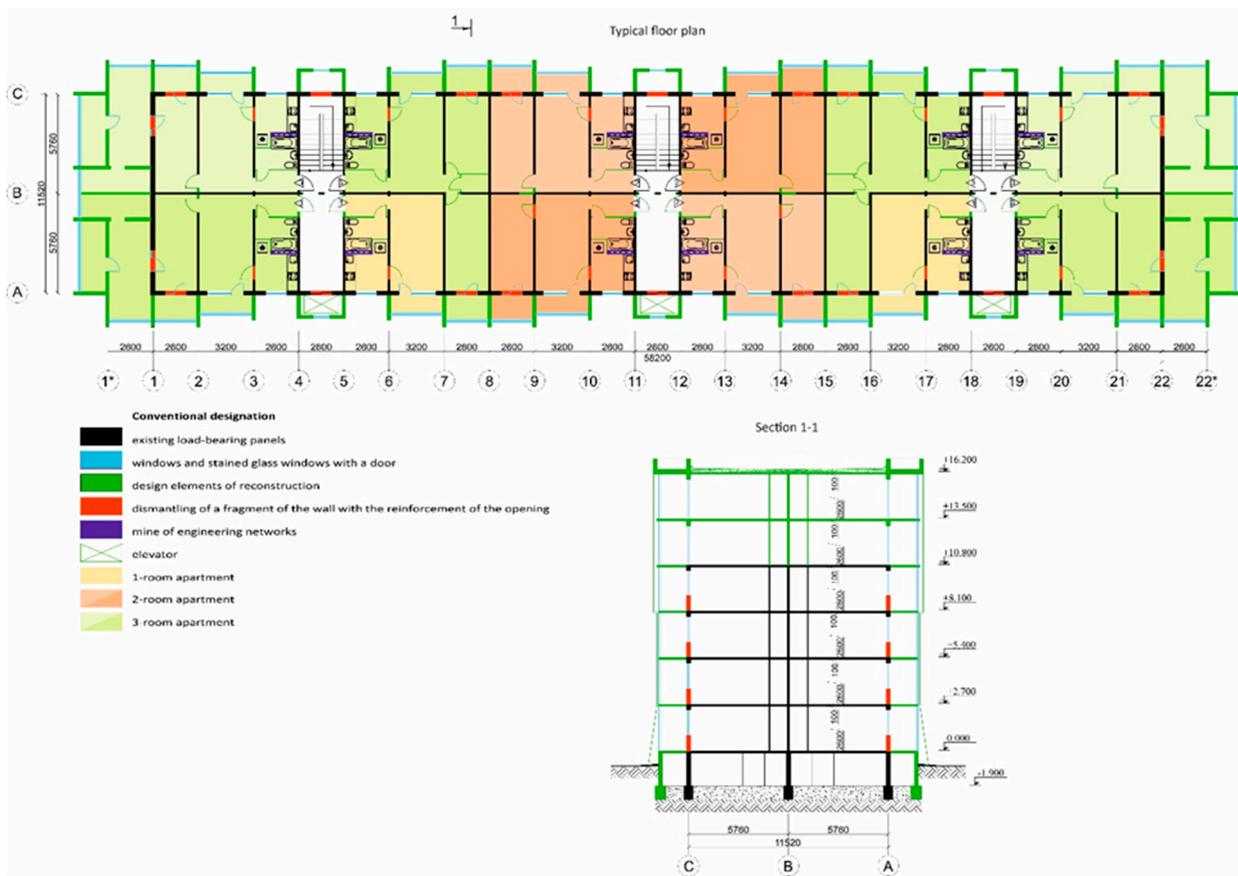
The design solution for the reconstruction of residential buildings—typical large-scale development of the Soviet period. Design proposal (author’s) for the reconstruction of a residential group of four-storey buildings in Almaty (Figures 19–22) [13,56,59,60].

The gardening and landscaping solution, applied to collective residential yards in microdistrict No. 1 of Almaty, is as follows.

This conceptual solution is based on the idea of the apple orchard as the symbol of the city of Almaty, together with the desire for the garden to affect all human feelings in the greatest possible way by offering space for deep philosophical reflections, thinking, moods, and poetic dreams [61,62].

