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Улогата на пејзажната архитектура во планирањето на патиштата

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Апстракт. Планирањето и развојот на патната инфраструктура традиционално биле насочени кон инженерската ефикасност, поврзаноста и економската одржливост, но тие процеси носат и значајни еколошки, социјални и визуелни последици. Интеграцијата на пејзажната архитектура во дизајнот на патиштата претставува современ пристап за подобрување на функционалноста и одржливоста на транспортните мрежи. Растечката свест за еколошката одржливост, социјалната еднаквост и отпорноста на пејзажот ја позиционира оваа дисциплина како клучна во современото планирање. Пејзажните архитекти имаат значајна улога во зачувување на биодиверзитетот, намалување на визуелното влијание, управување со ерозијата и усогласување на инфраструктурата со природниот и културниот пејзаж. Нивното вклучување овозможува инфраструктурните проекти да се справат со предизвици како фрагментација на живеалишта, управување со атмосферски води и климатски адаптации, создавајќи безбедни и естетски кохерентни транспортни коридори. Студијата ја нагласува потребата од институционално вклучување на пејзажната архитектура во патното планирање за постигнување одржлива и човеково-ориентирана инфраструктура. Преку анализа на национални примери и регулативи, се идентификуваат постојните ограничувања и се предлагаат насоки за институционално вклучување на пејзажната архитектура во планирањето на транспортот.

Клучни зборови. пејзажна архитектура; планирање на патишта; дизајн на инфраструктура; еколошка поврзаност; зелена инфраструктура.

The role of landscape architecture in road planning

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Abstract. The planning and development of road infrastructure have traditionally prioritized engineering efficiency, connectivity, and economic viability. The development of road infrastructure in the Republic of North Macedonia brings with it significant environmental, social and visual consequences. The integration of landscape architecture into road infrastructure design presents a transformative approach to enhancing both the functionality and sustainability of transportation networks. However, growing awareness of enviroanmental sustainability, social equity, and landscape resilience has positioned landscape architecture as a critical discipline in contemporary road planning. This paper examines the evolving role of landscape architecture in the conceptualization, design, and implementation of road networks, highlighting its capacity to mediate between the built and natural environments. Emphasis is placed on the function of the landscape architect in preserving biodiversity, reducing visual impact, managing erosion, and integrating infrastructure with the local cultural and natural landscape. Landscape architects contribute to road planning by integrating ecological systems, optimizing land use, enhancing visual quality, and promoting social inclusion through context-sensitive solutions. Their involvement ensures that infrastructure projects address challenges such as habitat fragmentation, stormwater management, erosion control, and climate adaptation while simultaneously creating safe and aesthetically coherent mobility corridors. Drawing on case studies and cross-disciplinary research, this study underscores the necessity of embedding landscape architectural perspectives within road planning processes to achieve sustainable, resilient, and human-cantered infrastructure outcomes. Through an analysis of national examples and regulations, current limitations are identified and guidelines for the institutional inclusion of landscape architecture in transportation planning are proposed.

Key words. landscape architecture; road planning; infrastructure design; ecological connectivity; green infrastructure.

1. INTRODUCTION

The expansion of road networks worldwide has generated significant challenges related to environmental degradation, fragmentation of habitats, and visual intrusion into natural and cultural landscapes. Landscape architecture, traditionally associated with aesthetics and recreational spaces, now plays a broader, integrative role in planning and designing road infrastructure. In the Republic of North Macedonia, numerous road corridors (such as Corridors 8 and 10) pass through environmentally sensitive and culturally significant areas. The need for an interdisciplinary approach to planning, where landscape architecture plays a key role, is becoming increasingly evident.
This paper investigates the value that landscape architects bring to road planning, particularly in harmonizing infrastructure with natural systems and human needs.

2. METHODOLOGY

This study employs a qualitative content analysis based on a review of scientific literature, spatial planning documents (patial Plan, Biodiversity Strategy, Environmental Impact Assessment), case studies from constructed sections, and international case studies from Europe, North America, and Asia. The research focuses on identifying key themes where landscape architecture intersects with road design and planning. We also examine several cross-disciplinary collaborations and policy frameworks that enable the inclusion of landscape considerations in transport infrastructure.

3. LANDSCAPE ARCHITECTURE IN ROAD PLANNING

3.1. Ecological Integration

Landscape architects contribute to preserving and enhancing biodiversity through the planning of ecological corridors, green bridges, and buffer zones. Proper vegetation design along roads reduces wildlife collisions, supports pollinators, and promotes habitat connectivity (Forman & Alexander, 1998).
In the context of the Republic of North Macedonia, this issue is particularly sensitive as the country is located at the crossroads of three biogeographic regions (Alpine, Mediterranean and Continental) and represents a “biological hotspot” with a high level of endemism, especially in regions such as Shar Planina, Mavrovo National Park, Pelister, Osogovo and Prespa.
Roads create physical barriers that restrict the movement of animal species and interrupt the natural flow of energy, water and organisms. This leads to “islands” of habitats that are smaller and more isolated, reducing their ecological value. In North Macedonia, an example of such a problem is the A2 highway (Gostivar – Kičevo), which passes through forest massifs inhabited by bears, wolves, roe deer and lynx – all species sensitive to fragmentation and human activity.

