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Solutions for climate change adaptive green spaces in Latvia-Lithuania cross-border areas

based on results of the urban greenery assessment in Šiauliai and Jelgava, and best practice example from Europe

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Enhancing Urban Resilience with Climate Adaptive Green Space Planning in Latvia and Lithuania . UrbanGreenAdapt (LL-00273)

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Introduction

The material “Solutions for climate change adaptive green spaces in Latvia-Lithuania cross-border areas” has been developed within the framework of the Interreg Latvia–Lithuania Cross-Border Cooperation Programme project “Enhancing Urban Resilience with Climate Adaptive Green Space Planning in Latvia and Lithuania” (UrbanGreenAdapt, LL-00273). The material has been prepared through collaboration between researchers in landscape architecture and spatial planning from the Latvia University of Life Sciences and Technologies and Lietuvos inžinerijos kolegija (Higher Education Institution). The material is based on the results of urban greenery assessments carried out in Šiauliai and Jelgava, as well as insights drawn from best practice examples across Europe.

Today, challenges related to climate change adaptation in urban public space planning are becoming increasingly significant, creating a growing need for research-based solutions. One such solution is the planning of urban greenery adapted to local environmental conditions and climate change. This approach enables the development of resilient and site-appropriate plant communities. In the long term, it contributes to enhanced biodiversity, reduced maintenance costs of green areas, improved living environments for residents, and increased public awareness of climate change adaptation. The developed solutions include plant lists suitable for urban climates, climate-adaptive planting tools, and recommendations for integrating these aspects into municipal legal and planning documents.

This material is integrated into manual “Five Steps to Climate Change Adaptive Green Spaces” as a key element for training program developed to increase the number of specialists in the Latvia–Lithuania Programme area who are capable of understanding and applying innovative, research-based solutions for climate-resilient urban greenery. The material can be used to support the planning and management of urban green infrastructure and planting systems within the Latvia–Lithuania cross-border area.

1. Policy and legal framework for climate-adaptive urban green spaces in Latvia–Lithuania cross-border areas

1.1. Role of climate-adaptive green infrastructure in urban resilience

Urban greenery has evolved from a primarily aesthetic component of cities into a multifunctional system of green spaces, or urban green infrastructure (GI), that delivers measurable environmental, social, and economic benefits. In the context of climate change, urban green spaces are increasingly recognised for their role in mitigating urban heat island effects, managing stormwater, improving air quality, and enhancing biodiversity. Therefore, ***it is essential to use plantings adapted to the urban and climate change factors in green spaces***, ensuring that the functions of these areas are maintained sustainably over the long term.

In the Latvia–Lithuania cross-border region`s cities, climate projections indicate a steady increase in average temperatures, more frequent and prolonged heatwaves, as well as changes in precipitation patterns, including both drought periods and extreme rainfall events. These trends significantly affect urban environments, where high levels of soil sealing, dense built structures, and limited vegetation exacerbate climate-related risks. As a result, ***climate-adaptive green infrastructure must be systematically integrated into urban planning and management practices***.

Unlike traditional green space planning, climate-adaptive approaches require that vegetation is selected, designed, and maintained based on its ability to withstand stress conditions such as drought, heat, pollution, and soil compaction. This shift necessitates a strong policy and regulatory framework that aligns strategic objectives with practical implementation tools.

1.2. International and European policy framework

At the European level, several key policy documents provide the foundation for climate-adaptive urban greening. ***The European Green Deal*** establishes the overarching goal of achieving climate neutrality by 2050 and explicitly highlights the importance of green infrastructure in urban areas. It promotes the integration of ecosystem-based approaches into urban planning and encourages cities to expand green spaces and tree cover.

The ***EU Biodiversity Strategy*** for 2030 further strengthens this direction by introducing specific targets related to urban ecosystems. It calls for the development of “Urban Greening Plans” in all cities with more than 20,000 inhabitants, aiming to increase

biodiversity, improve ecosystem connectivity, and enhance climate resilience. In addition, the ***EU Strategy on Green Infrastructure*** emphasizes the role of interconnected green and blue networks in delivering ecosystem services. It promotes a systemic approach where green infrastructure is treated as an integral part of spatial planning rather than an isolated element.

These policy frameworks share several key principles:

- integration of green infrastructure into spatial planning systems;
- prioritisation of nature-based solutions;
- enhancement of biodiversity and ecosystem services;
- long-term sustainability and resilience.

For cross-border regions such as Latvia–Lithuania, these EU-level frameworks provide a common policy foundation that can support harmonised approaches to climate adaptation.

1.3. National policy context (Latvia and Lithuania)

Both Latvia and Lithuania have developed national-level strategies addressing climate adaptation and sustainable urban development. However, their implementation mechanisms differ in scope and level of detail.

In Latvia, climate adaptation is addressed through national development planning documents and sectoral strategies, which highlight risks related to flooding, heat stress, and ecosystem degradation. Urban green infrastructure is recognised as a key adaptation measure, particularly in relation to stormwater management and microclimate regulation. However, national guidelines often remain general and do not provide detailed technical specifications for urban planting or species selection.

Lithuania similarly incorporates climate adaptation into national development strategies, with a focus on sustainable land use, environmental protection, and urban resilience. Urban greenery is acknowledged as an important element of adaptation, but as in Latvia, there is limited standardisation of technical requirements for planning, implementation, and maintenance of climate-adaptive plantings.