In this case, we propose to plant two to three apple trees in each residential yard in MCR1. They could be of an ornamental breed and will represent the garden of Eden. Here, we develop the idea of an oasis or a garden, in which man has lived since ancient times. This decision is also influenced by the need for underground parking in the courtyard and further greening of its roof (Figure 19). The greening of roofs is also offered for nine-story house-inserts. These pleasant roofs can be accessed by an elevator. There are two recreation areas: a sports area with a table tennis table and a quiet recreation area (a collection of walls and benches). The greening of roofs of residential buildings is minimal here, using removable pedestals (pots) for flower beds. Mobile shade canopies, or awnings, are used for sun protection in summer.

The issues associated with landscaping were solved via conceptual associations, including the following: a square-shaped depression for collecting rainwater, with the texture of rubble, represents a ditch; the flower beds and front gardens with shrubs, and southern facades planted with wild grapes that spread along the facade and, together with the sunscreens designed as decorative ornamental lattices and perspective portals looking onto the entrance to service facilities, convey regional character, capturing the “spirit of the place”.



**Figure 19.** Proposal for the redevelopment of a residential building with an attic floor superstructure (Author’s material).

The organization of new residential groups will be achieved via insertions into houses that create semi-enclosed shaded green spaces and watered residential courtyards; this represents a reconstruction of the unique planning structure of eastern cities, with shaded courtyards along blank walls, ensuring the harmony of the architectural environment with the natural and climatic conditions. The establishment of regional identity is based on the principle of the continuity and preservation of traditions. Our project provides an appropriate context for the cultural and historical symbol of the spatial environment—the apple orchard. The planning principles that correlate with historic housing development methods, the materials used, the color preferences, and the means of adaptation to natural and climatic conditions (supported by new technologies) will create a comfortable microdistrict that is both familiar to the inhabitants of the region and interesting and attractive to its guests.

The conception of the author’s vision of the project consists of the following criteria: (1) Creation of a semi-closed yard area for the formation of an internal eco-climate in hot summer and isolation from the pollution exhaust of transport of the nearest highways; (2) Saturation of unattended areas with new functional zones; (3) Gardening of the territory with fruit trees; (4) Aesthetic modernization of outdated facades of residential buildings; (5) Improvement of planning solutions.

All these innovations are necessary to improve the comfort of living for residents. Residential buildings of the Soviet period were famous for the speed of construction, but they suffered from quality execution and poor facade aesthetics. The author’s version of modernization allows us to take into account and supplement some modern trends and requirements in an outdated residential area without cardinal and painless transformations.



(a)



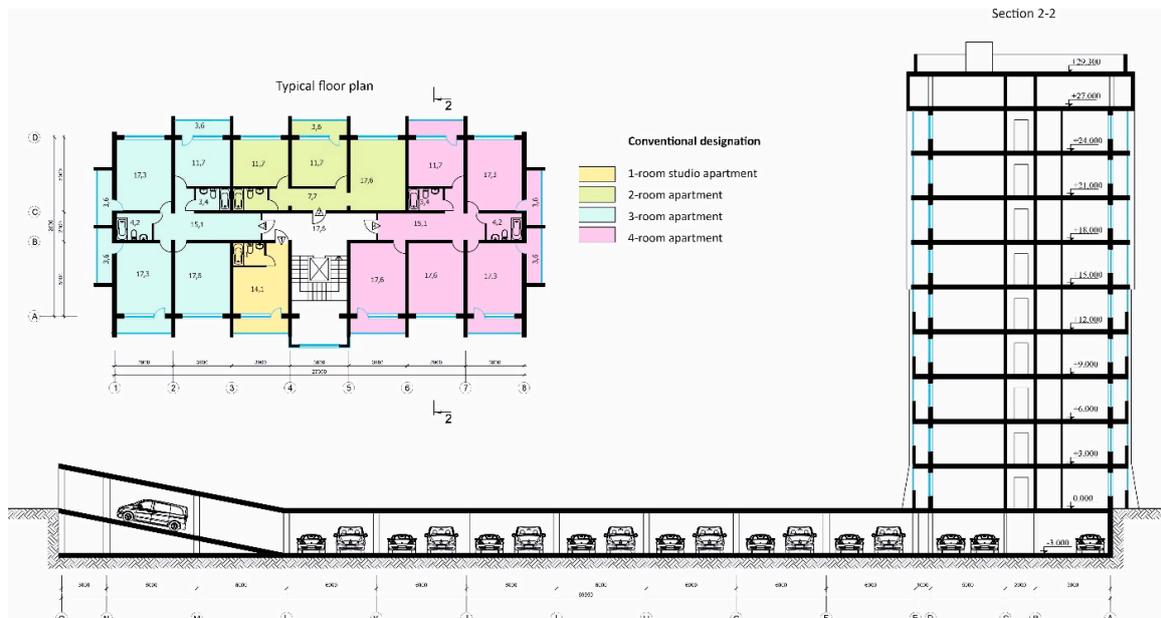
(b)

**Figure 20.** Project proposal (author's) for the reconstruction of a residential group in Almaty: (a) before reconstruction; (b) after reconstruction (Author's material).