Fig. 1: Model of sustainable urban transport with high landscape values (green infrastructure)

Landscape architects are key in identifying, designing, and preserving ecological corridors, which are critical for maintaining ecosystem connectivity. These corridors can be:

- Linear green structures along roads – with indigenous and habitat-friendly vegetation;
- Green bridges (eco-ducts) – as overhead animal crossings over highways, intended for small and large mammals;
- Underground passages – integrated with watercourses or specially built for amphibians and reptiles;
- Mosaic structures with alternative habitats, which allow a gradual transition from natural to anthropogenic environments.

In the planning of Corridor 8, the importance of these elements was not sufficiently taken into account, although the route passes through areas of high ecological value (e.g. the Babuna Valley and Mariovo). The involvement of landscape architects in the early stages would have enabled mapping of migration routes and recommendations for the placement of critical crossing points.

In addition to structural solutions, the choice of vegetation along roads plays an important role in supporting biodiversity. Instead of decorative, often invasive species (such as Ailanthus altissima or Robinia pseudoacacia), landscape architects recommend:

- Native and honey-bearing species (Crataegus, Cornus, Tilia, Salvia, Lavandula);
- Group planting of shrub and forest species that provide shelter and food;
- Green belt as a barrier from dust, noise and light pollution.

Examples of positive practices exist in sections of the Gevgelija – Negotino highway, where appropriately sized belts of acacia and pine trees were used for slope stabilization and visual integration, but a systematic approach to biodiversity was absent.
In the future, the road network of North Macedonia should be developed as a green transport system, in which roads are not barriers, but integrated lines with the function of an ecosystem connection, where landscape architecture plays a leading role.
Landscape architecture can offer solutions through:

- Design of green bridges and underpasses for wildlife as part of the infrastructure.
- Areas of native vegetation along roads that serve as habitats and visual screens.

3.2. Visual and Aesthetic Quality

Visual impact assessment is a crucial component of road design. Landscape architects mitigate the intrusion of roads into sensitive visual landscapes by introducing natural landforms, native vegetation, and context-sensitive design. This not only preserves the character of the region but also enhances driver experience and safety (Bell et al., 2012).
The Republic of North Macedonia is a country with a distinct landscape identity. Roads are not only transport corridors, but also influential visual structures that change the character of the space and affect the perception of the local population and visitors. The Macedonian landscape is rich in cultural values – archaeological sites, sacred buildings, traditional villages. In the Macedonian territory, numerous roads pass through high-value visual landscapes – such as the Galicica National Park, the Radika Valley, the Ohrid and Prespa regions, the wine valleys near Kavadarci and Tikvesh, as well as the cultural landscapes around Skopje, Kruševo, and Kratovo. In these areas there is a high degree of visual sensitivity, where any intervention in the visual field can cause a disruption of the ambience, tourist attractiveness, and local identity.
The application of Viewshed analysis in GIS tools is one way that landscape architects can predict the visual implications of a roadway before it is designed. This tool allows for the simulation of from which points in the landscape the roadway will be visible and what its visual effect on the surrounding area will be.
Landscape architecture offers strategies for contextual design, that is, shaping infrastructure in accordance with the natural forms, colors, textures, and cultural character of the area. This includes:

1. Terrain modeling: Modeling embankments and slopes in a way that follows the natural lines of the landscape;
2. Materials in harmony with the environment: Instead of the dominance of gray concrete, local stone materials, wood and green facades are used (especially on tunnels and sound barriers);
3. Plant barriers and afforestation: Introducing tree lines and greenery with indigenous vegetation along roads that reduce the visual dominance of the thoroughfare and restore a sense of landscape balance.

An example of successful (partial) application of such an approach is the section of the A1 highway between Smokvica and Gevgelija, where a green belt has been planted that serves as visual screening, but there is no clear concept of vegetation as an element of landscape design.
Impact on tourism and economic development. In tourist-developed areas such as Ohrid, Prespa or Dojran, the visual quality of access roads is part of the visitor's first impression. Roads must be designed as "gateways" into the landscape, not as industrial or technical barriers. This includes:

- Thematic entrance gates,
- Synchronization with local architectural style (e.g., stone walls, traditional roofs),
- Greened roundabouts and dividing islands.