A common challenge in both countries is the gap between strategic policy documents and practical implementation at the municipal level. This gap is particularly evident in:

- lack of binding standards for soil quality and planting conditions;
- insufficient guidance on climate-resilient species selection;
- fragmented maintenance practices;
- limited integration of monitoring and evaluation systems.

1.4. Municipal level planning and implementation challenges

Municipalities play a critical role in the implementation of climate-adaptive green infrastructure, as they are responsible for spatial planning, public space design, and maintenance of urban greenery. However, several structural challenges limit their capacity to effectively implement climate-adaptive approaches:

1. urban planning documents often treat green spaces as secondary elements rather than as essential infrastructure. This results in insufficient allocation of space and resources for vegetation, particularly in dense urban areas;

2. technical standards for planting are frequently outdated or inconsistent. In many cases, trees are planted in conditions that do not support long-term survival, such as insufficient soil volume, compacted substrates, and inadequate water availability. Research and practical guidelines demonstrate that such conditions significantly reduce tree vitality and lifespan;

3. species selection is often based on traditional preferences rather than climate resilience criteria. This leads to the overuse of a limited number of species, increasing vulnerability to pests, diseases, and climate stress;

4. maintenance practices are often underfunded and not aligned with lifecycle requirements. The establishment phase (first 3–5 years after planting) is particularly critical, yet it is frequently neglected, resulting in high mortality rates.

1.5. Recommendations for strengthening municipal frameworks

To address these challenges, municipalities in the Latvia–Lithuania cross-border region should adopt a more integrated and technically robust approach to climate-adaptive green infrastructure.

Integration into spatial planning. Green infrastructure should be recognised as a core component of urban systems and integrated into all levels of spatial planning. This includes:

- incorporating green spaces and corridors creating a green network into master plans;
- ensuring connectivity between green and blue infrastructure;
- allocating sufficient space for vegetation in urban development projects;
- preserve and integrate existing protected natural areas, valuable habitats, and forests into the overall green network.

Development of technical standards. Municipalities should establish binding technical standards for urban planting, including:

- minimum soil volume requirements (e.g. 15–30 m³ per tree depending on location);
- soil quality and permeability criteria;
- use of structural soils and sustainable drainage systems (SuDS).

Climate-resilient species selection. Species selection should be based on scientific and practical evidence, using tools such as:

- plant climate hardiness zones (zones 5, 6 for Latvia-Lithuania cross- border area);
- regional performance data (frost resistant and drought tolerant plants; in flooded areas – moisture tolerant species; primarily native plant species should be used);
- the use of invasive plant species should be avoided.

This approach should prioritise diversity and resilience, reducing dependence on a limited number of species.

Lifecycle based management. Green infrastructure should be managed throughout its entire lifecycle:

- planning (site analysis and design);
- implementation (plant selection, planting and soil preparation);
- maintenance (watering, pruning, monitoring).

Adequate funding and institutional capacity are essential to support these processes.

Public education and engagement are key to the successful adoption of climate-adaptive green spaces, ensuring long-term sustainability and community support:

- improve communication and awareness about the benefits of climate-adaptive green spaces (e.g., heat reduction, stormwater management, biodiversity) through accessible materials, signage, and digital platforms.
- provide targeted education and materials (e.g., residents – practical guidance on plant selection and maintenance);
- develop pilot sites showcasing climate-adaptive plantings that can increase public understanding and acceptance;
- encourage public participation in planning processes, support community initiatives, and promote co-creation of green spaces. Providing simple guidelines, plant lists, and recommendations—especially promoting native and non-invasive species—helps ensure consistent and sustainable implementation.

Cross-border cooperation. Given the shared climatic and ecological conditions, Latvia and Lithuania should strengthen cross-border cooperation by:

- developing joint guidelines and standards;
- sharing data on species performance;

- implementing pilot projects and knowledge exchange initiatives.

The policy and legal framework for climate-adaptive urban green spaces in the Latvia–Lithuania cross-border region is well established at the European and national levels. However, significant challenges remain in translating these frameworks into effective municipal practices.

