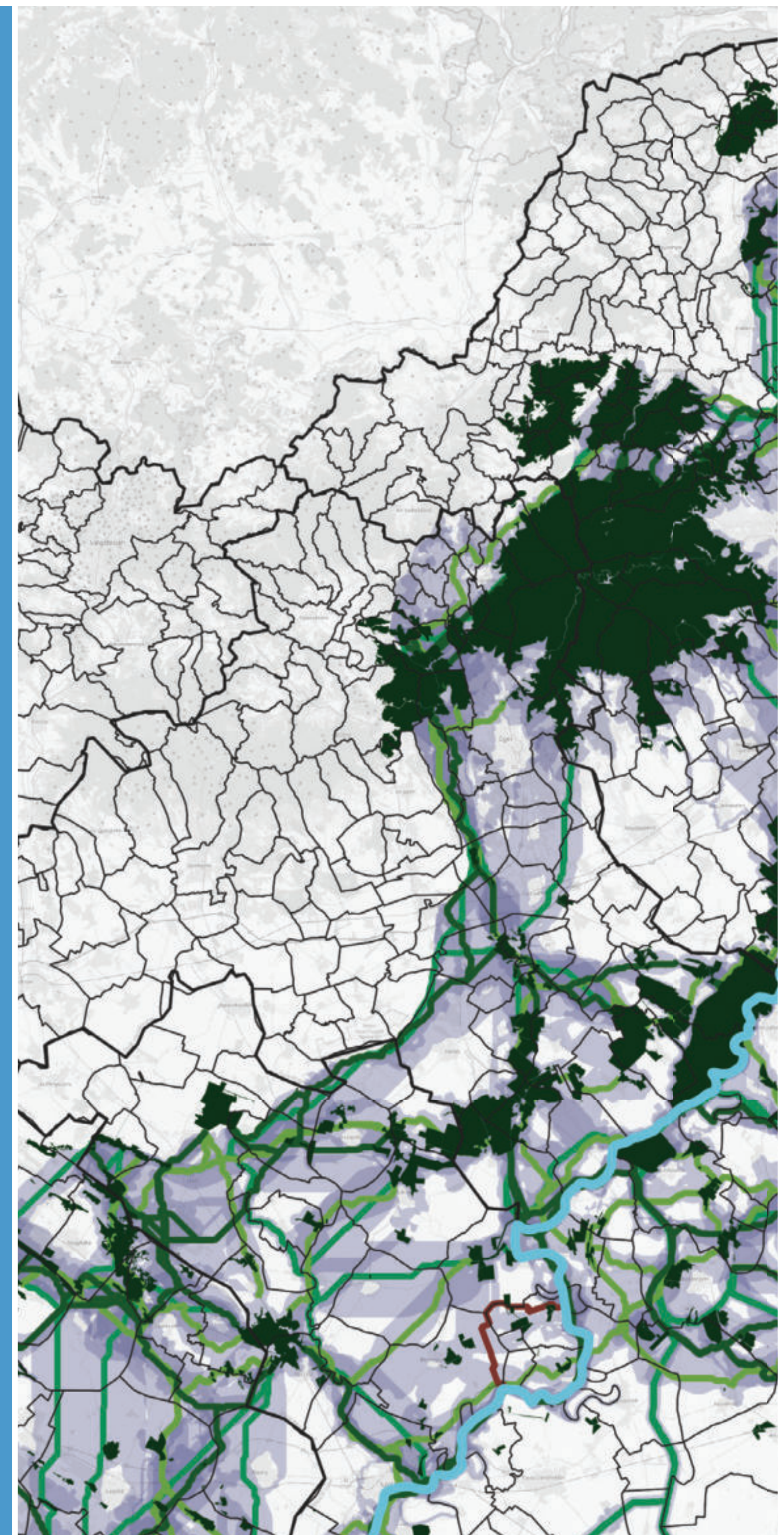
4D

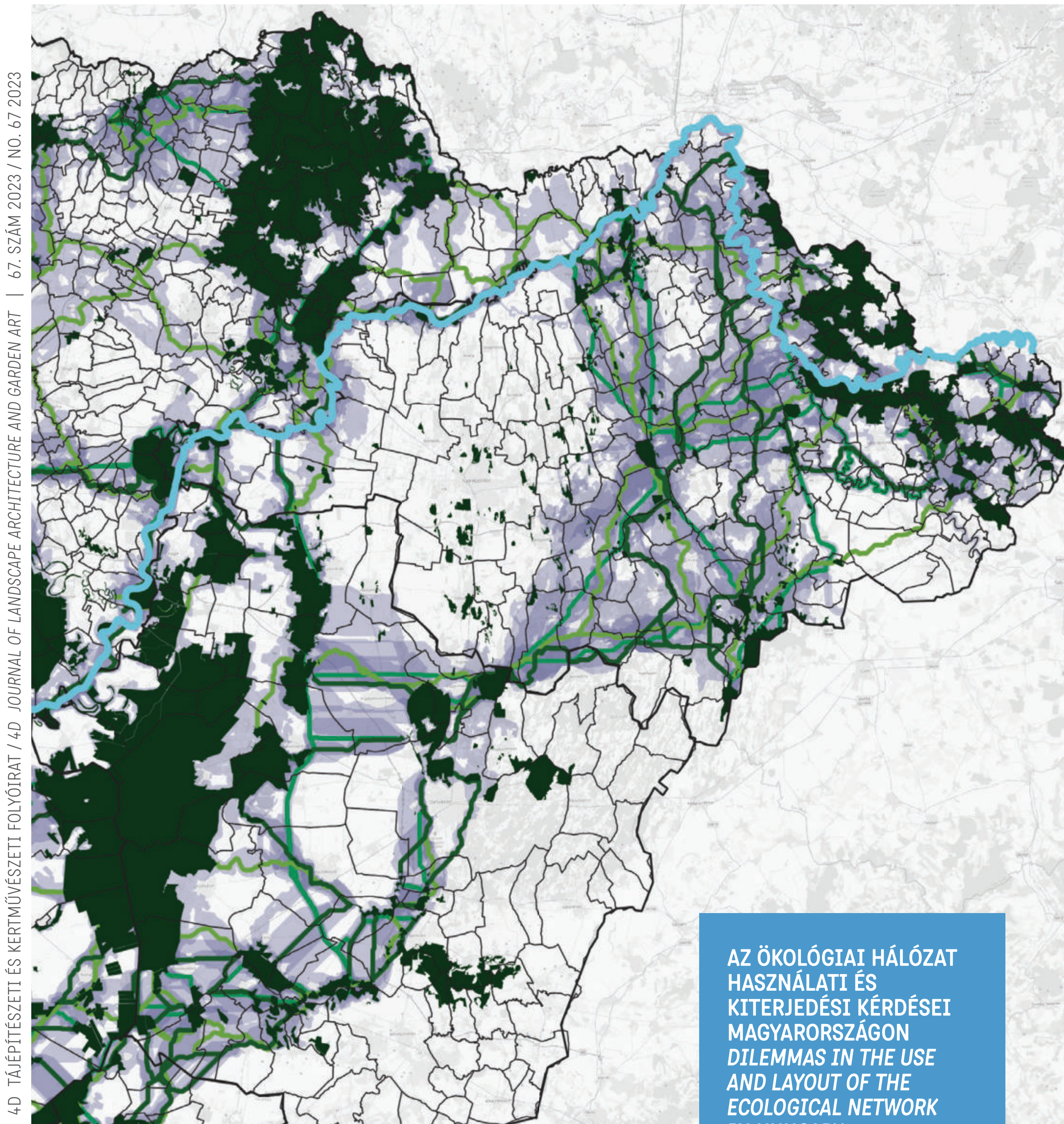
TÁJÉPÍTÉSZETI ÉS KERTMŰVÉSZETI FOLYÓIRAT / 67. SZÁM 2023
JOURNAL OF LANDSCAPE ARCHITECTURE AND GARDEN ART / NO. 67 2023

MATE

Magyar Agrár- és Élettudományi Egyetem
Tájépítészeti, Településtervezési és Díszkertészeti Intézet
H-1118 Budapest, Villányi út 35-43.
Telefon: +36 1 305 7291
E-mail: tajepiteszet@uni-mate.hu
Web: https://journal.uni-mate.hu/index.php/4D



4D TÁJÉPÍTÉSZETI ÉS KERTMŰVÉSZETI FOLYÓIRAT / 4D *JOURNAL OF LANDSCAPE ARCHITECTURE AND GARDEN ART* | 67. SZÁM 2023 / *NO. 67 2023*



AZ ÖKOLÓGIAI HÁLÓZAT HASZNÁLATI ÉS KITERJEDÉSI KÉRDÉSEI MAGYARORSZÁGON
DILEMMAS IN THE USE AND LAYOUT OF THE ECOLOGICAL NETWORK IN HUNGARY

4D/67

4D
TÁJÉPÍTÉSZETI ÉS KERTMŰVÉSZETI FOLYÓIRAT
4D
JOURNAL OF LANDSCAPE ARCHITECTURE AND GARDEN ART

SZERKESZTŐSÉG/*EDITORIAL OFFICE:*
Magyar Agrár- és Élettudományi Egyetem, Tájépítészeti, Településtervezési és Díszkertészeti Intézet – MATE-TTDI / *Hungarian University of Agriculture and Life Sciences, Institute of Landscape Architecture, Urban Planning and Garden Art – MATE-ILA, Budapest*

Postacím/*Mailing address:*
H-1118 Budapest, Villányi út 35-43.
Telefon/*Phone:*
06 1 305 7291
Szerkesztőségi e-mail/*E-mail:* tajepiteszet@uni-mate.hu
Honlap/*Web:*
https://journal.uni-mate.hu/index.php/4D

A KIADVÁNYT TERVEZTE ÉS TÖRDELTE/*DESIGNER AND LAYOUT EDITOR:*
SUSZTER VIKTOR, VERÉB GÉZA

NYOMDA/*PRESS:*
MATE EGYETEMI SZOLGÁLTATÓ NONPROFIT KFT.
2100 Gödöllő,
Páter Károly u. 1.

IssN 1787-6613
DOI: 10.36249/4d.67

TARTALOM / *CONTENTS*

4D/67

4D 67, 2–21. (2023)

DOI: HTTPS://DOI.ORG/10.36249/4D.67.4184

VÁROSI IDENTITÁS VIETNÁM ÉSZAKNYUGATI RÉGIÓJÁBAN

URBAN IDENTITIES OF THE VIETNAMESE NORTHWEST MOUNTAIN REGION

FEKETE ALBERT | DAM THU TRANG | DANG VIET DUNG

ABSZTRAKT

Vietnam északnyugati, hegyvidéki régiója északon Kínával, nyugaton pedig Laosszal határos, és hat tartományt foglal magában: Lao Cai, Yen Bai, Lai Chau, Dien Bien, Hoa Binh és Son La. Ez az erdők, hegyek, dombok, völgyek, folyók és patakok földje. A kulturális sokszínűség földje, ahol több mint húsz etnikai kisebbség él, saját szokásokkal és életmóddal, valamint számos egyedi tájértékkel, amelyek meghatározzák a falvak és a városi területek tájépítészetét. A társadalmi-gazdasági fejlődés folyamatában azonban ezek az értékek fokozatosan elveszítik eredendő identitásukat, és helyükbe új, hibrid tájépítészeti megoldások lépnek, amelyek nem illeszkednek a régió természeti, kulturális jellegzetességeihez és társadalmi-gazdasági feltételeihez. A kutatás céljai a következők: 1. A tájépítészet jelenlegi helyzetének felmérése és elemzése hat reprezentatív városi területen, nevezetesen Dien Bien, Lai Chau, Son La, Hoa Binh, Lao Cai és Yen Bai, az egész északnyugati hegyvidéki régió természeti, kulturális jellemzőinek és társadalmi-gazdasági feltételeinek általános összefüggésében. 2. A táj azonosítására és értékelésére szolgáló kritériumrendszer kidolgozása. 3. A tájépítészet helyi jellegzetességeinek azonosítása. 4. Tájépítészeti megoldások javasolása az északi hegyvidéki városi területek identitásának megőrzése és fejlesztése érdekében. ◉

ABSTRACT

The Northwest mountainous region of Vietnam is bordered to the north by China and to the west by Laos, including six provinces of Lao Cai, Yen Bai, Lai Chau, Dien Bien, Hoa Binh, and Son La. This is a land of forests, mountains, hills, valleys rivers and streams. A land of cultural diversity, with a population of more than twenty ethnic minorities with their own customs and lifestyles, and many unique values that determine the landscape architecture of the villages and the urban areas. In the process of socio-economic development, however, these values are gradually losing their inherent identity and being replaced by new hybrid landscape architectures, which do not fit the natural, cultural, characteristics and socio-economic conditions of the region. Therefore, the purpose and content of the article is: 1. Surveying and analyzing the current situation of landscape architecture in six representative urban areas, namely Dien Bien, Lai Chau, Son La, Hoa Binh, Lao Cai and Yen Bai, in the general context of natural, cultural characteristics and socio-economic conditions of the whole Northwest Mountainous region. 2. Developing a system of criteria for landscape identification and assessment. 3. Identifying the landscape architecture. 4. Proposing solutions with regard to landscape architecture in order to preserve and develop the identity of Northern mountainous urban areas.

