Conception of Green Infrastructure as a Tool of City Development Planning

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Abstract. The role of the greenery in the urban environment is priceless – both for maintaining ecological balance, and for enhancing visually aesthetic quality, as well as home for small habitats and the key to urban identity. The development of greenery structures in a city or part of a city is often chaotic and spontaneous – developing greenery only for certain objects and not linking it with one another. Planning of greenery in the urban environment is influenced by several regulatory documents, which mainly focus on the preservation of the existing greenery structure and the restrictions on the planning of the greenery. Unfortunately, the detailed guidelines for the planning of the greenery are not sufficiently reflected in the existing normative documents. The concept of greenery is one of the tools for urban planning that, together with other planning tools (infrastructure, spatial planning, architectural design, urban planning, economic urban development planning, etc.), forms a single framework for urban planning tools that helps to develop urban environment smoothly and identify priorities. The aim of the research is to develop a model of the concept of greenery of urban areas, which in practice can be used on the Latvian scale, as the planning document of greenery in local governments. The development of greenery plans and concepts has become topical in recent years and more and more municipalities are interested in this planning tool, which helps to plan the distribution of finances for maintaining the structure of greenery and developing new structure. In the last ten years, four concepts of greenery for medium-sized cities have been developed in Latvia.

1. Introduction

Planning of urban territories are more and more important due to the fact, that it has been estimated by The World Health Organisation that by 2030 more than a half of the world’s population will be living in an urban environment [1]. Cities and other urban areas are complex systems that have to provide different functions – economic, ecological, social, etc. At the same time, they need to create a safe, human-friendly environment that encourages people to be more active in outdoor activities, to use the activities and services offered by the city or urban area, thereby also contributing economic prosperity, and formation of the socially qualitative, responsible and shared communication–based and action–based community. These opinions have become important pillars in the planning of a modern urban space, highlighted by leading world urban planners who have worked on such an urban planning which nowadays is appraised as examples of good practice of sustainable cities (Copenhagen, Stockholm, Malme, etc.) [2, 3, 4].
Green infrastructure is not a new concept by itself. As a term it was used in 1994 for the first time in a government report. In this report the aim was to reflect that natural systems also are important components of infrastructure [5]. At a wider range green infrastructure can be used in landscape scale [6, 7, 8, 9], but not in the municipalities. In urban landscapes there is a need to look at the parcels and ownerships. But on the specific site scale it is possible to focus on more detailed scope – rain gardens, green roofs, permeable paving and other best practices [5].

The Benedict and McMahoy have defined Green infrastructure as strategically planned and managed network of wilderness, parks, greenways, conservation easements, and also working lands with conservation value that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to the health and quality of life [10, 11].

Organisation “Natural England” also uses this definition of green infrastructure. Green infrastructure typology can differ from the situation – aim and scale of the green infrastructure. Natural England used typology includes – parks and gardens, amenity green spaces, natural and semi-natural urban green spaces, green corridors and other. Other territories include allotments, community gardens, city farms, cemeteries and churchyards [12]. There is a need of policy support for green infrastructure. In Latvia typology of urban structures is based on General Regulations for the Planning. Used typology in planning documents in Latvia is – area of private house building; area of low–storey residential building; area of multi–storey residential building; area of mixed centre building; area of public building; area of industrial building; area of transport infrastructure; area of technical building; nature and greenery area; forest area; agricultural area; water area [13].

Green infrastructure can contribute in many ways for territory sustainable development. For example well planned green infrastructure encompassing new sites – contributes to high quality landscape, health of the natural environment, increases ecological connectivity. The creation of green infrastructure helps to create attractive places, strengthen links, brings in the natural world. Green infrastructure if it is multifunctional can provide a wide range of environmental, social and economic benefits. Green infrastructure also helps to secure environmental future [12]. There are many different concepts involved in green infrastructure planning as landscape is holistic research and planning object. Two of the concepts seem to be most important – place-making and multifunctionality. Nowadays more and more important is concept of place-making and green infrastructure can be important part in this process. Green infrastructure design principles are also important as they respond to landscape character. Multifunctionality is also important to approach to green infrastructure [12].