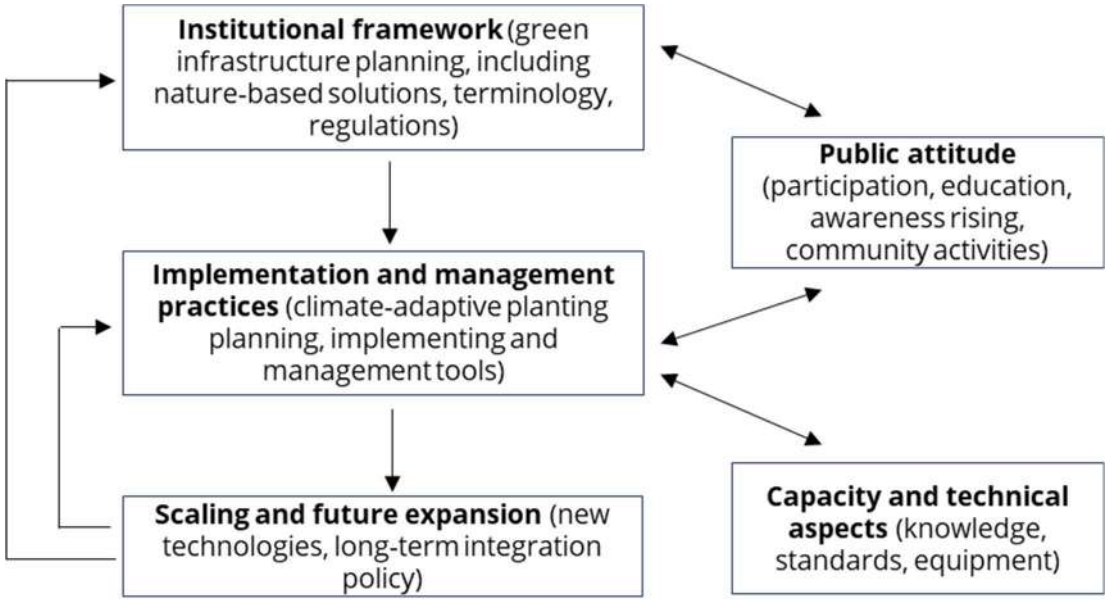

Figure 1.1. Municipal framework for planning, implementation and management of climate-adaptive green spaces and infrastructure.

Addressing these challenges requires a shift toward integrated planning, evidence-based decision-making, lifecycle management of green infrastructure and public engagement (*Figure 1.1*). By strengthening technical standards, improving species selection, and enhancing cross-border cooperation, municipalities can significantly improve the resilience and functionality of urban green spaces under changing climate conditions.

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2. Tools for planning, implementation and management of climate-adaptive urban green spaces

Climate change significantly affects urban plantings and existing vegetation, including peri-urban forests, by altering growing conditions and increasing environmental stress. In Latvia, rising average temperatures, a higher frequency of extreme weather events, and changes in precipitation patterns are observed, all of which impact plant vitality and ecosystem stability. Under these conditions, a transition towards climate adaptive plant species selection, based on their adaptive potential, becomes essential.

2.1. The role of climate adapted species and genotypes

Plant resilience under climate change conditions is closely linked not only to species selection but also to genetic characteristics. Research shows that different genotypes within the same species can vary significantly in their tolerance to drought, temperature fluctuations, and other abiotic stresses caused by climate change. Therefore, plant selection should be based on genetic diversity and breeding, identifying the most resilient genotypes.

"Climate Trees" approach in urban planting planning

In contemporary landscape architecture, the concept of "*climate trees*" is increasingly being applied, promoting the use of climate adapted plants in urban and peri-urban environments. These trees are selected based on their ability to withstand drought, heat, pollution, and other stress factors associated with climate change. This approach has already been implemented in Germany, where large tree nurseries, in collaboration with municipalities, conduct research, develop databases of resilient tree species, and integrate these findings into urban planning and design projects.

Climate adapted trees provide not only aesthetic value but also essential ecosystem services, such as microclimate regulation, air quality improvement, and mitigation of the urban heat island effect. Key selection criteria for such trees include:

- drought and heat tolerance;
- resistance to pests and diseases;
- ability to grow in restricted and degraded growing conditions;
- longevity and stable growth structure.

Biodiversity and planting structure

In the context of climate change, planting diversity is of key importance. Monocultural plantings are more vulnerable to climate variability, whereas mixed plantings provide greater ecosystem stability and resilience. A diverse species composition helps reduce risks associated with pest outbreaks, diseases, and extreme weather events.

Risks of invasive species

Climate change also facilitates the spread of invasive species, creating additional challenges for planting design and management. Invasive species can spread rapidly, outcompeting native species and reducing biodiversity. This, in turn, weakens ecosystem resilience and its capacity to adapt to changing climatic conditions. Therefore, a climate-adaptive approach involves not only the selection of resilient species but also the assessment and control of invasive species to maintain ecological balance.

Strategic approach to planting design

- Overall, climate-adaptive planning of plantings and existing vegetation requires an integrated approach that includes:
- selection of species and genotypes adapted to local climatic conditions;
- increasing planting diversity;
- monitoring and controlling invasive species;
- consideration of long-term climate scenarios (e.g., potential drought periods, flooding, strong winds).

This approach enables the development of resilient, functional, and sustainable green infrastructure that can adapt to climate change while ensuring a high quality of the environment.

2.3. Development of climate resilient plantings in different functional zones

Low-density residential areas

In low-density residential areas, the structure of plantings is based on the character of individual properties and a relatively low level of anthropogenic pressure. In these areas, it is recommended to use a diverse range of trees and shrubs, combining native species with ornamental introduced species. At the municipal level, plantings should be used along streets, as buffer zones separating residential areas from other land uses, and as windbreak plantings (*Figure 2.1*).