Keywords: Landscape Architecture, Urban identity, Traditional Townscape, Cultural Landscape, Landscape Heritage

INTRODUCTION

The Northern Mountainous Region (NMR) in Vietnam has its unique landscape thanks to the coexistence of natural conditions and the diversity of man-made landscapes shaped by the communities of ethnic minorities such as Thai, Mong, Dao, Nhang, Ha Nhi, and Muong. In the process of urbanization and expansion, however, the spontaneous urban development lacks strategic planning and control. Urban landscape planning and design are not in accordance with the natural and ecological characteristics [1], leading to a gradual loss of the inherent urban identities. Therefore, the article focuses on research, survey and analysis of the urban landscape architecture, developing a system of criteria for landscape identification and assessment, proposing a number of solutions with regard to landscape architecture in order to preserve and develop the identity of the NMR urban areas, as an important component of Vietnamese Cultural Landscape and Heritage.

MATERIALS AND METHODS

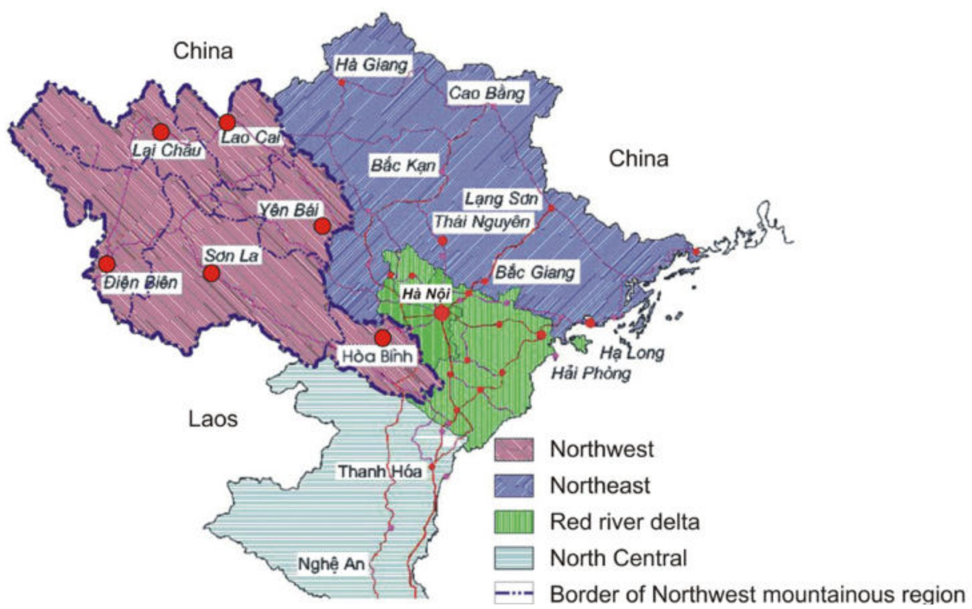
The methods used in the research are based on comparative research, using field survey, data collection and statistical analysis and synthesis.

The research is done in three steps. Step 1 is to inspect, survey and analyze the current landscape architecture practice for preservation and development of the identity of the NMR urban areas. Step 2 is to study the theoretical and practical scientific foundations, including theories of landscape analysis and landscape classification, landscape design, urban planning and visual perception, ecology and sustainable development of the landscape. Practical foundations include practical experiences in landscape architecture for conservation and development of other urban areas in the world and in Vietnam. The practical foundations affecting the landscape architecture in preservation and development of the NMR urban areas include: the impact of natural characteristics, population characteristics; climate change, socio-economic conditions [2]. Step 3 is about new proposals to build a system of criteria for identifying and assessing landscape architecture, preserving and developing the NMR urban identity; identifying and assessing landscape architecture to create an urban identity, and landscape architectural solutions to preserve and develop the NMR urban areas.

RESULTS AND DISCUSSION

1. Current landscape architecture of NMR urban areas

In order to obtain a general assessment of the current landscape architecture in Northern mountainous urban areas, the authors selected six cities for the study, which are large secondary and tertiary cities, capitals of provinces, and have very important and integrated roles, both in economic and political terms. Each of these urban areas representing a province has common characteristics with other cities in the province in terms of natural conditions, culture and landscape values and is facing more difficulties and challenges in the preservation and development of urban identity. The six urban areas are: Dien Bien, Lai Chau, Son La, Hoa Binh, Lao Cai and Yen Bai. (Figure 1, Figure 2) The study of the current



landscape architecture of these cities is based in the general context and impacts of natural, cultural, characteristics and socio-economic, and political conditions of the whole region [3].

1. Lai Chau City

The city is located in a rather narrow valley, with its surface sloping from the northwest to the southeast. The western and southwestern areas are high mountain ranges, the North and Northeast are interspersed with basins, and the South is represented mostly by agricultural use (rice fields and tea hills). The landscape is beautiful and majestic and bears the characteristics of a high mountain area.

Besides, Lai Chau City has many ethnic groups with cultural diversity, especially ethnic groups such as Thai, Giay, Mong etc.

Cultural phenomena such as flea markets, village festivals and local celebrations are imbued with highland ethnic culture, represented through costumes, house forms and other intangible cultural forms and created a special cultural ambiance. Green spaces, historical, cultural sites and monuments, water habitats and caves in the city and its vicinity increase the attractiveness of the landscape.

There is a phenomenon of hills and mountains are being flattened and demolished to build houses and farms. The newly constructed squares and large-scale buildings are disproportionate to the old spatial pattern and architecture.

2. Dien Bien Phu City

Dien Bien Phu City is located in a diverse topographical area, including valleys interspersed with low hills, and large fields. Primary forests, and high mountains with curved shapes surround the Dien Bien basin valley. The vegetation is tropical with relatively high surface cover. The river system, is dominated by the winding Nam Rom River, which collects the water flows of the whole basins and is linked with hundreds of other tributary streams. Many canals, ponds, lakes spread through the city and the surrounding areas such as Pa Khoang Lake, Huoi Pha Lake, creating beautiful scenery. The heritage value of the city is rooted among others in the system of existing historical monuments such as the Memorial of Dien Bien Ph victory, Citadel was bult by Hoang Cong Chat etc.

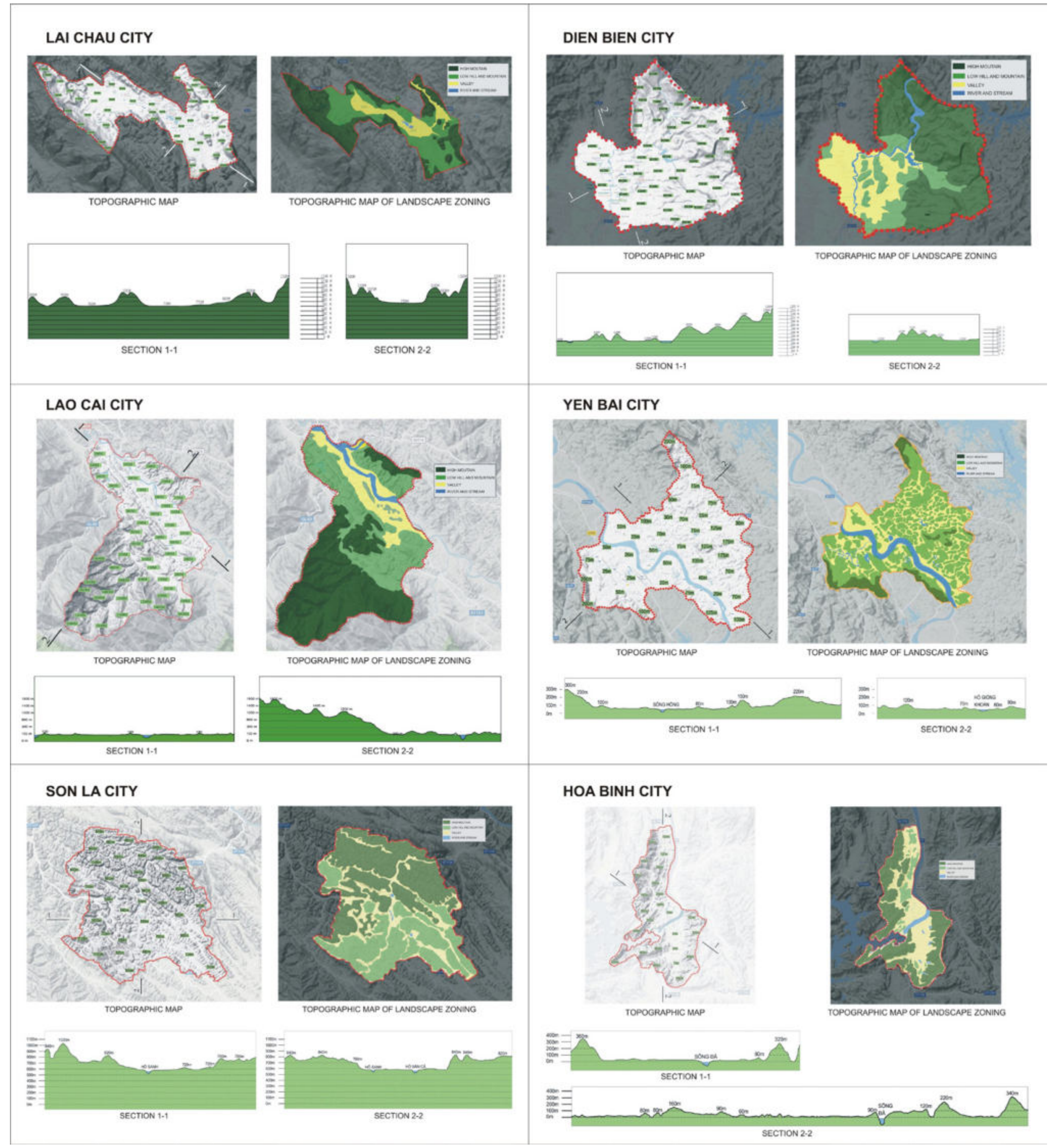
However, urban development is rampant and out of control. Urban planning with messy architecture and traffic system disrupts the urban landscape pattern.