It has been proved, that green infrastructure planning can mitigate climate change, alleviate flood risk, improve public health and promote economic viability [11, 14 15 16]. Several urban planners and researchers of the world have acknowledged the close link between positive human emotions, psychological health, stress relief, the intensity and the quality of outdoor usage, the creation of a sense of belonging, and the existence and quality of green structures in urban areas or rural areas. The theme of biological diversity conservation, environmental protection and climate change mitigation (such as flood risks), which is included in a number of European strategic and planning documents, still remains constantly topical. As a result, thematic blue–green structural planning have been increasingly included in the development plans of several European cities, within which a high–quality green structure is introduced at different scales – district scale, scale of urban area and local scale. In the Latvian context, the development of green structure plans is not legally defined and certain guidelines have not been applicable for its development. However, at present situation, the main conjunctive objective of the concept of greenery developed by own initiative of municipalities is the creation of a qualitative living space for residents and visitors, linking existing natural and cultural and historical values into a single network of greenery, thus ensuring safe stay and movement in urban spaces, expanding opportunities to create new recreation areas, cycle paths and tourism routes, to promote the economic and social activity of the area, to organize wisely the development and management of the territories.

Green infrastructure planning has been developing in different continents and it gives opportunity for wide range of discussions about theory and practice [11]. The planning of green structures in
Europe is closely linked to EU 2020 Biodiversity Strategy, for implementation of which the EU Strategy on Green Infrastructure was developed, within which EU Member States must implement green infrastructure development measures in different scale planning and regulatory documents (in national, regional, district and local scale) by 2020. At present, normative documents or guidelines on implementing the strategy have not yet been implemented in Latvia. But several Latvian municipalities, taking into account the spatial planning trends in Europe and in the world, have initiated the incorporation of planting structure plans into their normative documents.

The experience of Europe shows that it is important to divide several planning levels or scales (national, regional, and district, city or local level) into the planning of green structures, setting the objectives and tasks to be achieved in each of them, as well as the reciprocal hierarchy between levels. Planning scales and approaches greatly vary across different areas. On planning a green structure on a regional or district scale it requires a broader view of elements and connections, wide river and road corridors, larger tracts of forest or other large-scale green elements. Walking trails, gardens and other small structural elements are of great detailed importance on a local scale. Similarly, European urban planning documents emphasize that the planning and implementation of green structures should be extended both to national, regional, district and city institutions, and to private owners. In the context of private property, the concept of greenery is to be implemented both as recommended solutions, actions, and as mandatory conditions (for example, the preservation of significant space elements – large trees, etc.) in outdoor space creation.

In Latvian National development plan for 2014 – 2020, which is a key medium–term strategic planning document for the state development, issues related to the sustainable use of natural resources and the preservation of biological diversity have been highlighted in the context of green planning. These issues have also been highlighted in the National Program for Biological Diversity, further pointing out the need to reduce the significant fragmentation of natural areas and to promote the protection of migration routes closely linked to green infrastructure planning. In its turn the Sustainable Development Strategy of Latvia up to 2030 includes guidelines for the preservation of natural capital, the protection of unique landscapes, cultural and natural elements, as well as the creation of green corridors in urban spaces, improving the quality of the environment and safe access (bicycle paths, pedestrian road, etc.). At the local, city or local level, there still has not been developed a common methodology for developing planning for green areas (or concepts of greenery) in Latvia. At present, the concept of greenery has been developed for Lielvārde (2006), Olaine (2008), Kuldīga (2013), Liepāja (2016), Riga (2018), and Ikšķile (2019) by the initiative of municipalities [17, 18, 19, 20]. The concept of greenery for each of these cities is based on slightly different goals, emphasizing the specificity of each city, its traditions and the opportunities for economic development.

The aim of the research is to develop a model of the concept of greenery of urban areas, which in practice can be used on the Latvian scale, as the planning document of greenery in local governments.

2. Materials and methods

The theoretical model of the concept of greenery of urban areas was chosen as the object of the research, because the aim of the research by itself is to create a method for developing the concept of greenery of urban areas, which is designed to develop the concept of greenery of individual towns and villages, as an unified system that serves as a tool for structural planning and managing for urban greenery in municipalities.