Figure 2.1. Planting structure in low-density residential areas [1]

- **Recommended tree and shrub species.** Taking into account the spatial scale of the urban environment, small- to medium-sized woody plants should be used in low-density residential areas. For hedges, a variety of plant species can be applied, with the main unifying characteristics defined by hedge parameters—such as width and height—determined during the technical design stage. Along streets, plants with compact crowns are recommended. Freely growing shrub belts can be

[1] *Ltd, I. (n.d.). Housing - the landscape practice.* http://www.thelandscapepractice.co.uk/landscape-design/10/housing

established along fences on the street side, using a mix of deciduous shrub species, with plant height as the main unifying criterion. Large tree plantings near drainage ditches are not recommended if the distance from the planned tree trunk location to the edge of the ditch is less than 1.5 m. Ditch edges can be landscaped using low, flowering perennial herbaceous plants. Considering the limited available space along streets, recommended plant species for street greenery in private residential areas include low-growing trees with compact crowns, medium-sized shrubs, low shrubs, perennials, ornamental grasses, and, in some cases, climbing plants (particularly where the available planting strip is narrower than 1 m).

- Recommendations based on soil, climate, and pollution conditions. Plant selection should consider moderately fertile soils and variable moisture conditions; therefore, preference should be given to species with moderate drought tolerance. In some cases, avenues are planted along access roads to private properties. In such situations, tree species should be selected that are tolerant of air pollution and capable of growing in roadside soils affected by contaminants.
- *Recommendations for planting intensity and diversity* – planting intensity should be moderate, with an emphasis on seasonal ornamental value and multi-layered plantings (trees–shrubs–perennials–ground cover–climbers), which help regulate the microclimate. Multi-layered plantings enhance shading and reduce temperatures in urban environments. Where new linear tree plantings are required, they should extend at least along one block to create a visually coherent yet diverse planting composition;
- *Recommendations for cost-effective maintenance solutions* – from a maintenance perspective, it is recommended to apply mulching, local rainwater collection and reuse for garden needs to reduce resource consumption, as well as to incorporate swales and open drainage or overflow ditches.

Low-rise residential areas

In low-rise residential areas, plantings should ensure a balance between private and public space. Similar to single-family residential areas, it is recommended to use a diverse range of trees and shrubs, combining native species with ornamental introduced species. At the municipal level, plantings should be implemented along streets, as buffer zones separating residential areas from other land uses, and as windbreak plantings (*Figure 2.2*).

- *Recommended tree and shrub species* – taking into account the spatial scale of the urban environment, low-rise residential areas should use small- to medium-sized woody plants that provide not only privacy but also help create semi-public outdoor spaces. A variety of plat species can be used for hedges, with the main unifying characteristics defined by hedge parameters - such as width and height -

determined at the technical design stage. Along streets, plants with compact crowns are recommended. Freely growing shrub belts can be established along fences on the street side, using a mix of deciduous shrub species, with plant height as the main unifying criterion. Large tree plantings near drainage ditches are not recommended if the distance from the planned tree trunk location to the edge of the ditch is less than 1.5 m. Ditch edges may be landscaped with low, flowering perennial herbaceous plants. Considering the limited available space along streets, suitable plant species include low-growing trees with compact crowns, medium-sized shrubs, low shrubs, perennials, ornamental grasses, and, in some cases, climbing plants (where the available planting strip is narrower than 1 m);

- ***Recommendations based on soil, climate, and pollution conditions*** – plant selection should consider moderately fertile soils and variable moisture regimes; therefore, preference should be given to species with moderate drought tolerance. In some cases, avenues are planted along access roads to private plots; in such situations, tree species should be selected that are tolerant of exhaust gases and capable of growing in roadside soils affected by pollution;
- ***Recommendations for planting intensity and diversity*** – planting intensity should be moderate, with an emphasis on seasonal ornamental value and multi-layered plantings (trees–shrubs–perennials–ground cover–climbers), which help regulate the microclimate. Multi-layered plantings enhance shading and reduce temperatures in urban environments;
- ***Recommendations for cost-effective maintenance solutions*** – from a maintenance perspective, it is recommended to apply mulching, local rainwater collection and reuse for garden needs to reduce resource consumption, as well as to incorporate swales and open drainage or overflow ditches. Planting intensity should remain moderate but well-structured - group plantings help reduce maintenance costs while improving visual quality.

Figure 2.2. Planting structure in low-rise residential areas [2]

[2] *Ltd, I. (n.d.). Housing - the landscape practice.* http://www.thelandscapepractice.co.uk/landscape-design/10/housing

High-Rise Residential Areas

High-rise residential areas are characterized by high usage intensity, compacted soils, and limited growing space. These areas represent some of the most intensively used environments in the urban landscape, often combined with traffic pressure and multifunctional land use.

- ***Recommended tree and shrub species*** – as these areas are frequently used by children, it is not advisable to use woody plants with thorns or species with toxic plant parts. Selected species should be resistant to intensive use and tolerant to vandalism;
- ***Recommendations based on soil, climate, and pollution conditions*** – plant selection should consider moderately fertile to poor soils, often with construction debris beneath the topsoil layer, and low moisture availability. Therefore, preference should be given to species with high drought tolerance that are capable of growing in low-fertility soils;
- ***Recommendations for planting intensity and diversity*** – planting intensity should be high, as vegetation plays a crucial role in improving the microclimate in residential courtyards, providing shade, wind protection, and social functions (*Figure 2.3*). In urban environments, trees help reduce the urban heat island effect and improve air quality;

Figure 2.3. Plantings in residential areas [3]

- ***Recommendations for cost-effective maintenance solutions*** – plantings should be designed as long-lasting, large groups while maintaining species diversity. It is recommended to reduce areas of intensively maintained lawns (especially in courtyard-adjacent zones), replacing them with ground cover plants or meadow-type vegetation. By selecting low-maintenance, resilient species that tolerate urban conditions and diseases, and are capable of self-regeneration, as well as ecologically compatible plant combinations, it is possible to create naturally sustainable and cost-efficient planting systems.