3. Lao Cai City

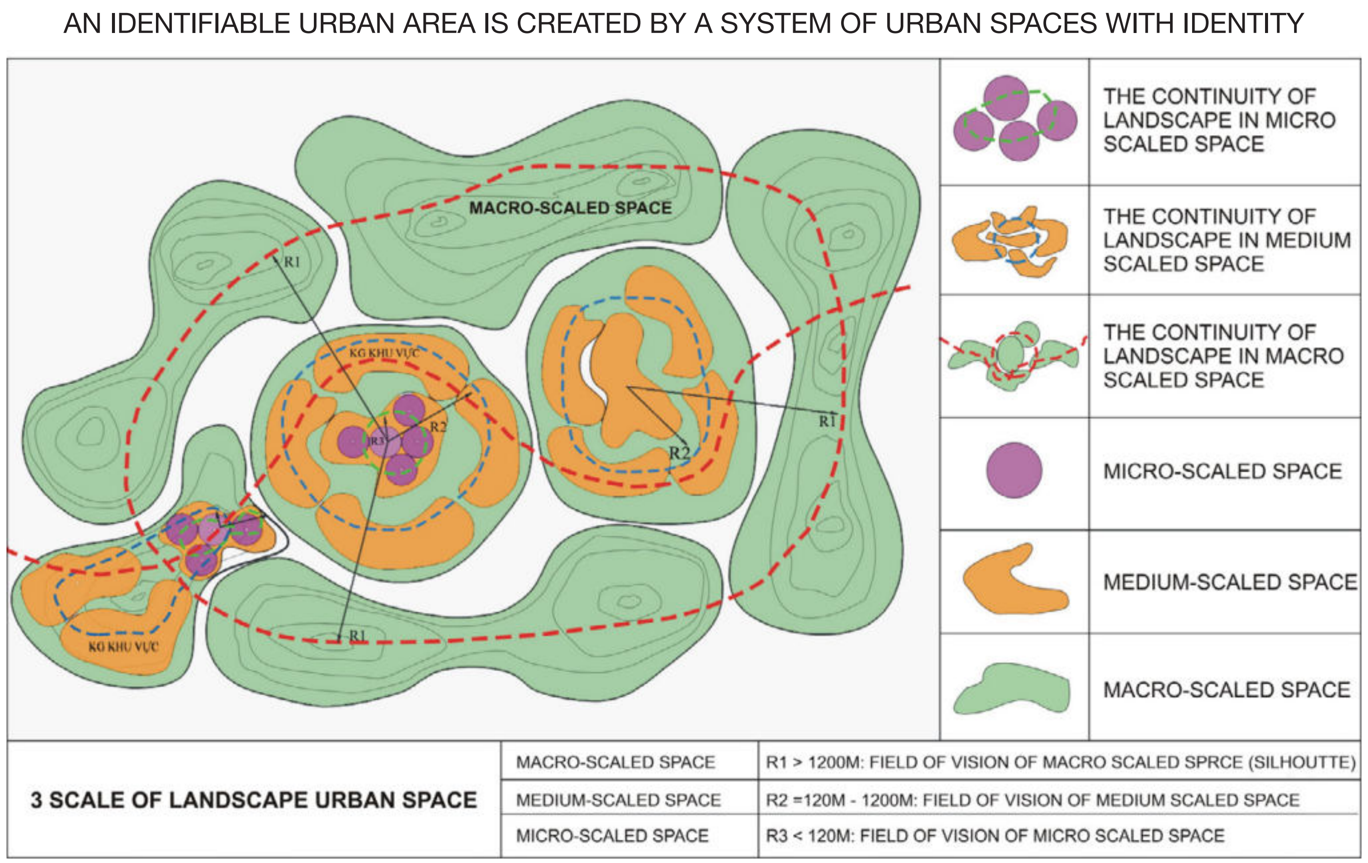
Lao Cai City is in the Red River valley area, flanked by two mountain ranges, the Elephant and the Hoang Lien Son. The terrain tends to slope gradually from the Northwest to the Southeast, from the Hoang Lien Son range to the Red River, and is divided by rivers, streams, waterways, hills, etc. Lao Cai is located on both sides of the Red River and it is surrounded by hills and mountains. The city has three types of terrain: hilly terrain, valley terrain and river delta terrain.

The natural landscape is in harmony with the characteristics of rivers and water bodies in the heart of the city. However, the city is divided by the infrastructure system. The Noi Bai – Lao Cai highway is the dividing line between the inner city and the suburban area. Urban architecture has not been harmonised. The downtown area of Lao Cai City, with its main and secondary roads, has a herringbone structure, with neighbourhoods characterized by traditional commercial streets with busy commercial activities (small shops, vendors along the sidewalk).

Fig. 1: The location of the Northwest Mountain Region in Vietnam
Fig. 2: The overall natural topography of Lai Chau, Dien Bien, Lao Cai, Yen Bai, Son La, Hoa Binh cities



4D 67, 2–21. (2023)



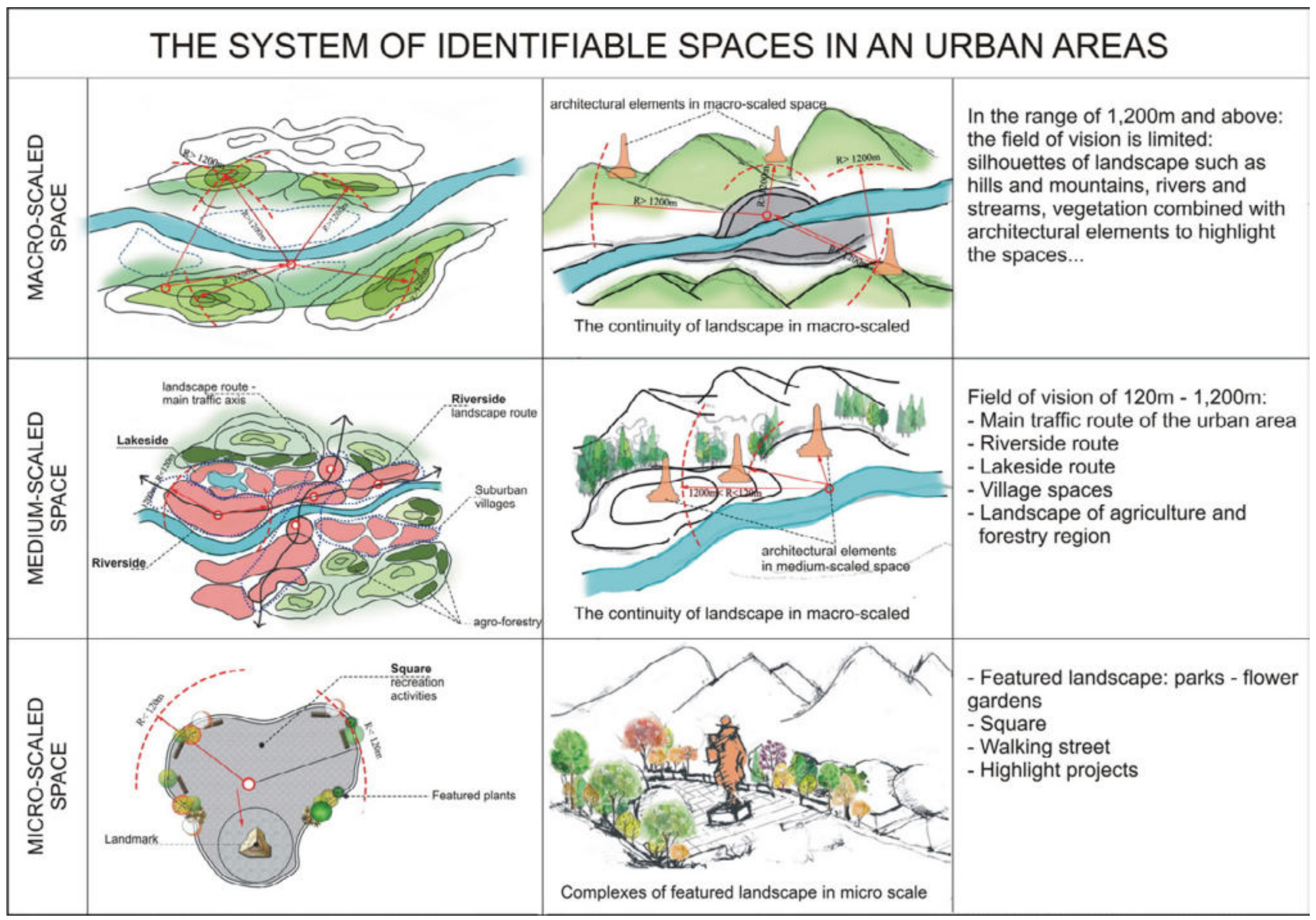


Fig. 3: Illustration of an urban area with an identity created by a system of urban spatial levels with identity
Fig.4: The urban area has an identity that is recognized by the system of architectural and landscape spaces with the identity in the field of the vision

Lao Cai City has valuable and significant historical and cultural monuments such as the ancient citadel and fortress, etc. and Cam Duong revolutionary historical relic complex, which is a historical site associated with the formation and development of the Provincial Committee of the Lao Cai Party. The monuments were planned and embellished in order to preserve the fine traditions of the nation and be a tourist attraction.

4. Yen Bai City

The city is located on both sides of the Red River, with its topography consisting of a riverside alluvial strip, an ancient alluvial plain on the riverbed, low hills with round, bowl-shaped peaks, valleys and streams interspersed with hills and mountains and undulating fields running along the riverside.

The network of water bodies is rich, with the Red River flowing through and several lakes, lagoons, creeks, and streams. Hilly land and forests contribute positively to creating a typical landscape. The city's commercial buildings have recently tended to be developed in the form of modern high-rise complexes, and disrupt the landscape. The city's green space and water network is very large, but it is in a wild and unexploited form, and there is a lack of parks and flower gardens in the city. Housing is mainly low-rise, built by the people themselves, but currently the city is piloting the construction of high-rise apartment buildings on Nguyen Thai Hoc Boulevard.

Besides, the urban layout of Yen Bai City is scattered and fragmented, and there is a lack of spatial and architectural highlights.

5. Son La City

Son La City has Nam La Stream, flowing from the Pac-Mo Mountain range in the south of the city. The overall topography of the city includes high mountains occupying a large area. The hillside terrain occupies a small and scattered area. Fields are located along both sides of the Nam La Stream.

Sn La has a rich system of cultural buildings, revolutionary, and historical relics. There are still traditional villages with typical architecturural buildings, and folk houses. However, the city is facing the problem where hills were flattened and ferests were destroyed to build large projects. The central square is too big, empty and flat, with a spatial design, landscape design, and architecture not suitable for a high mountain city.

6. Hoa Binh City

Hoa Binh City has a valley terrain lying on both sides of the Da River, surrounded by hills and mountains. Da River flows in the center of Hoa Binh City, with both sides of the river having river valley and mountainous terrains. In addition to the Da River and the Hoa Binh Lake, Hoa Binh City also has a number of small lakes such as Quynh Lam Lake, De Lake, Minh Thinh Lake, and Dung Stream Lake and Dam.

The entire urban space is distributed within the valley and there are high mountain ranges of the Da Bac, the Ky Son and the Cao Phong. Urban space is still scattered and not very coherent. New architectural buildings, public spaces were built are not associated with the terrain and natural landscape. For urban development, higher slopes will have to be exploited, but the current popular practice is flatting hills and mountains for construction is a serious mistake that needs immediate intervention.

Especially, it is necessary to connect the traditional villages scattered in the Cham Mat, Su Ngoi, which bear the traditional Muong culture.

2. Building a system of criteria to identify and evaluate landscape values for conservation and development of the identity of Northern mountainous urban areas

2.1. Criteria group 1: General identification of urban landscape morphology

An identifiable urban structure is created by a system of urban spaces with identity. According to Ian Mcharg (1995) there are three spatial levels to study: Macro-scaled space, medium-scaled space and micro-scaled space (Figure 3, Figure 4).