The process of developing the concept of greenery is related both to the planning of landscape elements of different scales or levels, and the study of the interaction of these elements, and the functional load of greenery and the usage of aesthetic – decorative, social and physical qualities of the greenery in the urban planning process, following the canon of a sustainable urban environment. The method of developing the concept of greenery of urban areas by itself is based on the research and determination of successive landscape elements of all scales or levels, combining several cartographic and descriptive methods and approaches below each stage of research or planning.
The methodology for developing the concept of greenery of urban areas identifies the following stages:

1st stage – the research and the analysis of the current situation of urban areas:
- Determination of the spatial structure of the urban area and its formative elements – the structure and the size of the building, the structure of roads, the research of the existing natural base structure – cartographic materials and field studies, performing photo fixations and markings on cartographic materials on elements of existing spatial structures – axes, building structure and density;
- Determination of planting formative elements and their quality throughout the whole territory – parks, squares, the structure of the greenery of multi-storey and residential building, the greenery of public areas, avenues, street greeneries, cemeteries – field studies, making photo fixations and markings on the cartographic materials on location of landscape elements;
- Sights analysis – views on entering the urban area, views of cultural and historical objects and dominants, traditional sights of urban environment – field studies, photo fixation and sight mapping on cartographic material;
- Analysis of pedestrian and transport traffic – determination of transport load, tourist routes, population daily routes – field researches by marking cartographic materials on routes and destination points, as well as marking conflict places;
- Research and analysis of existing municipal–level normative documents in the context of planning, planting and caring of the greenery – desk studies.

2nd stage – the formation of the development plan of the planned structure and the improvement proposals for the greenery
- Planning of the network of the city–level greenery – existing and potential links and nodal points marked on cartographic material, suggestions in writing on the development potential of the urban greenery network, using the existing greenery structure as the basis, as well as applying the principles of sustainable urban environment development, principles of site ecology, principle of social communication, as well as highlighting the identity of the urban area. The planned structure of the greenery at level of city planning should form a unified network of the greenery consisting of separate nodal points and their connecting elements. The development of a unified network of the greenery is based on worldwide used formation approaches of the Blue-Green Infrastructure that are capable to secure and promote the ecological linking of the landscape, protection of natural values and biological diversity, the visual unity of the space and better orientation in the urban space, emphasis and availability of the identity–forming landscape elements, safe movement for citizens and tourists.
- Planning of a locality–level greenery structure – the level of locality planning allows understanding the values, dominants, natural and cultural–historical objects of each locality and village that, together with the activities and traditions of the population, form the identity of the locality and villages. Suggestions include scenarios for strengthening local identity, opportunities for organizing the functional load of the landscape space, values of places important for the inhabitants that should be preserved and emphasized with the help of greenery and landscape improvement;
- Development of a unified greenery structure and development plan – proposals for further development of the greenery should be used as a guideline for the development of any area of the territory or for the detailing of any type of the greenery;
- Planning of individual types of landscape spaces greenery and selection of plant assortment – suggestions for greenery design, construction and usage – tables of existing situation and development proposals analyzing the most important as well as the most problematic aspects of the particular type of the greenery which are opposed to possible variants of the development solution, schematic cuts;
• Development of recommendations for supplement of normative documents in the context of planning, planting and caring of greenery;
• Development of the implementation stage plan of the concept of greenery – three priority groups of the greenery have been created for planning the implementation of the concept of greenery, taking into account the importance and intensity of the daily usage of greenery areas, as well as the importance of the greenery areas for attracting future investments, including tourism development;
• Terms, their explanations with pictures – a glossary of used terms with illustrative material.

During the development of all stages, communication with the working group from the municipality – the team of managing specialists – architect, landscape architect, spatial planner, land survey specialist, tourism specialist, and municipal services specialist should be ensured. In addition, it is advisable to invite advisers in cultural–historical issues, biologists and ornithologists, dendrologists and arborists, specialists in organizing cultural events in the city. Involvement of residents in the development process of the concept of greenery in urban areas is also important.

3. Results and discussion
The final result of the method of developing the concept of greenery of urban areas is the model of the concept of greenery of urban areas (Figure 1), which reflects the multidisciplinary approach to the methods of the development of concept of greenery, and incorporates the basic principles of the formation of the structure of greenery in a cultural, historical, social and aesthetic visual context. The sequential execution of the method is important, as the data and results gained in each stage are included in the next stage, consecutively reaching the concept of greenery of urban areas.