[3] *Pedersen, K. H. (2025, May 1). The Social Spine - Øresundskollegiet's new rooftop park — SLA. SLA. https://www.sla.dk/cases/the-social-spine/*

Mixed-use central and public development areas

In central urban areas, plantings are exposed to high levels of air pollution, limited soil volume for tree growth, intensive building density and paved surfaces, as well as dense underground utility networks that restrict the possibilities for increasing tree planting intensity. In addition, these areas experience high pedestrian flows and multifunctional land use. An important aspect is the representative function of these areas—mixed-use central districts serve as the "face" of the city, where both residents and visitors are present daily. These areas are often active during night time as well and are characterized by intensive traffic. The primary function of plantings in these areas is representational; however, green spaces may also serve additional functions, such as recreational areas for employees and visitors, children's play areas, and educational or interactive spaces (*Figure 2.4*).

Figure 2.4. Urban square plantings [4]

In administrative and public service buildings, where activities are primarily concentrated indoors, landscape planning mainly serves a representational function. In contrast, in the territories of schools, kindergartens, and hospitals, outdoor spaces should support not only recreation but also outdoor learning, education, social interaction, and sports activities.

- ***Recommended tree and shrub species*** – plants should be resistant to intensive use and vandalism, while also maintaining a high aesthetic quality with long-lasting ornamental value throughout all seasons and a stable crown structure. The use of woody plants with thorns or species with toxic plant parts is not recommended;
- ***Recommendations based on soil, climate, and pollution conditions*** – plant selection should consider moderately fertile to poor soils, often with construction debris beneath the topsoil layer, and low moisture availability due to extensive paving and building coverage. Therefore, preference should be given to species with high drought tolerance that can grow in low-fertility

[4] *Skerl, U. (2024, April 19). White Horse Square by DSDHA. Landscape Architecture Platform | Landezine.* https://landezine.com/white-horse-square-by-dsdha/

soils;

- ***Recommendations for planting intensity and diversity*** – plantings should be of high quality and representational, with a clear structure and composition, while maintaining diversity and emphasizing the identity of the city (through appropriate species selection, colour palette, and design composition);
- ***Recommendations for cost-effective maintenance solutions*** – plantings should be designed as decorative and long-lasting groups, arranged in larger masses while still ensuring species diversity.

Industrial and Technical development areas

These areas are characterized by a strong production-oriented function, with large proportions of surfaces covered by buildings and impermeable materials. Therefore, plantings should help mitigate the environmental impacts by providing shading, reducing potential soil pollution (phytoremediation), and establishing buffer planting zones that can help attenuate both noise and air pollution (*Figure 2.5*).

Figure 2.5. Plantings in industrial areas [5]

- ***Recommended tree and shrub species*** – plant species should be selected that are well adapted to local site conditions and resistant to existing or potential pollution associated with industrial areas;
- ***Recommendations based on soil, climate, and pollution conditions*** – for noise reduction and pollution mitigation, woody plants with large, broad leaves or dense foliage are typically used. In cases of contamination, phytoremediation methods can be applied. Phytoremediation is an environmentally friendly approach that uses plants to clean polluted soil, water, or air, based on their ability to absorb, degrade, or stabilize harmful substances;
- ***Recommendations for planting intensity and diversity*** – to create an effective planting structure, trees should be grouped together with shrubs, and shrub plantings should be arranged in layers, combining both lower and taller species. Establishing shrub plantings beneath trees creates dense vegetation belts that effectively filter and reduce pollution, visually screen industrial

[5] *Brezar, Z. (2023a, March 29). Werkspoorkathedraal Utrecht by Flux. Landscape Architecture Platform | Landezine. https://landezine.com/werkspoorkathedraal-utrecht-by-flux/*

facilities (especially where buildings are of low aesthetic quality), produce oxygen, and contribute to the overall urban green infrastructure;

- ***Recommendations for cost-effective maintenance solutions*** – it is recommended to reduce areas of intensively maintained lawns (especially adjacent to industrial sites), replacing them with meadow-type vegetation. By selecting low-maintenance, resilient species that tolerate urban conditions and diseases, and are capable of self-regeneration, as well as ecologically compatible plant combinations, it is possible to create naturally sustainable and cost-efficient planting systems.

Transport infrastructure areas

In transport infrastructure areas, plants are exposed to extreme conditions, including road salt and de-icing agents, drought, air pollution, and compacted soils. Under such conditions, soil resources for tree growth are limited, and dense underground utility networks further restrict the possibilities for increasing tree planting intensity. Street plantings also serve as a filter, capturing harmful emissions and improving air quality (*Figure 2.6*).