Table 1: Proposing a scored evaluation based on groups of criteria to identify and evaluate the landscape values

No.	Elements for assessment	Points 1	2	3
1	Identification of morphology of identifiable macro-scaled landscape			
1.1	Mountain morphology	Lack of characteristics in the silhouettes of mountains	Characteristic mountainous topography	Mountain morphology has its own characteristics, possible to determine and denominate
1.2	Water bodies morphology	Lack of characteristics in the distribution and shapes of the water bodies	Characteristic in shape, colour or static-dynamic nature	Having own characteristics in shape, colour or static-dynamic nature
1.3	Plant morphology	Lack of characteristics in the layout and colours	The layouts of plants can be clearly recognized.	Having characteristics in the layout and colours
1.4	Architectural elements	Featureless, hard to recognize	Easy to recognize	Having impressive characteristics in shape, ratio, colour in space
1.5	Capability to form a systemed spaces of urban landscape	The morphology of landscape lacks completeness and characteristics	The morphology of natural-artificial landscape is quite complete. There is a link between the overall space and its details with a special character	The morphology of natural-artificial landscape is complete, from the overall space to details, with a distinctive local character
Point (1)		5	10	15
2	Criteria for open spaces in identifiable urban areas			
2.1	Criteria for macro-scaled space with an identity			
2.1.1	Morphology of topography	Lack of distinctive characteristics	Distinction of the macro-scaled silhouettes	Mountain morphology has its own characteristics, able to be named
2.1.2	Morphology of water bodies	Lack of distinctive characteristics	Clearly distributed and easily distinguished	Having its own characteristics in shape, color, static-dynamic level
2.1.3	Morphology of vegetation	Lack of characters	The layout and coloration are quite clear	Special in the layout and salient coloration, the ecosystem is diversed and sustainable
2.1.4	Architectural elements	Lack of harmony and impact	The shape and layout harmonize with the macro-scaled landscape	Having special characteristics
2.1.5	Continuity of the field of view of the macro-scaled landscape	The layout and connection of landscape is incomplete and the field of view is interrupted	The layout and connection of landscape is distinctive and the field of view is uninterrupted	The field of view is uninterrupted; the layout of landscape is distinctive and salient
2.1.6	Cultural-historical values	Valuable	Typically valuable	Having salient and special values
Point (2.1)		6	12	18

No.	Elements for assessment		Points 1	2	3
2.2	Criteria for medium-scaled space with an identity				
2.2.1	Natural land-scape	Topography	Lack of characteristics	Distinctive topography, slope, types of rocks and soils	Characteristic topography, slope, types of rocks and soils, sizes, colours
		Water bodies	Lack of characteristics	There are characteristics that are easy to reconize	Morphology of the water body, colour, flow velocity, ecosystem have distinctive characteristics
		Vegetation	Native plants in small quan-tity, unimpressive design	More than 40% distinctive native plants, unimpressive design	More than 40% distinctive native plants, impressive design
2.2.2	Architectural elements		Featureless, indistinct traditional architecture	Distinctive traditional architecture, harmonious with overall landscape	Architectural forms with attractive, outstanding salient and local identity;
2.2.3	The layouts of landscape are locally distinctive (water wheels, bridges over streams multi-layered tree canopy, stilt houses)		The design is discontinuous; small quantity and lacks characteristics	Medium quantity; continuous design creating landscape identity and characteristics	Large quantity; beautiful and impressive design;
2.2.4	Cultural activities	Urban open space for activities	Lack of identity; irregular	Locally rooted cultural characteristics	Special and regular cultural activities
		Relationship with cultural-historical values	Valuable	Typically valuable	Outstanding values
2.2.5	The continuously connected landscape images create the identity of the spaces		Discontinuous, interrupted	Continuously maintained as landscape chains	Continuously maintained as landscape chains
Point (2.2)			8	16	24
2.3	Criteria for micro-scaled space with an identity				
2.3.1	Natural landscape	Topography	Lack of characteristics	Distinctive slope, types of rocks and soils	Characteristic slope, types of rocks and soils, sizes, colours
		Water bodies	Lack of characteristics	There are characteristics that are easy to reconize	Morphology of the water body, colour, flow velocity, have distinctive characteristics
		Vegetation	Native plants in small quan-tity, unimpressive design	More than 40% distinctive native plants, unimpressive design	More than 40% distinctive native plants, impressive design
2.3.2	Architectural elements		Featureless, indistinct traditional architecture	Distinctive traditional architecture, harmonious with overall landscape	Architectural types with attractive, outstanding salient and local identity;
2.3.3	The layouts of landscape are locally distinctive (water wheels, bridges over streams multi-layered tree canopy, stilt houses)		The design is discontinuous; small quantity and lacks characteristics	Medium quantity; continuous design creating landscape identity and characteristics	Large quantity; beautiful and impressive design;
2.3.4	Cultural activities	Urban open space for activities	Lack of identity; irregular	Locally rooted cultural characteristics	Special and regular cultural activities
		Relationship with cultural-historical values	Valuable	Typically valuable	Outstanding values
2.3.5	The continuously connected landscape images create the identity of the spaces		Discontinuous, interrupted	Continuously maintained as landscape chains	Continuously maintained as landscape chains
Point (2.3)			8	16	24
Total of points (1+2.2+2.2+2.3)			27	54	81

- Macro-scaled space has a wide field of view, in distance of 1200 m or more, to help to identify the overall landscape features in the form of silhouettes and contours [4]. Identification of the overall landscape features at this visual range includes mountain morphology, water bodies morphology (rivers, streams, lakes), natural green tree morphology and architectural elements with scale, volume, and salient features. In this context, the morphology of the overall natural landscape becomes the backdrop of the landscape of other areas in the urban area.
- Medium-scaled space has an average visibility from 120 m – 1200 m, [5] within this range, it helps us to recognize the features of natural landscape, artificial landscape and activity landscape. Identification of mountain morphology is the identification of the characteristics of the mountain, such as shapes, slopes, colours. Identification of water bodies morphology is the identification of the shape of the water body, the colour of the water, and even the landscape tipes near the water edges. Identification of vegetation morphology is the identification of character of line, form, colour and texture exhibited by vegetation. Identification of artificial landscapes is the identification of the structural morphology of functional areas in the urban area. Identification of the active landscape is the identification of typical activities in space.
- Micro-scaled space has a clear view within less than 120 m: within this range, the details of landscape can be identified. Identification of topography is identifying of slope, shape, characteristics and colour of the terrain, types of soil and rock. Identification of water includes the identification of shape, colour, dynamic – static nature of the water surface, landscape layouts with their own characteristics near the water surface area. Identification of plants is identifying of plant species. Identification of architecture is about identifying shapes, colours, and formal features of architecture. Identification of active landscapes includes identification of activities in space, such as colours, characteristics of costumes, voices, sounds and specific human activities. An urban area is classified as having identity when the ability to connect spatial levels, including Whole-Area-Small levels, ensures the continuity of route in sequence of characteristic images, without interruption in the range of view.

2.2. Criteria group 2: Assessment of urban landscapes with an identity

a. Criteria for the identifiable macro-scaled space [6]: The morphology of the natural landscape combined with architectural elements must be symbolic, creating a distinct image. In terms of topography, it is a hilly morphology with distinctive features of shape. The overall landscape of the mountain morphology can be taken as a symbol for the area. The water bodies morphology is a water body with special characteristics, for example zigzag shape and the colour of the water with its own characteristics. The colour of the vegetation changes, creating seasonal effects in the macro-scaled space.

If in the field of view of the Macro-scaled space, there is a natural landscape form lacking an identity, it must be added in combination with special artificial architectural elements in the Macro-scaled space.

b. Criteria for the identifiable medium-scaled space: The urban medium-scaled space has an identity consisting of landscape units with their own identity and identifiable landscape architectural materials, forms, and fabrics. In terms of topography, it is necessary to maintain the natural hilly form, without being flattening. The slope of the hillside and the rocks of the mountain have distinct characteristics. In terms of water bodies, the morphology of the water bodies must have distinctive characteristic, with static-dynamic nature (fast flowing, calm), the water surface must have colour (opaque red, clear blue, white...). At least 40% of the trees on the mountains and hills must be native varieties. Architecture must have its own characteristics in the form of indigenous traditional architecture, biomimetic architecture, architecture suitable to the living and production conditions of local people. The urban landscape must have a linear continuity, uninterrupted, making the identification and perception of the architectural space complete.

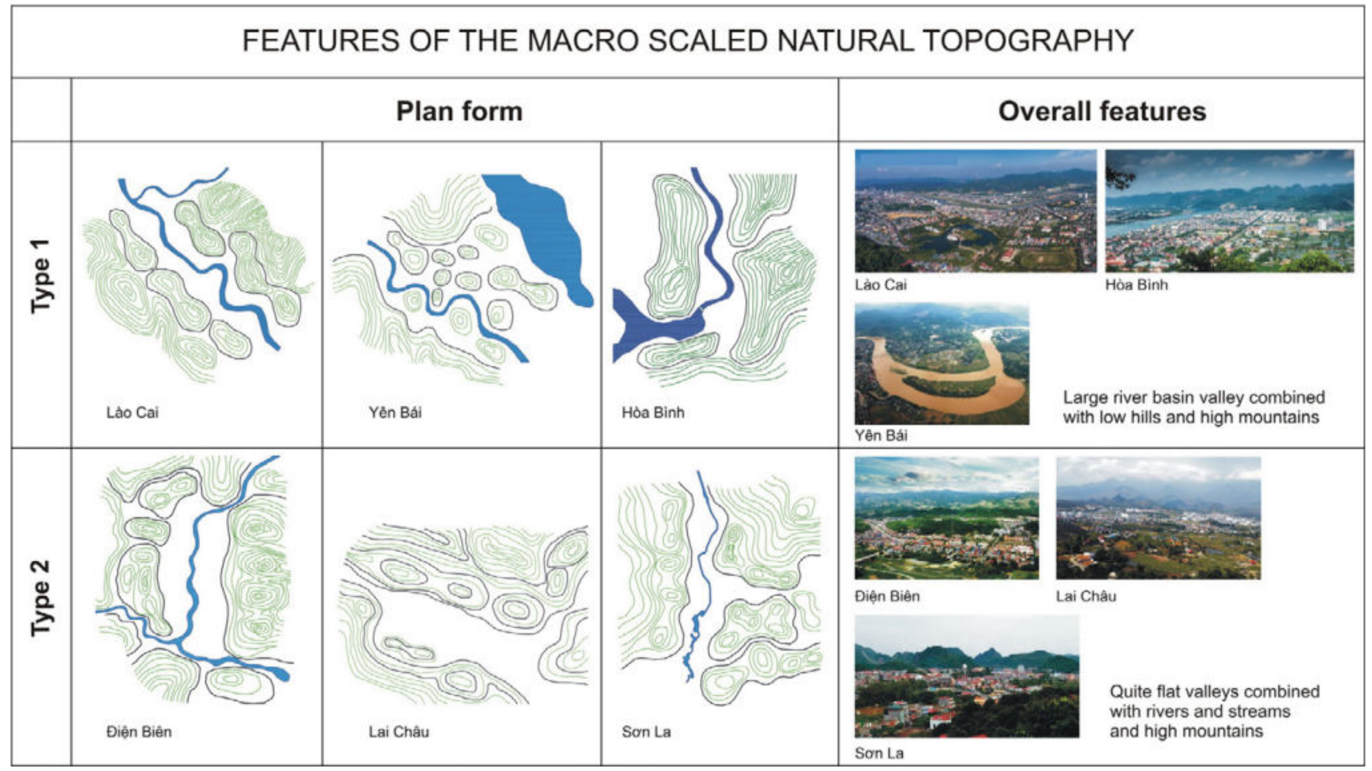
c. Criteria for the identifiable micro-scaled space: The combination of Topography – Trees – Water Bodies – Architecture has a distinct characteristic. Urban landscape design must have an identity with the main components of small spaces, such as the ground surface, roads, urban amenities, public art, architectural highlights, bearing cultural imprints and local characteristics. We should explore the images of stilt houses, terraced fields, water wheels, bridges over streams, native trees.