The concept of greenery in urban areas is based on the three–level / scale greenery system planning based on widely used in Europe formation approaches of green infrastructure, green network, green grid, etc., ecological design and basic principles of the urban acupuncture – urban space activation with point–like public outdoor objects, elements, territories. The levels included in the concept of greenery of public areas – cities, locality or village, landscape space and object levels – form a hierarchical system in which each next level details the previous one, which allows the guidelines introduced in the concept of greenery, if necessary, to include in different scales strategic and planning documents of municipalities.

The scale of the district should also be solved separately, where wider ecological, natural and cultural–historical links between individual, significant natural objects and urban areas can be considered, taking also into account the specifics and landscape values of rural areas of the district. At the scale of the district, the green structure consists of large–scale elements – forests, rivers, lakes, large ponds, wide areas of allotments, flooded meadows, swamps, etc. natural elements, as well as private recreation areas, domestic producers, biological organic farms, business parks with the usage of eco–technologies, etc., can be included in the green structure. The size of the structural elements as well as their availability to any interested person is important at the county scale. Analyzed approaches and routes need to be designed as link elements between the green structures, ensuring movement throughout the whole road section.

Planning levels separated in the concept of greenery can also serve as a basis for attracting investments in several project programs in the following sustainable development priorities – economy: economic growth and employment; environment: protection and preservation of cultural heritage; preservation of cultural landscape and natural environment; conservation of biological diversity; adaptation to climate changes and their mitigation; social: education of the population; healthy communities; environment conducive to health and well–being; access to natural resources, etc.
Figure 1. Methodology and basic principles of the concept of greenery.

The most important natural and cultural–historical elements of the city, the objects and territories of everyday importance, which are divided as the “nodal points” of the city and the planned “linking elements” between them – strategically important streets, walking and tourism routes, have been identified and analyzed in the concept of greenery at city level. "Nodal points" and "linking elements" are analyzed in two directions at city level – objects and territories significant in everyday life and important for tourism development. All elements should be marked on the cartographic material and serve as a network of the greenery structure and foundation for greenery formation elements at other planning levels.

Figure 2. Urban level planning.

At the urban planning level, the planned structure of the greenery in urban areas should form a unified network of the greenery consisting of separate nodal points and their connecting elements. The development of a unified network of the greenery is based on worldwide used formation approaches of the Blue-Green Infrastructure (Blue-Green infrastructure, Green Network) that are capable to secure and promote: the ecological linking of the landscape; protection of natural values and biological
diversity; the visual unity of the space and better orientation in the urban space; emphasis and availability of the identity–forming landscape elements; safe movement for citizens and tourists.

The highlighting of certain "nodal points" (greenery, environmental objects, activities and recreational facilities, etc.) in different parts of the city, not only in the centre, but also in the locality of the city, also makes it possible to activate the city as a whole, which is also supported by the idea of urban acupuncture (Urban Acupuncture) already developed in the planning of several European cities. "Nodal points" in urban areas include urban forests and parks, squares and „green pockets” (pocket gardens), separate recreation areas, children's playgrounds, training grounds, public green areas, public buildings, residential buildings, etc., areas, cemeteries and church gardens, places of cultural heritage, potentially developing public outdoor spaces, etc.

Landscape elements are adopted as a "linking elements" at the urban planning level, serving as a safe movement and / or delay between the "nodal points" in everyday life and in the promotion of recreation and tourism, and at the same time also providing ecological linkage. Linking elements in the city are well organized green areas of the streets, pedestrian roads and bicycle paths; water courses reservoir areas, linear nature and green areas, etc.

Two main directions are identified as the basis for identification of the existing nodal points and their linking elements and new planning – the improvement of the quality of life environment of inhabitants and development of tourism, which are emphasized also in the normative and strategic documents of the region (long–term development strategy, tourism development strategy, etc.).

Nodal points of landscape spaces of the urban areas and their linking elements in the context of improving the quality of life environment of the inhabitants are defined and planned according to the following criteria:

• Frequently daily visited public objects (educational institutions, municipal buildings, cultural institutions, sports grounds and recreation places, major shopping and entertainment places, etc.)