Figure 2.6. Buffer and Intensified Plantings along Transport Corridors [67]

- ***Recommended tree and shrub species*** – plant species should be selected that are well adapted to site-specific conditions and resistant to existing or potential pollution caused by transport. Preference should be given to species capable of providing sufficient shading to reduce surface overheating;
- ***Recommendations based on soil, climate, and pollution conditions*** – trees planted along roads are exposed to strong winds, dust, and exhaust gases; therefore, species suitable for such conditions should be selected. The planting of cultivated fruit tree varieties is not recommended;
- ***Recommendations for planting intensity and diversity*** – linear (row) plantings are generally not recommended. Trees should be planted in groups near public transport stops or rest areas; however, they must not obstruct road visibility;

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[6] *Brezar, Z. (2024, January 15). Rather Korso by DTP. Landscape Architecture Platform | Landezine.* https://landezine.com/rather-korso-by-dtp/

[7] *Requalification de l'avenue Mermoz – Suppression de l'autopont A43. (n.d.). Atelier Aup.* https://atelieraup.fr/project/requalification-de-lavenue-mermoz-suppression-de-lautopont-a43/

Recommendations for cost-effective maintenance solutions – during street design, it is essential to ensure the longevity of existing and planned plantings by incorporating комплекс protective measures against mechanical damage and soil contamination. These include tree trunk guards, tree pit grates, root protection systems, raised planting beds, and similar solutions.

Natural and forest areas

In these areas, priority is given to naturalness and biodiversity. It is recommended to use native species that are adapted to existing habitats, while controlling the spread of invasive species. An important role of natural areas is also in forming "green corridors" and an integrated green network, connecting public green spaces. Such ecological networks are essential for maintaining the continuity of ecological processes and ensuring the diversity and quality of the human living environment (*Figure 2.7*).

Figure 2.7. Natural areas in the city [8]

- ***Recommended tree and shrub species*** – selection depends on the site context, including the existing habitat and growing conditions; priority should be given to the preservation of existing vegetation;
- ***Recommendations based on soil, climate, and pollution conditions*** – pollution is generally limited in natural areas, while soil conditions depend on the existing habitat; therefore, planting and management should follow the natural soil characteristics of the site;
- ***Recommendations for planting intensity and diversity*** – natural areas have the greatest potential to support high plant diversity by maintaining a full vegetation structure, including ground cover, climate-adapted plantings, woody species, perennial communities, as well as wild bulbs, climbers, and annual species. Appropriate management should aim to preserve and support existing vegetation diversity;
- ***Recommendations for cost-effective maintenance solutions*** – areas of intensively mown lawns should be reduced, transitioning to extensively managed grasslands or meadows. The spread of invasive species should be regularly

[8] *La forêt humide et secrète | Atelier Paul Arène. (n.d.). https://www.paul-arene.fr/la-foret-humide-et-secrete*

monitored and controlled. Maintenance should be extensive, allowing natural processes such as deadwood retention and the presence of standing dead trees. Overall, priority should be given to a sustainable and self-regulating vegetation system that reduces maintenance costs while ensuring long-term ecological stability.

Public green spaces

Public green spaces, together with natural territories, form the foundation of the green network (*Figure 2.8*), serving as so-called "nodes." The primary function of "green corridors" is to ensure continuous connectivity between natural or artificially created habitats. Street plantings can also function as green corridors, linking natural areas, parks, and squares. By connecting larger green areas within urban environments, natural territories, and waterfronts through green corridors, it is possible to enhance the viability of bird and small animal populations, thereby improving overall biodiversity.

Figure 2.8. Diverse planting structures in urban parks [9]

- ***Recommended tree and shrub species*** – in planting areas (parks and squares), a greater diversity of introduced species is acceptable, serving as a means of testing and adapting new species to urban conditions under changing climate scenarios. These areas provide controlled conditions for evaluating the suitability of different species and cultivars, particularly their tolerance to drought, temperature fluctuations, pollution, and other urban stress factors. Parks and squares thus function as important experimental and demonstration sites for the gradual introduction of climate-adapted taxa, while maintaining landscape quality and biodiversity;
- ***Recommendations based on soil, climate, and pollution conditions*** – planting areas generally have fewer pollution sources and allow for better growing conditions than other urban areas; therefore, ornamental value becomes a primary consideration;

[9] *Brezar, Z. (2024, January 15). Rather Korso by DTP. Landscape Architecture Platform | Landezine.* https://landezine.com/rather-korso-by-dtp/

- ***Recommendations for planting intensity and diversity*** – planting areas can incorporate a wide variety of flowering plants and species with decorative branches, foliage, or distinctive crown forms. It is important to ensure that introduced species are selected responsibly, taking into account the risks of invasiveness and their compatibility with local ecosystems, in order to create resilient, sustainable, and diverse plantings in the long term;
- ***Recommendations for cost-effective maintenance solutions*** – areas of intensively maintained lawns should be reduced, transitioning to extensively managed grasslands or meadows. The spread of invasive species should be regularly monitored and controlled. Preference should be given to species that do not require frequent irrigation or intensive maintenance, such as pruning.

Agricultural areas

Agricultural areas play a significant role in climate change processes, as they influence carbon cycles, water regimes, and soil quality. Intensive agricultural use can contribute to soil erosion, carbon loss, and nutrient runoff into water bodies, thereby exacerbating the impacts of climate change. At the same time, these areas have considerable potential for climate change mitigation. Purposefully designed plantings, such as windbreaks, buffer strips, and wetlands, can reduce wind and water erosion, improve soil moisture conditions, and enhance carbon sequestration. These solutions help stabilize the microclimate, reduce pollution entering water bodies, and increase biodiversity. Thus, integrated plantings in agricultural areas serve as an effective tool for promoting sustainable land use and mitigating the impacts of climate change (*Figure 2.9*).