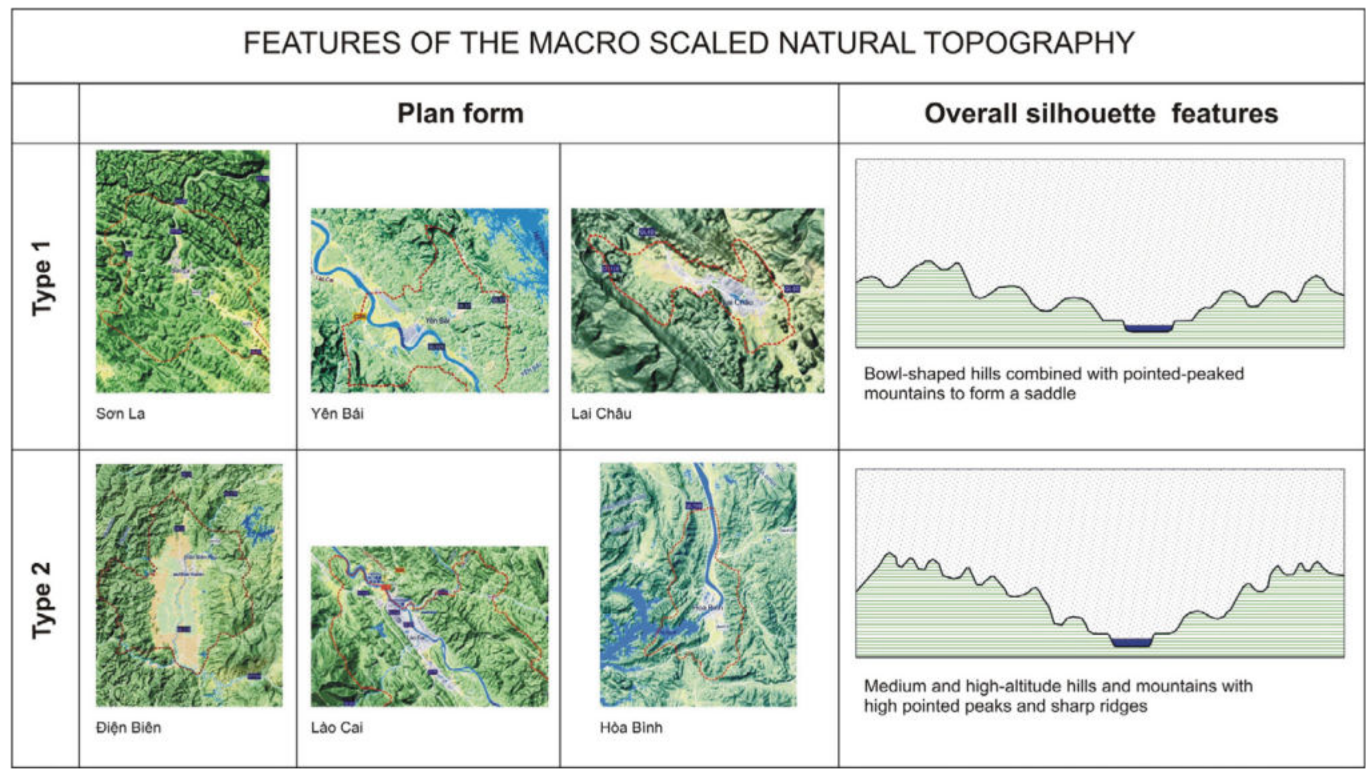
3. Overview of urban landscape character in the Northwest Mountainous Region

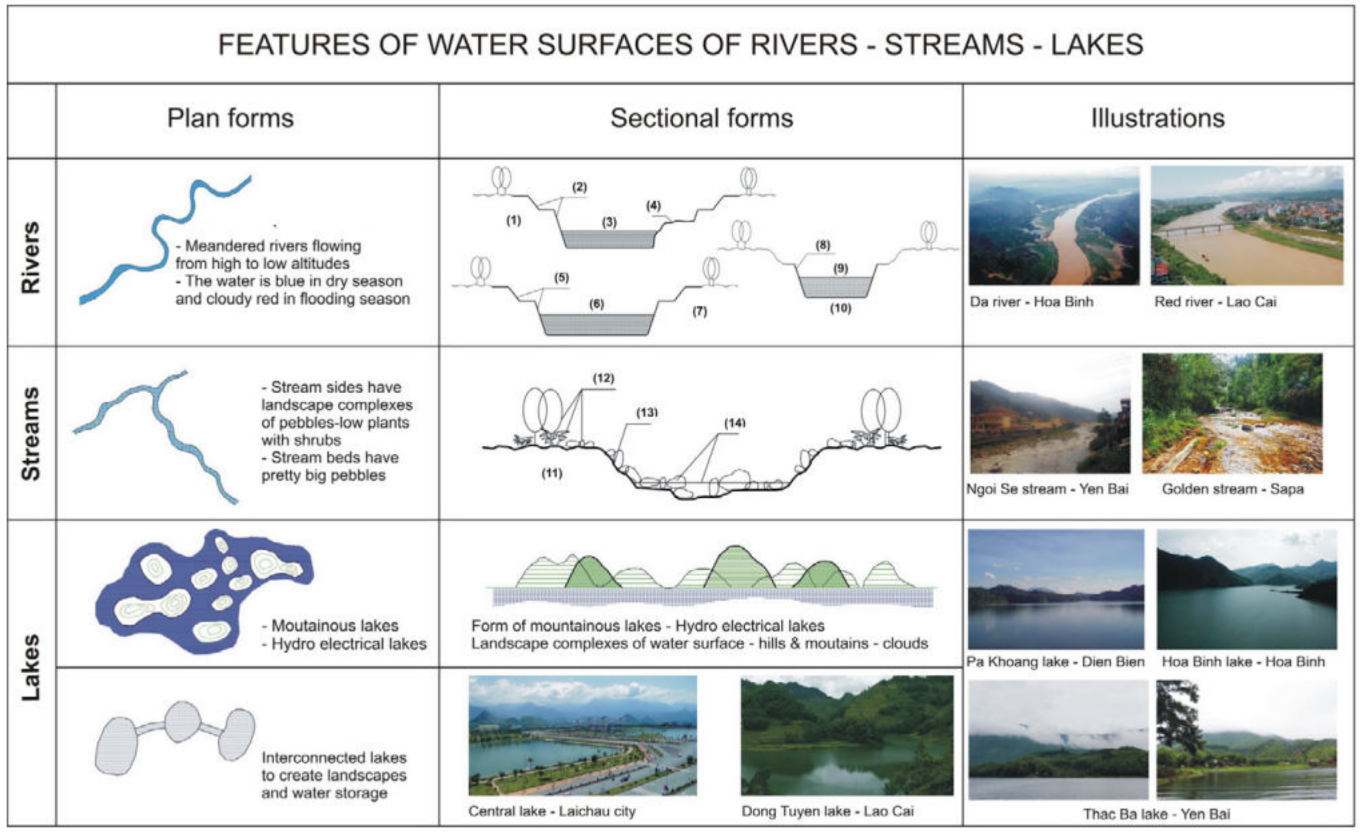
3.1. Features of natural topography

a. As shown in Figure 5, the general morphology of the natural topography includes two types. Type 1 is a valley in a large watershed combined with low hills and high mountains (Lao Cai, Yen Bai, Hoa Binh cities). Type 2 is the valley area in the watershed of small streams combined with hills and mountains of medium and high altitude (Dien Bien, Lai Chau, Son La).

Fig. 5: Identification of characteristics of the overall natural topography on plan of the Northwest mountainous urban areas
Fig. 6: Identification of characteristics of the overall natural topography in the cross-section - silhouette of the Northwest mountainous urban areas







b. According to the cross-section – silhouette shown in Figure 6, the general morphology of the natural topography includes two types. The first is when the rivers and streams are combined with bowl-shaped hills and mostly sharp-peaked mountains connected to form a saddle (Son La, Yen Bai, Lai Chau cities). The second is when the rivers are combined with mountains of medium and high altitude, pointed peaks, and sharp ridges (Dien Bien, Lao Cai, Hoa Binh).

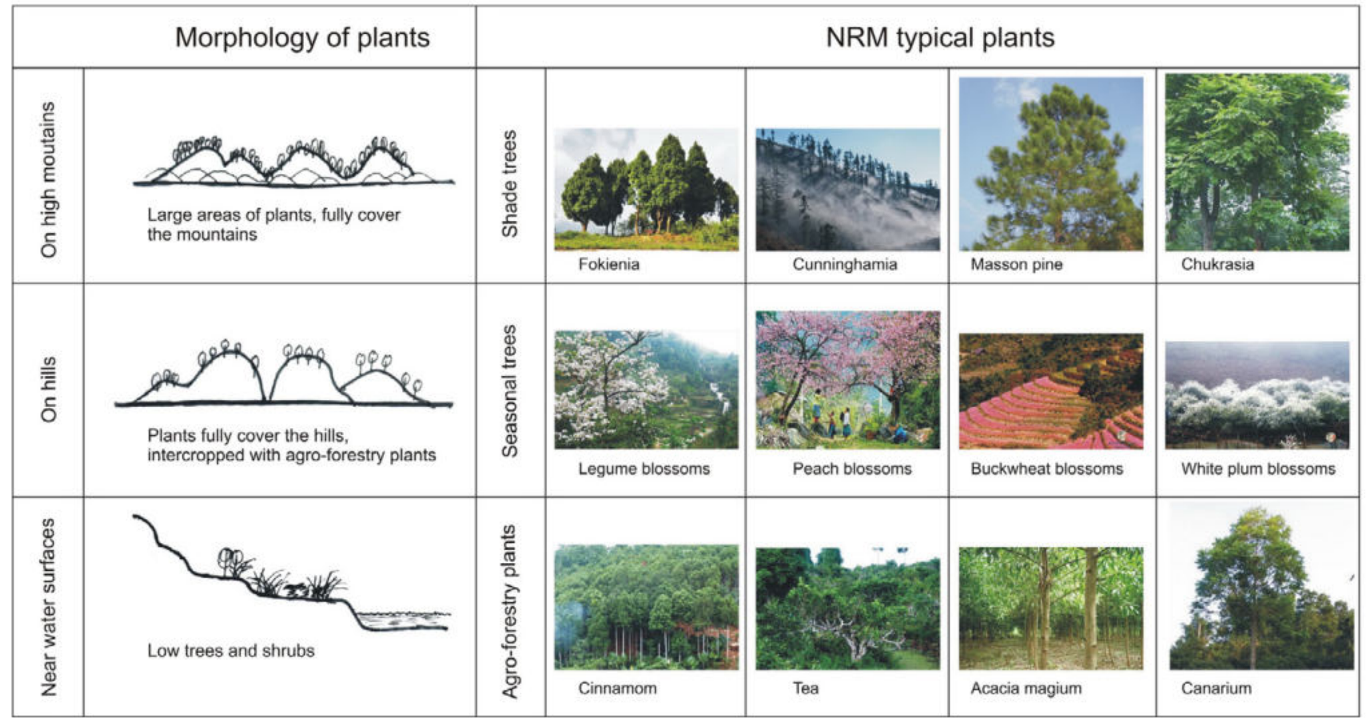
3.2. Features of water bodies

- Rivers of NMR urban areas include large rivers such as the Red River (Lao Cai, Yen Bai), the Da River (Hoa Binh) with zigzag and meandering flow from the Northwest to the Southeast (Figure 7) [8]. The water colour of the rivers is usually clear in the dry season and cloudy red in the flood season. Most of the big rivers have terraced embankments on both sides of the section flowing through the urban areas to avoid the risk of urban landslide in the flood season.
- Streams and creeks of NMR cities include large streams such as the Nam Rom (Dien Bien), the Nam La (Son La), the Ngoi Se (Yen Bai). The stream bed has rather large pebbles and the stream bank has a natural landscape, with a combination of pebbles and shrubs which are characteristic features.
- There are major lakes such as the Dong Tuyen Lake (Lao Cai), the Yen Hoa Lake, the central lake (Yen Bai), the Thac Ba hydroelectric lake (Yen Bai), the Pa Khoang, the Huoi Pha (Dien Bien), the Hoa Binh Lake (Hoa Binh), the Thuy Son Lake (Lai Chau). These lakes store water, creating landscapes and generating hydroelectricity. Therefore, the components creating a very typical landscape complex are water bodies - hills - clouds.