The role of visual quality in safety. Research shows that the monotony of the landscape can cause fatigue in drivers. Landscape architecture provides visual breaks and variations in the landscape scene that increase alertness and improve the psychological comfort of

passengers. Especially on long sections, aesthetically designed elements (tree rows, tunnels, panoramic views) improve the functionality of the road and reduce the risks of traffic accidents.

Fig. 2: Visually well-integrated roads

3.3. Visual and Aesthetic Quality

Through the use of bioswales, permeable surfaces, and vegetated embankments, landscape architecture aids in managing runoff and reducing erosion, particularly in hilly and fragile terrains (Shafique et al., 2018). These nature-based solutions are more sustainable and cost-effective compared to traditional engineering methods.

Fig. 3: Example of integration of landscape architecture into a planned road corridor

Mountainous sections (e.g. Struga – Debar – Gostivar) are exposed to erosion processes. Landscape architects can apply:

- Biotechnical measures (bio-moats, geogrids).
- Terrain modeling and planting with root-stable plants (Salix, Tamarix spp.).

3.4. Cultural and Social Context

Roads pass through diverse cultural and historical landscapes. Landscape architects ensure that planning respects heritage sites, local traditions, and community needs, thereby reducing opposition and promoting public support for infrastructure projects (Taylor & Lennon, 2011).
Many of Macedonia's roads pass through areas of high cultural and historical value, such as:

- archaeological sites (Heraclea, Stobi, Bargala),
- traditional villages (Galichnik, Lazaropole, Vevchani),
- sacred buildings and old church complexes (e.g. in Kratovo, Veles, Krushevo),
- rural and urban landscapes shaped by indigenous architecture and agricultural mosaics.

In such contexts, uncontrolled expansion of the road network, inadequate embankments, artificial walls, inauthentic materials, and modern concrete bridges can radically disrupt the cultural legibility of the landscape. The landscape architect has the task of:

- recognize cultural layers in the space (traditional patterns, routes, agro-landscapes),
- propose an integrated design that respects local morphology and architectural logic,
- avoid visual dominance of the road over the authentic landscape,
- introduce materials, textures and forms that communicate with the history of the location.

Roads affect the perception of space by the local population. One of the negative examples is the expansion of the Prilep – Bitola road, where the route passes near the archaeological site

of Heraclea Lyncestis, but without visual or informational integration with the site. Instead, the space looks like a periphery with an urban-rural transition without cultural character.
In contrast, parts of the road network in the Kratovo region have potential for cultural storytelling, where landscape architects could design:

- viewpoints towards cultural objects with urban furniture and information boards;
- restored traditional stone crossings and bridges with appropriate signage;
- thematic roundabouts or gates that reflect the cultural theme of the region.

Cultural and social context must not be marginalized in road planning. Roads must be designed as an infrastructure of coexistence, which not only connects space, but also tells the story of the place. Landscape architecture enables such holistic thinking, where the road is not just a function – but an experience, an identity and a mutual recognition.

4. CASE STUDIES

1. Demir Kapija – Smokvica section (A1) - This section is part of the Pan-European Corridor 10 and represents one of the most significant road projects in the country. It passes through a gorge with complex geomorphology and high biodiversity, characterized by limestone rocks, forests and karst systems.
During the construction phase, landscape aspects were neglected, but with the finalization of the reclamation plan, green forest barriers were introduced, with limited effect due to non-indigenous vegetation.
Problems and potentials:
1.Ecological risks: The section intersects natural habitats of globally significant species, such as mouflons, eagles and rare plant communities.
2.Visual potential: The road offers impressive panoramic views that are not exploited through the design of resorts or viewpoints.
3.Engineering focus: The project is dominated by an engineering approach without integrated landscape analysis or ecologically perceptive design.
Recommendations:

- ✓ Design of ecological passages (eco-ducts) over sensitive areas;
- ✓ Planting of indigenous vegetation on slopes and embankments with a stabilization and masking function;
- ✓ Introduction of visual frames and points for education and interpretation;
- ✓ Resorts with renewable architecture that use local materials and respect the geology of the area.

2. The planned highway section **Ohrid - Kichevo (A2 highway, Corridor 8)** - this project is currently in the phase of expansion and reconstruction. The section passes through mountainous terrain with unstable soils, numerous landslides and water flows, as well as through territories with traditional architecture and tourist potential. Key problems:
1.Poor erosion control: Uncontrolled landslides were registered in several places due to the absence of biotechnical stabilization;
2.Insufficient visual integration: The road appears as a dominant structure in the landscape, with no attempt at contextualization with the landforms;
3. Neglect of cultural context: No integration with local villages, commercial routes or tourist routes is foreseen.
Recommendations:

- ✓ Involvement of landscape architects in the analysis of visual points with tourist potential (e.g. viewpoints towards Debarca, Jablanica);
- ✓ Application of geogrids and bioengineering systems for slope stabilization;
- ✓ Revision of the project with the inclusion of cultural narratives and information structures along the route;
- ✓ Design of rehabilitated public spaces near open sections.