Figure 2.9. Agricultural fields integrated into the green network of natural areas, promoting biodiversity [10]

- ***Recommended tree and shrub species*** – in agricultural areas, plantings primarily serve a functional role, providing soil protection, microclimate regulation, and

[10] *HOPS Rescue Plan: Nature-Based Solutions Response to Climate change. (n.d.). ASLA.* https://www.asla.org/awards-events-main-landing/honors-awards/pro-student-awards/2024-student-awards/10402

stabilization of water regimes. In windbreak belts, it is recommended to use resilient and fast-growing tree species, while the shrub layer should include species that reduce wind flow and enhance biodiversity. In flood-prone areas and wetlands, moisture-tolerant species should be used;

- ***Recommendations based on soil, climate, and pollution conditions*** – soils in agricultural areas are often exposed to erosion, drying, and nutrient leaching. Therefore, when establishing windbreaks and protective plantings, it is essential to select species with deep root systems and high tolerance to drought and wind. The ground layer should include perennial grasses and meadow species that help stabilize the soil and reduce erosion. To promote biodiversity, flowering, climate-adaptive planting strips can be established along fields to attract pollinators. Considering potential pollution from agricultural activities (fertilizers and pesticides), buffer zones and wetlands should include plant species with phytoremediation potential, capable of absorbing excess nutrients and reducing their runoff into water bodies;
- ***Recommendations for planting intensity and diversity*** – planting intensity in agricultural areas should be low to moderate, with an emphasis on linear and structured elements such as windbreak belts, buffer strips, and wetlands. Windbreaks should be designed as multi-layered systems, combining trees and shrubs in several rows to effectively reduce wind speed and improve the microclimate. Such systems can reduce soil erosion, moisture loss, and increase crop productivity. In flood-prone areas, wetlands should be established as natural water retention and filtration systems, helping to manage excess water and reduce flood risks. To ensure biodiversity, it is important to use a combination of different species that form stable ecosystems;
- ***Recommendations for cost-effective maintenance solutions*** – in agricultural areas, extensive and self-regulating management approaches are recommended. Once established, windbreaks and wetlands require minimal maintenance, mainly periodic care and control of invasive species. Cost efficiency can be improved by using native species that are better adapted to local climate conditions and do not require additional irrigation or fertilization. Nature-based solutions, such as wetlands, should be integrated, as they simultaneously provide water regulation, purification, and biodiversity functions. Overall, planting design in agricultural areas should focus on functional and sustainable solutions that reduce maintenance costs while improving environmental quality and resilience to climate change.

Water areas

Watercourses, water bodies, and their adjacent areas, similarly to natural, forest, and green space territories, are important elements of the green network and ecological corridors, providing essential ecosystem services for the city as a whole. They support biodiversity, regulate the microclimate, improve water quality, and offer

recreational opportunities. Aquatic and riparian habitats are particularly sensitive to various changes, such as pollution, alterations in spatial structure, and anthropogenic pressure. Therefore, balanced and well-considered management is essential in these areas. Priority should be given to preserving existing vegetation and maintaining natural processes rather than implementing intensive new plantings. The establishment of new plantings should be limited to cases where it is necessary for ecosystem stabilization, such as erosion control or habitat restoration, using native and moisture-adapted species (*Figure 2.10*). This approach ensures sustainable development of these areas while preserving their ecological value and functionality.

Figures 2.10. Landscape design of waterfront areas [11],[12]

- ***Recommended tree and shrub species*** – selection should be based on the specific riparian habitat, including water-loving species, species tolerant of temporary flooding, and those capable of withstanding dry conditions on slopes;
- ***Recommendations based on soil, climate, and pollution conditions*** – in the coastal zones of water bodies and watercourses, plant selection should be based on the moisture regime, soil stability, and potential pollution from surface runoff originating from adjacent areas. Priority should be given to native, moisture-tolerant, and ecologically appropriate species that can stabilize shorelines while also providing filtration functions;
- ***Recommendations for planting intensity and diversity*** – planting intensity in water-related areas should be low to moderate, with an emphasis on natural and multi-layered vegetation structures. Transitional zones between water and land should be created, where plant composition gradually shifts from aquatic plants to shrubs and trees. Biodiversity is a key factor for the stability of these areas; therefore, the use of diverse species and avoidance of

[11] Newly opened Rifle Range Nature Park offers 7km-long trails, rain garden and a clifftop view. (2022, November 25). The Straits Times. https://www.straitstimes.com/singapore/new-rifle-range-nature-park-offers-trails-and-a-clifftop-view?utm_source=Pinterest&utm_medium=organic

[12] Xiangyu Park, China by Yihe Planning and Design. (n.d.). Gooood. https://www.gooood.cn/xiangyu-park-china-by-yihe-planning-and-design.htm?lang=en&utm_source=Pinterest&utm_medium=organic

monocultures is recommended. Diverse plantings enhance ecosystem resilience to climate change and pollution, while also supporting habitat creation for various species;

- ***Recommendations for cost-effective maintenance solutions*** – extensive management approaches based on natural processes are recommended in water-related areas. The use of native species reduces the need for irrigation, fertilization, and intensive maintenance. Maintenance costs can be minimized by establishing naturalistic plantings that require limited intervention, such as periodic invasive species control and selective maintenance. Additionally, nature-based solutions such as rain gardens and wetlands should be applied, as they provide both purification and landscape functions. Overall, priority should be given to sustainable and self-regulating vegetation systems that reduce maintenance costs while ensuring long-term ecological stability.