• Daily more actively used accesses to these objects (streets, pedestrian roads and bicycle paths).

In addition to nodal points and linking elements, approaches having places with specific infrastructure to provide access to a particular object / area (underground passages under the highway; environmental accessibility elements, ramps, etc.) are marked at the urban planning levels. In the context of a unified structure of the greenery, the most important places of view are also recommended, where it would be advisable to plan small recreation places and „green pockets”.

All the elements forming the structure of the greenery of all urban areas are summarized in a table and graphically on the cartographic material:

| Title                          | Element improving the quality of everyday / living environment | Element promoting tourism development |
|-------------------------------|---------------------------------------------------------------|---------------------------------------|
| 1. Nodal points of the city   |                                                                |                                       |
| 2. Linking elements           |                                                                |                                       |
| 3. Approaches or accesses (existing approaches, planned approaches) |                                                                |                                       |
| 4. Sights                     |                                                                |                                       |

Landscape spatial elements, approaches, and viewpoints contributing both the development of everyday life and tourism, form the common greenery structure. Elements forming the greenery structure – nodal points, linking elements, approaches and viewpoints are described in the table “Formative elements of the unified greenery structure of urban area”. The numbered elements in the table can be viewed together with the diagrams in the graphical part.

At the level of urban locality, more emphasis is placed on the formative elements of the identity of the place and the common structure of the greenery. The level of locality planning allows
understanding the values, dominants, natural and cultural–historical objects of each locality and village that, together with the activities and traditions of the population, form the identity of the locality and villages. Suggestions include scenarios for strengthening local identity, opportunities for organizing the functional load of the landscape space, values of places important for the inhabitants that should be preserved and emphasized with the help of greenery and landscape improvement.

The landscape spatial structure, local identity, certain landscape values, functional and visual links are analyzed for each locality. The division of localities helps to divide urban areas by groups of landscape spaces with their identity, the nature of the landscape and historical development, as well as to plan the development of each locality separately so that the city develops smoothly as a whole.

According to the urban research in nature, several spatial structure parts have been identified and separated for each locality based on spatial structure differences – applied to cartographic material and summarized in the table (Table 2). The parts of the spatial structure are important from the point of view of planning, because each of them has a changing spatial structure of the existing landscape and the role of landscape elements in it.

Table 2. Spatial structure of local centre.

| Legend in scheme | Features of the spatial structure of the existing greenery | Recommendations for improvement of spatial structure of the greenery |
|------------------|----------------------------------------------------------|---------------------------------------------------------------|
| Spatial structure A | | |
| Spatial structure B, etc. | | |

The parts of the spatial structure of the locality, as an integral part of the landscape, have also been studied beyond the administrative boundaries of the city.

At the locality planning level there are defined for each locality: local identity (vegetation / greenery, coverings, materials and elements); landscape values of the locality, landmarks, dominants; functional and visual links.

At the level of landscape spaces and objects there are detailed elements of the greenery in the particular functional zones and situations of the city (street greenery, greenery of residential areas, etc.), according to which different types of the greenery and corresponding variants of the solutions are distributed – assortments of recommended plants, size of plant groups, etc.

The level of landscape space and landscape elements planning – the planned situation is resolved by separate types of functional landscape space, in accordance with municipal territorial planning documents: areas of residential building (areas of private houses / low–rise residential building, areas of multi-storey residential building); areas of public buildings, mixed building; areas of production and technical building; areas of liner construction (street and road greenery, railway); natural base area; areas of parks, squares and greenery; cemetery areas; water areas; cultural–historical and specially protected objects and territories; temporary greenery. For each type of the landscape space, common development proposals have been provided, starting with the main aspects of the greenery development or desirable standards – the proportion of the greenery structure in each area, types of street greenery and hedge heights and the assortment to be used, planning criteria for protection greenery, types and technologies, types of lawn and alternative solutions for lawns, etc.

Separately, each type of landscape space has been provided with tabular proposals, including both the issues of the existing situation and the solution proposals – using 3D models. Additionally there is recommended assortment of the plants for each situation (Table 3).