3.3. Features of vegetation in natural landscape

The typical plants of the NMR cities are distributed according to the elevation of the terrain(Figure 8) [9]. The plants on high mountain areas often grow following the Plant Strata form, refer to the various horizontal layers that constitute a plant community: canopy, understory, shrub, and ground cover, covering the mountains. Commontree species in high mountain areas are: masson's pine (*Pinus massoniana* Lamb) fujian cypress (*Fokienia hodginsii* (Dunn) A. Henry et Thomas), cunninghamia

Fig. 7: Identification of features of water surface landscapes in urban areas
Fig. 8: Identification of the landscape of activities bearing the identity of the Northern mountainous region



(*Cunninghamia lanceolata* (Lam.) Hook). The plants on low hills often cover the hills, interspersed with agro-forestry plants such as: acacia (*Acacia auriculiformis* A. Cunn. ex Benth), eucalyptus (*Eucalyptus globulus* Labill), cinnamon (*Cinnamomum cassia* Nees & Eberth), canarium (*Canarium tramdenum* Dai & Ykovl), tea (*Camellia sinensis* (L.) Kuntze). Plants in valleys and river basins are usually seasonal plants such as bauhinia (*Bauhinia variegata* L), peach blossoms (*Prunus persica* (L.) Batsch), white plum (*Prunus mume* (Siebold) Siebold & Zucc), buckwheat blossoms (*Fagopyrum esculentum* Moench).

3.4. Landscape units OR character types bearing the identity of the NMR

The Northwest mountainous region has unique landscape layouts and connectedness with their own identity [10], including six types of layouts such as the natural landscape layouts of mountains – streams (water gathering), are located in ravines in the mountainous area with medium and high altitudes. Natural landscape complexes of mountains – rivers – valleys are located in river basins. Natural landscape layouts of pebbles – shrubs – water surface located in river and stream basins. Artificial landscape layouts include terraced fields – stilt houses – streams are located in stream basins and low hills.

These are also landscape of bridges over rivers and streams. Especially the image of water wheels on the streams and river banks serving people's daily life and irrigation is a very typical image of exploitation on natural energy and natural materials for life.

3.5. Morphology of urban layout

It can be seen that the morphological characteristics of the NMR cities are mostly organic shapes in harmony with the natural topographical features of hills, rivers, streams and valleys (figure 9) [11]. It is possible to classify the layout of NMR cities into 3 types:

① Striped layout combined with radial development: Urban development comes from valleys, river basins, dispersed into radial development interspersed with mountainous terrain around the valley and part of the river and is limited by the surrounding alpine terrain. The urban areas of Lao Cai and Yen Bai have this layout, the urban space develops gradually on the slope of the hillside, a part of the urban area lies on both sides of the river.

② Bowl structure: The city develops in basins at the foot of the mountain and is limited by the surrounding high mountainous terrain forming a bowl; the city is located in a fairly wide and relatively flat valley. Dien Bien and Son La urban areas have this structure.

③ Stripe layout: Urban development lies on the banks of the rivers and streams in the foothills and is limited by high mountain terrain on both sides, forming narrow valleys. Lai Chau and Hoa Binh urban areas have this structure and develop along river basins in the form of a stripe.

3.6. Landscape of activities bearing the identity of the NMR

The typical landscape of activities in the space of urban areas in the NMR is easy to see through festive activities of the New Year, at the occasion of harvesting crops (Figure 10) [12]. The space of activities is very lively and colorful, presented in traditional costumes as well as unique cultural activities of ethnic minorities in the NMR.

4. Landscape architectural solutions to preserve and develop the identity of Northern mountainous cities

4.1. Solutions to organize the urban landscape architecture to create the overall spatial identity of the city

- Zoning to designate areas with characteristic features of the natural landscape, including mountain morphology, water surface morphology, vegetation morphology, landscape features of special value [13].
- Identification and classification of the field of vision according to the A-B-C levels. With type A field of vision landscape features are promonent and visible clearly. With type B field of vision, typical landscape features are visible. With type C field of vision that are lacks of landscape features.
- Determination of the landscape viewpoint according to the levels V1-V2-V3 to identify the typical overall landscape in urban spaces.
- The V1-levelled viewpoint is the dominant viewpoint of the field of view, helping to fully and clearly identify the landscape identity of the overall space. The V2-levelled viewpoint is a viewpoint that helps to identify the relatively typical landscape of the space, because at this viewpoint, it lacks a certain part of the feature such as mountain morphology, or water surface morphology, or vegetation morphology, or the architectural element of the field of view lacks typical character. The V3-levelled viewpoint is the viewpoint that lacks many features of the landscape.
- From the zoning, classification of fields of view, identification and classification of landscape viewpoints in the above steps, the next step is to propose solutions to organize the landscape to create identities for B-C fields of view and V2-V3 levels viewpoints for clearer and more typical landscape. The proposed solutions use architectural elements and planting design to create identity by:
  - Establishment of more architectural works bearing special features, local characteristics. In the scope of the overall field of view, there is a distance of over 1200 m, so it is necessary to pay attention to the background and silhouette; the architectural elements need to have a prominent proportion and volume as the highlight works to combine with the natural landscape to create and increase the identity of the overall space.
  - Establishment native tree forms with characteristic colours and combinations to impress and characterize the space; typical plants combined with earthwork, water bodies and architectural elements to help increase the identity of the overall space.

4.2. Landscape architectural solutions to preserve and develop the spatial identity at the urban area

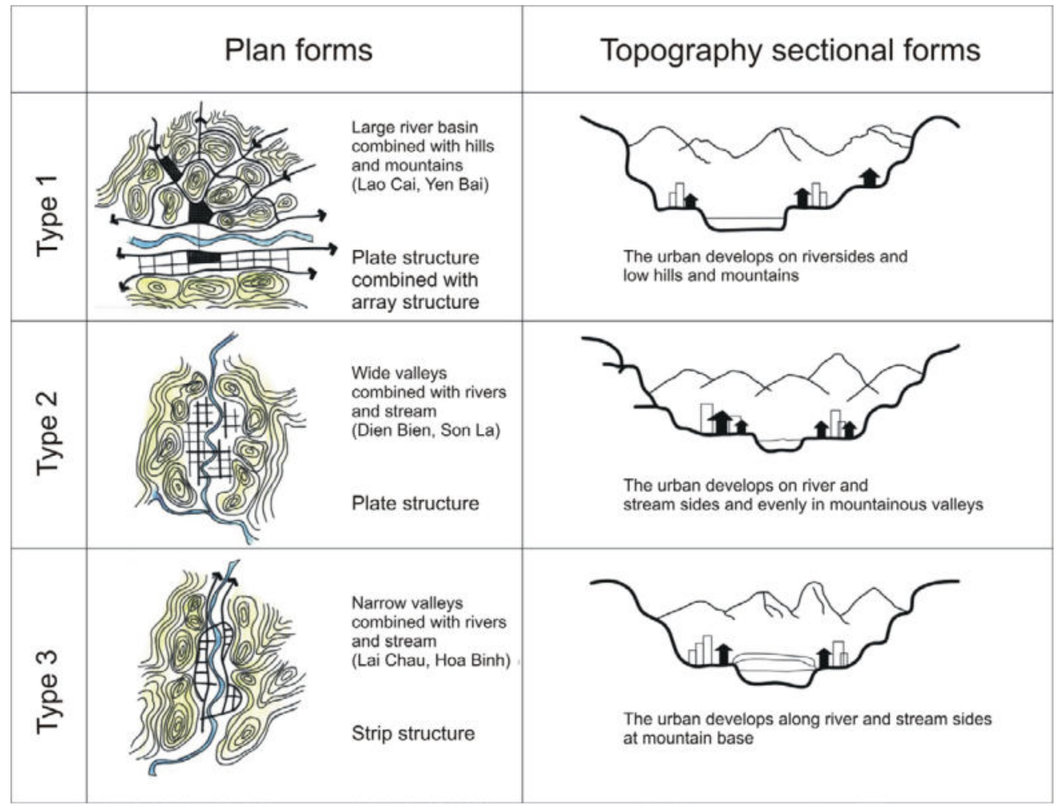
At the urban area level, the landscape areas level [14] (Figure 12, 13) has features to create an identity for urban, including areas such as: Landscape routes along rivers and streams, lakeside landscape route, the main urban axes, peripheral space: residential villages, agro-forestry production areas: hilly areas where industrial crops are grown, rice cultivation areas and terraced fields, gateway area – urban entrance.

a. Landscape route along rivers and streams. Landscape architecture solutions to create identity for landscape routes along rivers and streams:

- Establish a smooth route for areas along rivers. Landscape routes on both sides of rivers and streams need to be connected with each other and connected with other areas of the city by visual links and viewpoints.

↘

Fig. 9: The solutions to organize the landscape architecture to create the overall spatial identity of the cities
Fig. 10: Diagram of landscape architecture solutions to preserve and develop the identity of the city at the area level



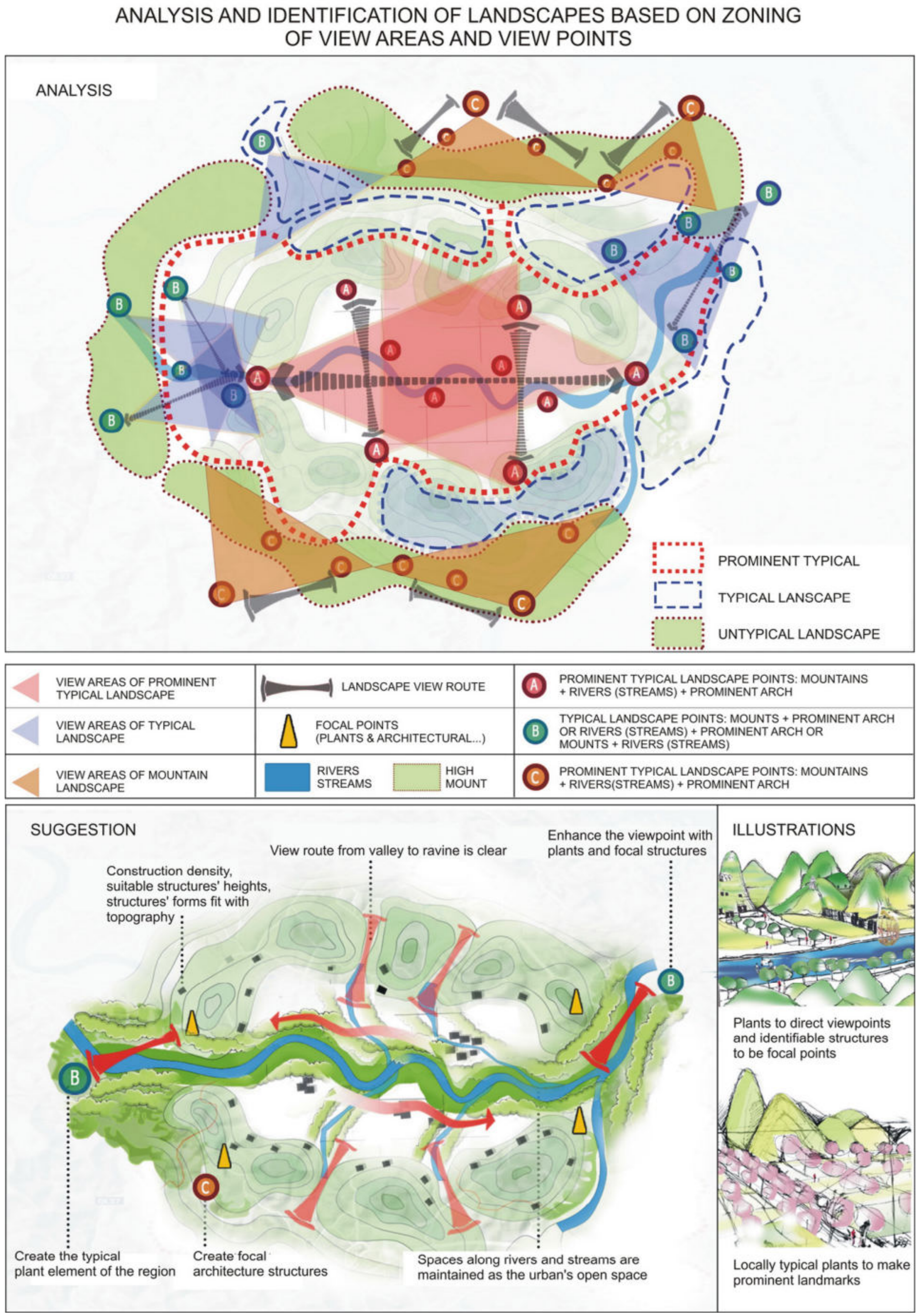


Fig. 11: The solutions to organize the urban landscape architecture to create the overall spatial identity of the cities

The field of view of the space at area level has a range from 120 m – 1200 m, therefore, if there is a lack of features on the route, outside of this range, it is necessary to establish additional the characteristic landscape layouts, architectural highlights, to ensure the continuity, and uninterrupted of the landscape image chains.