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3. Recommended climate resilient plant species for cities in the Latvia–Lithuania cross-border area

3.1. Selection of climate resilient tree species in Latvia and Lithuania

In Latvia and Lithuania, the selection of climate adapted species is based on similar climatic conditions and shared ecological characteristics. In the context of urban plantings and peri-urban vegetation in both countries, the selection of climate-adapted species is based both on the ecological suitability of native species and their ability to withstand urban environmental stress. The Riga City Council tree planting guidelines emphasize that species selection should be tested against specific climatic and urban conditions, including the evaluation of different taxa in real planting environments. While Riga provides specific planting guidelines, similar approaches are implemented in Vilnius through integrated planning documents and climate policies.

In Latvia and Lithuania, species considered most suitable for local climatic conditions are ***primarily native species*** that have adapted over centuries to the regional climate zone. These species generally ensure higher stability and ecological resilience. Among the most important and widely used resilient species in Latvia are:

- *Quercus robur*
- *Tilia cordata*
- *Acer platanoides*
- *Pinus sylvestris*
- *Picea abies*
- *Betula pendula*
- *Alnus glutinosa*

These species are well adapted to local climatic conditions; however, under climate change their resilience may be affected, particularly in relation to drought stress and pest outbreaks.

At the same time, in urban environments the suitability of plant species depends not only on climate adaptation but also on their ***ability to tolerate urban stress factors***, such as:

- drought;
- heat stress;
- soil compaction;
- limited rooting space;
- urban pollution (air, soil, water);

- irregular water availability;
- temperature fluctuations.

Therefore, the development of climate resilient plantings increasingly relies on a combined approach - maintaining native species as a foundation while complementing them with selected or non-native taxa that demonstrate higher tolerance to drought and heat. An important principle is also the testing and gradual introduction of species, particularly in urban environments, where new taxa can be evaluated under real conditions to assess their suitability for future climates. Overall, in the Latvian and Lithuanian context, the development of climate resilient plantings is based on a balance between the use of native species, the introduction of new adaptive species, and increased planting diversity, ensuring long-term ecosystem stability.

3.2. Criteria for climate resilient species selection

Based on scientific research and practical guidelines, species should be evaluated using the following criteria:

- Abiotic stress tolerance
  - Drought tolerance (critical due to increasing summer dryness);
  - Heat tolerance (urban heat island conditions);
  - Frost resistance (important in Baltic climate);
  - Tolerance to soil compaction and sealing.
- Urban stress resistance
  - tolerance to air, soil and water pollution;
  - resistance to road salt;
  - ability to grow in limited rooting space.
- Biological stability
  - resistance to pests and diseases;
  - structural stability (wind resistance, branch strength);
  - longevity.
- Ecosystem service potential
  - shading capacity;
  - evapotranspiration (cooling effect);
  - biodiversity support (flowers, fruits, habitat);
  - contribution to stormwater management.
- Maintenance requirements
  - water demand during establishment;
  - pruning needs;
  - tolerance to neglect.

3.3. Plant selection based on urban functional zones

Urban environments are heterogeneous, and different areas require different planting strategies. A functional zoning approach helps to match plant selection and design with site-specific conditions.

Zone	Characteristics of zone	Functions	Tools
Residential areas	• moderate environmental stress; • high social use; • need for aesthetic and microclimatic comfort.	• shading and cooling; • recreational value; • biodiversity support.	• mixed planting (trees + shrubs + groundcover); • use of drought-tolerant but visually attractive species; • integration of small-scale water management (e.g. rain gardens).
City centres and dense urban areas	• high temperatures (urban heat island effect); • limited space; • high soil sealing and compaction.	• cooling and shading; • air quality improvement; • visual quality.	• compact or columnar tree species; • structural soils and underground rooting systems; • green roofs and vertical greening; • use of highly stress-tolerant species.
Transport corridors	• exposure to pollution and road salt; • compacted soils; • mechanical stress.	• protection from wind and noise; • visual buffering; • safety (clear visibility zones).	• salt-tolerant and drought-resistant species; • simplified planting schemes; • reinforced planting pits and soil systems.
Parks and natural areas	• lower environmental stress; • larger available space; • ecological importance.	• biodiversity enhancement; • ecosystem connectivity; • recreation.	• use of native and regionally adapted species; • multi-layered vegetation structure (trees, shrubs, herbaceous plants); • minimal intervention management approaches.

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Final remarks

Climate-adaptive species selection requires a shift from traditional planting approaches toward diversified, evidence-based strategies. Key conclusions: species must be selected based on stress tolerance and ecosystem functions; shrubs play a critical role alongside trees; diversity is essential for resilience; selection must be aligned with functional zoning and site conditions. By applying these principles, municipalities can significantly increase the long-term performance and sustainability of urban green infrastructure in the Latvia–Lithuania cross-border region.