To realize such an example of modernizing residential development, State support is necessary. Programmatic stimulation for compacting development can become the main source of attracting private investment, but under the conditions of mandatory modernization of such residential areas, at the expense of investors.



**Figure 21.** Residential yard reconstruction project (Author’s material). 1: Reconstructed 4-story residential apartment building with an extension of an additional floor with an attic; 2: Project 9-storey apartment building with commercial premises and an operational roof; 3: Entrance to underground parking located under the yard area; 4: Fire passage; 5: Flower bench; 6: Bench with a tree; 7: Bench with apple tree; 8: Streetball sector; 9: Gazebo Type-1; 10: Gazebo Type-2; 11: Gazebo Type-3; 12: Outdoor exercise equipment sector; 13: Training horizontal bars sector; 14: Playground sector for active games; 15: Children’s sandbox sector with an umbrella; 16: Flower myths; 17: Tennis tables; 18: Entrance group with a ramp under the canopy; 19: Solar panels; 20: Operated roof; 21: Decorative awnings or umbrellas; 22: Elements of landscaping.



**Figure 22.** Underground parking with a proposal for the new development of a 9-story residential building (Author’s material).

## 6. Significance and Discussion

The novelty of the methods proposed by the authors, as well as differences to the traditional methods of reconstruction for residential buildings among large-scale buildings from the 1960s, are here explained.

Residential environments are typically improved, and courtyard spaces are typically landscaped via a method that increases the comfort level of the urban environment based on the reconstruction and renovation of large-scale residential buildings. Here, the authors resolve this problem by not only employing the latest technical achievements in residential construction, but by emphasizing the society inhabiting it, as well as the semantic content of the environment, its saturation with revived folk traditions, and corresponding symbols. At the same time, we appeal to the semantic and symbolic characteristics of the Russian (Soviet) avant-garde, which laid the foundations of modernism in architecture, upon which the projects of residential areas in the 1960–1970s were carried out. That said, the appeal of the artist-leaders of the Russian avant-garde to the fundamental principles of artistic form and its primary elements organically merges with the symbolism and proto-forms of archaic (primitive) folk art [29]. In addition, the avant-garde artists turned to the creative methods of folk art and the traditions of ancient folk architecture [63,64].

The following conclusions were drawn as a result of the study.

This article is important since it examines the current state of the housing stock in large-scale developments in a city while also considering its architectural and urban planning prospects relating to its renewal by reconstructing residential buildings and landscaping residential yards using the latest roof greening technologies. All of this is intended to increase the level of comfort, as well as create a more sustainable living environment in the city while reviving the cultural identity of the people.

The authors have demonstrated a specific approach to reconstructing residential buildings of mass series from the 1960s in Almaty. The choice of reconstruction methods was based on the principle of the trinity: the revival of the idea of a dwelling space as Eden; the development of the ideas of the Russian (Soviet) avant-garde, which underpin modernist architectural solutions applied to large-scale residential series; and an emphasis on society, with attention paid to its history, traditions and modern needs.

This publication is important as it considers the current condition of the housing stock in large-scale residential developments in the city, as well as the architectural and urban planning prospects for its renewal by reconstructing residential buildings and landscaping residential courtyards using the latest roof gardening technologies. All of this is intended to increase comfort, to create a more sustainable urban living environment, and to revive the cultural identity of the inhabitants.

**Author Contributions:** Conceptualization, K.M., E.L. and A.T.; methodology, K.M., E.L. and A.T.; software, K.M., E.L. and A.T.; validation, K.M., E.L. and A.T.; formal analysis, K.M., E.L. and A.T.; investigation, K.M., E.L. and A.T.; resources, K.M., E.L. and A.T.; data curation, K.M., E.L. and A.T.; writing—original draft preparation, K.M., E.L. and A.T.; writing—review and editing, K.M., E.L. and A.T.; visualization, K.M., E.L. and A.T.; supervision, K.M., E.L. and A.T.; project administration, K.M., E.L. and A.T.; funding acquisition, K.M., E.L. and A.T. All authors have read and agreed to the published version of the manuscript.

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