Table 3. Planning level of the landscape space and landscape elements.

| Type / subtype of the greenery | Existing situation / issues | Planned situation / proposals | Assortment of the plants |
|-------------------------------|-----------------------------|------------------------------|--------------------------|
| Type A – subtype A1, A2, A3   |                             |                              |                          |
| Type B – subtype B1, B2, B3, etc. |                             |                              |                          |
One of the sections of the concept of greenery in urban areas is **guidelines for planting and caring of the greenery**. The guidelines for planting / construction and tending of the greenery are applicable to the revision of the regulations for the maintenance and care of the territory of the urban areas, as well as the reference in the Territorial planning documents.

It is advisable to prepare and include the following sections in the regulations for the maintenance and care of residential areas and buildings:

- Quality standard for construction and care for all types of lawn;
- Quality standard for planting and care for all types of greenery – high-rises, free-range trees, street greenery, hedges, shrub groups, summer flower beds, bulb beds, mixed hollows (perennials, shrubs, bulbs, etc.), container type greenery;
- Guidelines for greenery assortment colour palette for the short-term greenery;
- Guidelines for colour palettes for environmental objects and improvement elements and for the application of materials used.

In the closing concept of greenery of urban areas there are the stages and priorities of the implementation of the concept of greenery. Several priority groups of the greenery have been set up to plan the implementation of the concept of greenery, taking into account the importance and intensity of daily use of greenery areas, as well as the importance of greenery areas for attracting future investments, including tourism development. Priority greenery groups are described in the table (Table 4), which can be viewed together with the figure attached in the graphic part.

**Table 4.** Elements of the greenery structure of urban areas in the context of the priorities of the implementation of the concept of greenery.

| Title / name / term | Priority |
|---------------------|----------|
| Nodal points of the city | |
| Linking elements | |

The concept of greenery in urban areas also requires the development of graphic materials:

- Planned structure of greenery
  - Formative elements of the unified greenery structure of the urban area: elements improving the quality of everyday / living environment
  - Formative elements of the unified greenery structure of the urban area: elements promoting tourism development
  - Formative elements of the unified greenery structure of the urban area: elements improving the quality of everyday / living environment and elements promoting tourism development
- Priority stages of implementation of the concept of greenery
  - Priority groups of elements and greenery forming the unified greenery structure of the urban area

A summary of all sections provides a multifunctional approach to the concept of greenery document, incorporating versatile information both about the structure of existing greenery, and the structure of the planned greenery. The sections of the model can be complemented according to the specificity of the urban area by retaining the three-level planning method and the degree of detailed elaboration for each landscape space, while retaining the flexibility possibilities that may occur in the development process of urban areas.

**4. Conclusions**

The final result of the method of developing the concept of greenery of urban areas is the municipal planning tool – the concept of greenery, which is based on the model of the concept of greenery developed as a result of the research.
The concept of greenery is a planning document for the development of the territory of the municipality, which determines the common structure of the greenery and its distribution in different types of the greenery according to the usage of the territory and functional zones. The document also includes the requirements set by the municipality for the improvement of each area, the design, planting and caring of the greenery; suggestions for selection of greenery assortment and qualitative indicators of the greenery for each of the given types.

The purpose of the concept of greenery is to develop guidelines for planning, improvement and care of the greenery of the urban area, respecting the cultural and historical heritage, spatial structure of the territory, identity of the place and natural values.

Benefits of the concept of greenery:

- highlighting the value and potential and creation of the identification / recognition of the greenery existing in urban areas by promoting the identity of the place, tourism development, a sense of belonging to the population and improvement the quality of life;
- clear structure of the greenery of the urban area, which consists of the existing "nodal points" and their connecting „linking elements”, ensuring safe and easy movement and orientation in the urban environment, promoting the creation of a unified city image;
- structured approach to the planning and management of the greenery of the urban area, providing financial distribution, support for the preparation of design tasks, and determination of priorities and intensity of maintenance of the territory.

The model of development of the concept of greenery of urban areas can be used as the basis for developing the concept of greenery of urban areas and to be integrated into the planning documents of the municipalities of Latvia. The form and legal framework of the concept of greenery document itself has still to be clarified in consultation with the executive institutions and industry experts.

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