- Landscape layouts designed along rivers and streams are influent from the characteristics of natural, man-made landscapes and local cultural activities. Landscape routes along rivers and streams can be designed using images of stilt houses, water wheels, bathing wharfs, images of bridges crossing streams, a combination of cobblestones - streamside shrubs, a combination of multi-layered trees on the mountain to create ecological diversity along the water surface.
- Landscape route along rivers and streams helps to establish open spaces and green corridors for urban areas, therefore, the organization of landscape architecture for this area is the solution to protect the water bodies and corridors along rivers and streams. The landscape architecture of the riverside and streamside routes plays an important role in creating and preserving the overall as well as helping to connect the landscape with other functional areas of the city.

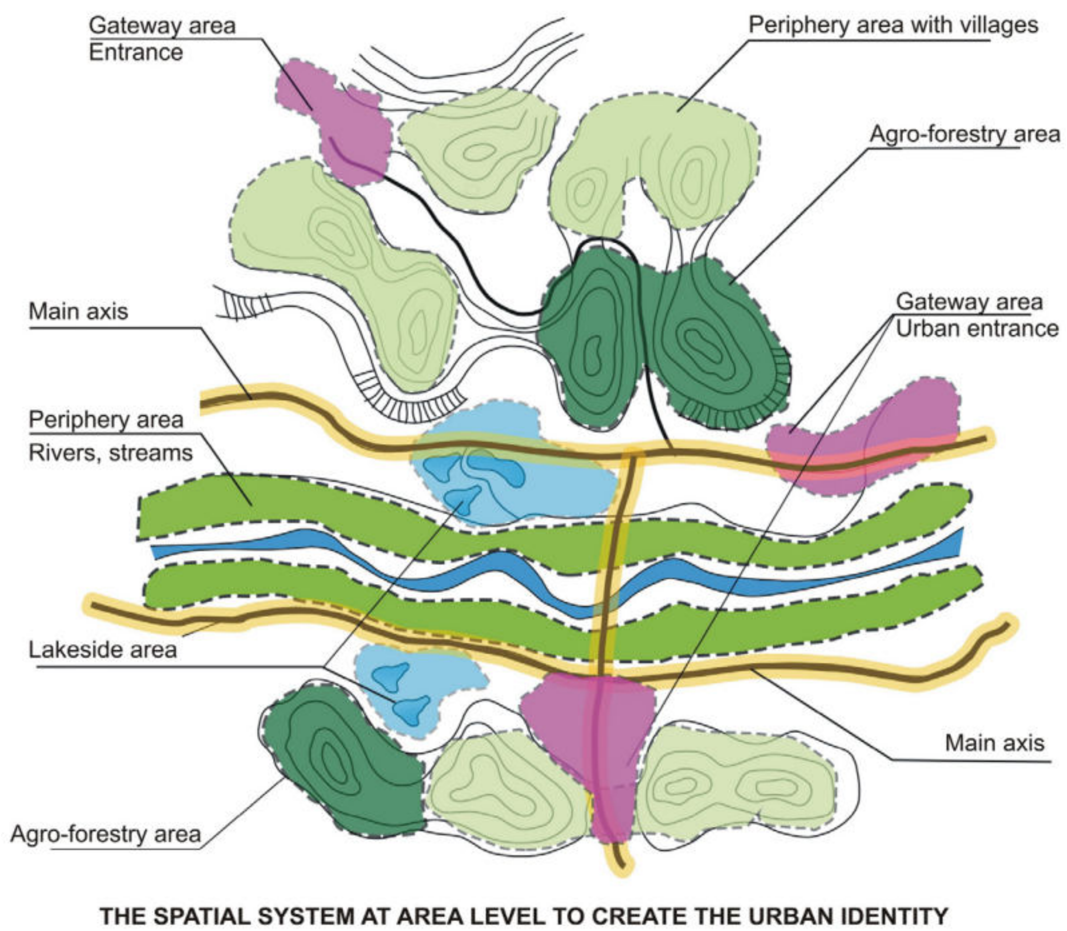
b. Landscape routes along the lakesides. Solutions to organize landscape architecture to create identity for landscape routes along the lakesides:

- Establish a smooth route for areas on lakesides to create open space for the city. Lakeside areas need to be connected with other areas of the city by visual links and viewpoints.
- Landscape layouts long the lakesides are influent from the characteristics of natural, man-made landscapes and local cultural activities. Landscape routes along rivers and streams can be constructed using images of stilt houses, water wheels, combination of cobblestones - streamside shrubs, combination of multi-layered trees to create ecological diversity along water edges.

c. Main axes. The main routes and axes of the cities have the role of connecting the landscapes of the cities, therefore, the landscape architecture of the route needs to be designed with characteristics and organization to create an identity for the whole route. These roads need to comply with the principle of reasonable road width ratio, avoiding bulldozing to make large, straight roads like boulevards, thus losing the characteristics of mountainous terrain. Landscape architecture with identity on the entire routes must be continuously identifiable within the scope of regional visibility. The landscape architecture is designed needs to exploit the elements of architecture, public art, urban amenities, materials with typical images of indigenous cultures, and typical landscape layouts that need to be emphasized. The vegetation needs to be planted with typical local plant species.

d. Landscape areas in the suburban areas.

- Landscapes of traditional villages
  - Integrate traditional villages of ethnic communities living in the periphery of Northern mountainous cities, such as the Muong (Hoa Binh), the Thai (Son La, Lai Chau, Yen Bai), the Dao Do (Yen Bai, Lai Chau), the H'mong (Lao Cai, Yen Bai, Lai Chau, Son La) with general urban planning in terms of landscape, culture, and production.
  - Preserve the layout of the villages such as the layout of roads and preserve the form of local traditional houses of the ethnic groups (stilt houses, traditional houses built with local materials such as earth, stone, wood, neohouzeaua, bamboo).
- Landscapes of agro-forestry
  - Preserve and develop agricultural production landscapes, rice cultivation areas and terraced fields, thereby contribute to the creation and preservation of the overall landscapes with the identity of the NMR urban areas. The landscape architecture of the agro-forestry production areas has both the effect of local economic development and the contribution to the landscapes to serve the needs of tourism development.



◦ Zone the areas of forestry production, plant economical industrial trees, such as cinnamon, tea, acacia, canarium, on the hills while preserve the typical hilly landscape.

4.3. Landscape architectural solutions to preserve and develop the identity of Micro-scaled urban spaces

Micro-scaled urban spaces are spaces with clear visibility within <120 m range, such as squares, parks, flower gardens, architecture public art works, etc. The spaces and buildings must be harmonious and cohesive, and based on the shape and line of sight of hills, rivers and trees to avoid disrupting the area and overall landscape [15].

These spaces must have a continuous connection of characteristic landscape images within the visual range. Research from indigenous cultural elements and images with typical characteristics such as stilt houses, water wheels, topography, trees, traditional cultural activities of local ethnic communities, etc. to use in the design of landscape architecture to create an identity for the space.

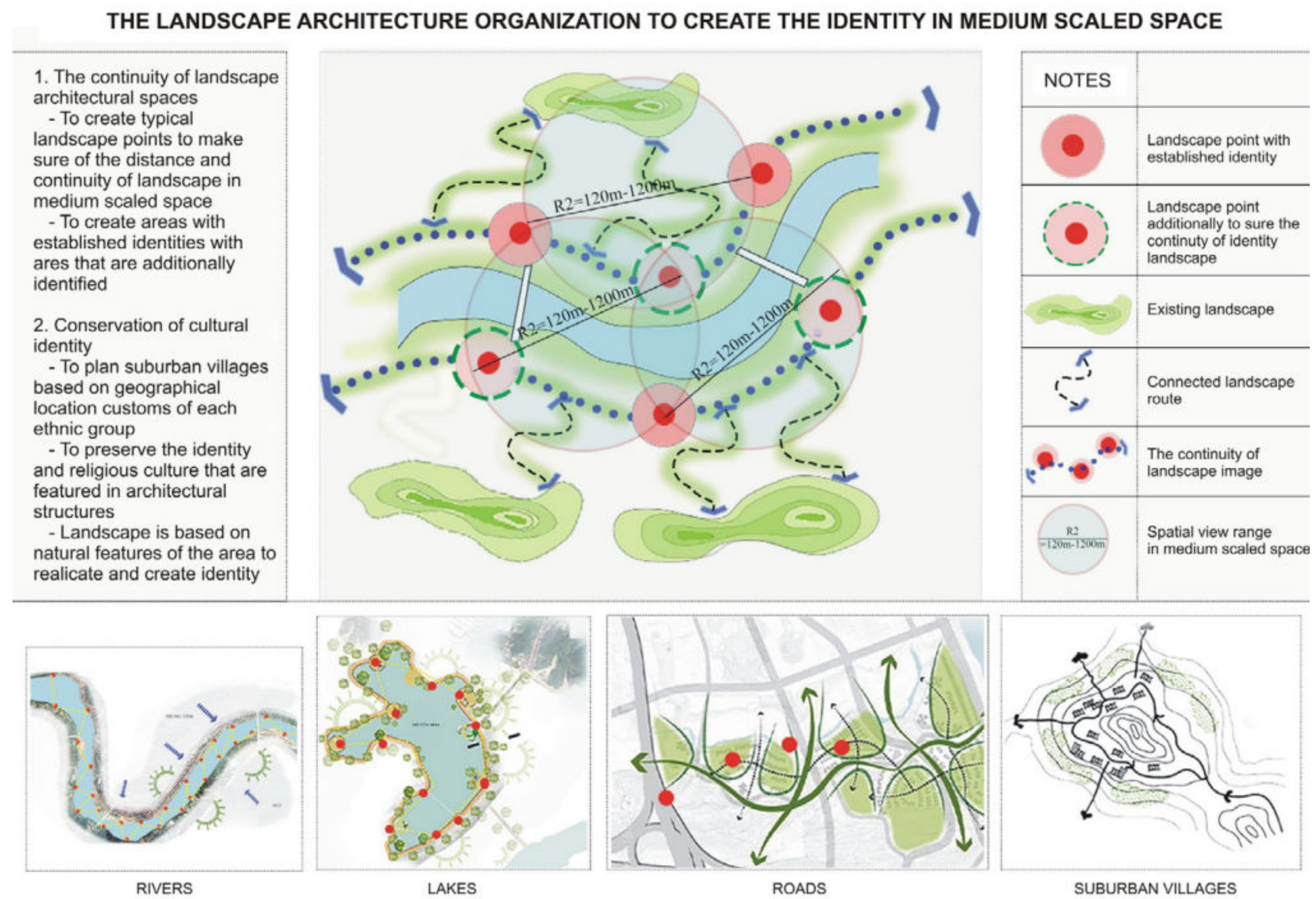
Organizing urban facilities, public art works with local identity associated with spaces for outdoor cultural activities such as squares, flower gardens, and pedestrian streets which are suitable to the topography and natural landscape to emphasize the identity of these spaces. To enhance the character of the places, it is possible to add architectural highlights and monuments.