4. The planned highway section **Gostivar – Kichevo** - Region with high biodiversity value (Mavrovo), where the expert public demanded the involvement of an ecologist and landscape architect for optimal routing and minimizing the impact.
5. **Wildlife Crossings in Banff National Park (Canada):** Landscape architects collaborated with engineers to design vegetated overpasses that have significantly reduced wildlife-vehicle collisions.
6. **The Dutch Green Roads Program:** The Netherlands integrates green infrastructure along highways, incorporating water management and pollinator habitats.
7. **Slovenia's Ecological Connectivity Corridors**: As part of the TEN-T network, Slovenian road planning mandates landscape input for biodiversity preservation.

5. DISCUSSION

The findings underscore the need to shift from conventional road planning towards integrated, multidisciplinary models. Landscape architects serve as mediators between ecological systems and technical infrastructure, offering design solutions that are context-sensitive and future-oriented. The early involvement of landscape professionals in transport projects correlates with improved environmental outcomes and long-term cost savings.
Challenges remain, particularly in regulatory frameworks that prioritize speed and cost over ecological and visual considerations. Education, policy reforms, and stronger cross-sector collaboration are necessary to institutionalize the role of landscape architecture in infrastructure projects.
Compared to European countries (Austria, Sweden, Slovenia), where roads are planned as "green corridors" with multi-layered functions (ecological, cultural, recreational), North Macedonia still does not have formalized:

- standardized visual and landscape criteria for road design;
- protocols for bioengineering interventions and slope stabilization;
- multisectoral collaboration between engineers, ecologists, urban planners and landscape architects;
- a system for monitoring the environmental impact after construction.

The introduction of such criteria would enable the integral design of roads as part of the living landscape, with benefits for biodiversity, public space and tourism development.
There are several restrictions in the Republic of North Macedonia:

- There are no clear legal requirements for the involvement of a landscape architect in the conceptual design phase.
- Ecological and aesthetic aspects are often considered secondary.
- Lack of national standards for landscape road design.

However, there is room for progress through:

- Institutionalizing landscape architecture in spatial and urban planning law,
- Training engineers and planners in the basics of landscape ecological analysis,
- Using GIS and 3D visualizations for transparency and public support.

6. RECOMMENDATIONS

To improve the quality of planning and advance the role of landscape architecture in road infrastructure in the Republic of North Macedonia, the following specific steps are proposed:

1. Institutionalization and politics
   - ✓ Inclusion of a landscape architect as a mandatory member of the project teams in the conceptual and basic design phases;
   - ✓ Development of National Guidelines for Green Road Infrastructure, in accordance with European models (e.g. CEUD, Green Roads Manual);

•Integration of landscape architecture into spatial plans and strategic infrastructure documents.

2. Design and planning
   - ✓ Introduction of standard protocols for visual analysis, erosion assessment and selection of native vegetation;

- ✓ Design of ecological crossings, bio-fences, retention belts and panoramic points;
- ✓ Stimulation of pilot projects of culturally integrated road segments, with local thematic identities.

3. Education and public awareness
   - ✓ Developing programs for continuous education of engineers, urban planners and public institutions on the role of landscape architecture;
   - ✓ •Promoting good practices through public competitions, exhibitions and publications;
   - ✓ Encouraging citizen participation in the early stages of design, through public hearings and field workshops.
4. Research and monitoring
   - ✓ Conduct regional studies of visual sensitivity, ecological connectivity and climate risks in route selection;
   - ✓ Develop a model for post-implementation monitoring of biological, visual and hydrological effects;
   - ✓ Encourage collaboration between universities, planners and public enterprises to create a database and practical guidelines.

7. CONCLUSIONS

Landscape architecture is not a complementary service in road planning but a fundamental discipline that ensures infrastructure is sustainable, humane, and ecologically resilient. Landscape architecture should be treated as an essential part of the planning and construction of road infrastructure in North Macedonia. Its role is not limited to "greenery", but to the comprehensive management of space, ecology and cultural context. It is advisable to establish interdisciplinary teams from the initial planning phase, where the landscape architect will have an equal role with engineers and urban planners. In a time of climate change, cultural erosion, and spatial fragmentation, roads must not be built just for faster movement – they must be roads that connect people, landscapes, history, and the future. Landscape architecture is precisely the discipline that allows the road to become a space, not just a route. The integration of landscape architecture enables the creation of infrastructure that is sustainable, resilient and human-centered. The impact is seen through ecological, cultural and social benefits, which can transform travel into an authentic and aesthetic experience.

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