CONCLUSIONS

Vietnam is in a strong process of urbanization. Economic pressure, the need for urban expansion, the high demand for land use – resource use in general and landscape

↗

Fig. 12: The solutions to organize the urban landscape architecture to preserve and develop the spatial identity at the urban area level – Medium-scaled urban spaces
Fig. 13: The solutions to organize the urban landscape architecture to preserve and develop the spatial identity at the urban area level – Medium-scaled urban spaces



resources in particular – are the reasons why urban areas, especially the NMR with its very own character, gradually lose their characteristic features. What perspectives, principles, methods and solutions are appropriate for the preservation and development of identity are big questions for the cities. In Vietnam, there are many concepts, methods and solutions to preserve and develop urban identity, but research on landscape architecture to create an urban identity, especially in Northern mountainous areas, are still scarce. The paper presents some answers and approaches to the above questions. Therefore, the study on preserving and developing the identity of Northern mountainous areas using landscape architectural tools have contributed to Vietnam's general studies on conservation and development.

However, in order to provide specific solutions for planners and designers, it is necessary to carry out additional in-depth studies on specific areas, such as each urban area of the region. ⦿

1 Trang Thu Dam and Dung Viet Dang. (2015) *Organization of landscape architecture to create the identity of mountainous cities in the Northwest of Vietnam.* Hanoi University of Civil Engineering; Trang Thu Dam and Dung Viet Dang. (2020) Landscape Architecture creates urban identity, Construction Magazine, Ministry of Construction; Trang Thu Dam and Dung Viet Dang. (2021) *Principles for building Landscape Architecture to create urban identity of the Northwestern mountainous region Viet Nam.* Construction Magazine, Ministry of Construction; Trang Thu Dam, Dung Viet Dang and Linh Hoang Nguyen. (2018) *Identity of the world urban landscape architecture.* Construction Magazine, Ministry of Construction; Trang Thu Dam. (2018) *Identification of the landscape architectural identity of urban Vietnam.* Construction Magazine, Ministry of Construction; Ware, C. (2008) *Visual Thinking for Design.* Burlington, Morgan Kaufmann Publishers

2 Đàm Trung Phng, (1995) *Vietnam urban I – II.* Construction Magazine, Ministry of Construction; Dramstad, et. al. (1996) *Landscape Ecology Principles in landscape architecture and land-use plannning.* Havard University and Island Press, Washington D.C; Ian L. Mcharg. (1995) *Design with nature.* John Wiley and Sons, INC. New York. Chichester. Brisbane. Toronto. Singapore; Motloch, John L. (1995) *Introduction to Landscape Design.* ASLA; Lê Bá Tho. (1998) *Vietnam and Geography Areas.* Hanoi magazine; Lê Bá Tho. (2004) *Vietnamese Nature.* Magazine Educational ministry; Lê Phng Tho Phm Kim Chi. (1980,1993) *Plantings in the urban. 1,2.* Construction Magazine, Ministry of Construction; Nguyn Đc Thim. (2002) *Easten urban spaces.* Vietnamese architectural magazine number 9; Nguyn Mnh Thu. (1998) *Reserving of heritage cultural in Vietnamese northwest areas.* HUCE publicer; Nguyn Mnh Thu. (1995) *Architecture following ecology method.* Construction Magazine, Ministry of Construction; Nguyn Th Bá. (2004) *Planning of urban.* Construction Magazine, Ministry of Construction; Nguyn Th Thanh Thu. (1992) *Landscape architecture.* Sience and Tecnology ministry. Trang Thu Dam et. al. (2020) Landscape Architecture creates urban identity, Construction Magazine, Ministry of Construction

3 Dramstad, et. al. (1996) *Landscape Ecology Principles in landscape architecture and land-use plannning.* Havard University and Island Press, Washington D.C; Eckbo, G. (1969) *The Landscape We See.* New York; McGraw-Hill; Forman, R. T. T. (1995) *Land Mosaics: The Ecology of Landscapes and Regions.* Cambridge; Fuller, R. B. (1965) *Conceptuality of Fundamental Structures. In Structure in Art and in Science.* Kepes György, editor. New York: Braziller; Haken, H. and Portugali, J. (2003) *The face of the city is its information.* Journal of Environmental Psychology

4 Bell, S. (1993) *Elements of Visual Design in the Landscape. London.* E&FN Spon.; Higuchi, T. (1975) *The Visual and Spatial Structure of Landscapes.* Cambridge, The MIT Press.; Valánszki I.; Kristensen, L.S.; Jombach, S.; Ladányi M.; Filepné Kovács K.; Fekete A. (2022): *Assessing Relations between Cultural Ecosystem Services, Physical Landscape Features and Accessibility in Central-Eastern Europe: A PPGIS Empirical Study from Hungary.* Sustainability 2022, 14, 754. https://doi.org/10.3390/su14020754

5 Bell, S. (1993) *Elements of Visual Design in the Landscape.* London. E&FN Spon; Higuchi, T. (1975) *The Visual and Spatial Structure of Landscapes.* Cambridge, The MIT Press; Valánszki I. et. al. (2022): *Assessing Relations between Cultural Ecosystem Services, Physical Landscape Features and Accessibility in Central-Eastern Europe: A PPGIS Empirical Study from Hungary.* Sustainability 2022, 14, 754. https://doi.org/10.3390/su14020754

6 Appleton, J. (1975) *The Experience of Landscape.* New York: John Wiley & Sons; Blake, R., and Sekuler, R. (2006) *Perception.* New York, McGraw-Hill; Cooper CM, Francis C. (1998) *People places.* New York: Wiley; DeChiara, J., and Koppelman L. (1982) *Urban Planning and Design Criteria* (Third edition). New York: Van Nostrand Reinhold; Dramstad et. al. (1996) *Landscape Ecology Principles in landscape architecture and land-use plannning.* Havard University and Island Press, Washington D.C; Eckbo, G. (1969) *The Landscape We See.* New York; McGraw-Hill; Forman, R. T. T. (1995) *Land Mosaics: The Ecology of Landscapes and Regions.* Cambridge; Haken, H. and Portugali, J. (2003) *The face of the city is its information.* Journal of Environmental Psychology; Hall, E. (1966) *The Hidden Dimension. Garden City,* NY: Doubleday; Handley, J. Wood, R. and Kidd, S. (1998) *Defining Coherence for Landscape Planning and Management: a regional landscape strategy for North West England.* Landscape Research; Hofstadter, D. (1985) *Metamagical Themas: Questing for the Essence of Mind and Pattern.* New York: Basic Books; Jane Jacobs. (1992) *The Death and Life of Great American Cities.* Vintage Books; Jellicoe, G., and Jellicoe, S. (1975) *The Landscape of Man: Shaping the Environment from Prehistory to the Present Day.* New York; Viking Press; Kaplan R., Kaplan S., Ryan RL. (1998) *With people in mind. Design and management of everyday nature.* Washington, DC: Island Press; Kaplan, R., and Kaplan, S. (1989) *The Experience of Nature. A Psychological Perspective.* Cambridge, Cambridge University Press; Laurie, M. (1975) *An Introduction to Landscape Architecture.* New York: Elsevier Science Publishing Co., Inc; Leitmann, J. (1999) *Sustaining cities. environmental planning and mamagement in urban design.* New York: Mc Graw-Hill; Lewis, Pierce. (1979) *"Axioms for Reading the Landscape."* The Interpretation of Ordinary Landscapes, Meinig, D.W. Ed. Oxford University Press; Massachusetts, The Riverside Press (Houghton Miffl in Company). Rogers, E.B. (2001) *Landscape Design. A Cultural and Architectural History.* New York, Harry N. Abrams; Meinig, D. W., ed. (1979) *The Interpretation of Ordinary Landscapes.* New York; Oxford University Press; Norberg-Schulz, C. (1980) *Genius Loci: Towards A Phenomenology of Architecture.* New York; Rizzoli; Perin, C. (1970) *With Man in Mind: An Interdisciplinary Prospectus for Environmental Design.* Cambridge, MA: MIT Press; Pregill, P., and Volkman, N. (1999) *Landscapes in History. Design and Planning in the Eastern and Western Traditions* (Second Edition). New York, etc., John Wiley & Sons Inc; Rapoport, A, (1969) *House Form and Culture.* Englewood Cliffs, NJ; Prentice-Hall; Repton, H. (1907), *The Art of Landscape Gardening. Including his Sketches and Hints on Landscape Gardening and Theory and Practice of Landscape Gardening.* Edited by J. Nolen. Cambridge; Tuan, Yi-F. (1974) *Topophilia: A Study of Environmental Perception, Attitudes, and Values.* Englewood Cuffs, NJ; Prentice-HaU; Turner, T. (1987, updated 1998) *Landscape Planning and Environmental Impact Design.* London; UCL; Ware, C. (2008) *Visual Thinking for Design.* Burlington, Morgan Kaufmann Publishers

7 Laurie, M. (1975) *An Introduction to Landscape Architecture.* New York: Elsevier Science Publishing Co., Inc; Pearce, P. (1978) *Structure in Nature Is a Strategy for Design.* Cambridge, MA: MIT Press; Holden, R., Liversedge, J. (2014) *Landscape Architecture: An Introduction.* Laurence King Publishing; Roe, M. H. (2000) *Landscape Planning for Sustainability: community participation in Estuary Management Plans.* Landscape Research; Salingaros, N.A. (2005) *Principles of Urban Structure.* Amsterdam, Techne Press; Swaffield, S. (2002) *Theory in landscape Architecture: A Reader (Penn Studies in Landscape Architecture).* University of Pennsilvania Press.; Simonds, JO. (1998) *Landscape architecture. A manual of site planning and design.* New York: McGraw-Hill; Snowden, R., Thompson, P. and Troscianko, T. (2006) *Basic Vision. An introduction to visual perception.* Oxford, Oxford University Press; Steffennijhuis. 2011. *Visual research in Landscape architecture.* TUDelf

8 Dee, Catherine. (2001) *Form and Fabric in Landscape Architecture – A visual introduction.* London & New York: Spon press – Taylor and Francis group; DeChiara, J., and Koppelman, L. (1982) *Urban Planning and Design Criteria* (Third edition). New York: Van Nostrand Reinhold; Dramstad et. al. (1996) *Landscape Ecology Principles in landscape architecture and land-use plannning.* Havard University and Island Press, Washington D.C; Gibson, J.J. (1986) *The Ecological Approach to Visual Perception.* London, Lawrence Erlbaum Associates (Original edition 1979).; Handley, J. et. al. (1998) *Defining Coherence for Landscape Planning and Management: a regional landscape strategy for North West England.* Landscape Research; Hough, M. (1995) *Cities and natural process.* London: Routledge; Mcharg, Ian L. (1995) *Design with nature.* John Wiley and Sons, INC. New York. Chichester. Brisbane. Toronto. Singapore; Motloch, J. L. (1995) *Introduction to Landscape Design.* ASLA; Laurie, M. (1975) *An Introduction to Landscape Architecture.* New York: Elsevier Science Publishing Co., Inc; Pearce, P. (1978) *Structure in Nature Is a Strategy for Design.* Cambridge, MA: MIT Press; Holden, R. et. al. (2014) *Landscape Architecture: An Introduction.* Laurence King Publishing; Roe, M. H. (2000) *Landscape Planning for Sustainability: community participation in Estuary Management Plans.* Landscape Research; Swaffield, S. (2002) *Theory in landscape Architecture: A Reader (Penn Studies in Landscape Architecture).* University of Pennsilvania Press.; Simonds JO. (1998) *Landscape architecture. A manual of site planning and design.* New York: McGraw-Hill; Turner, T. (1987, updated 1998) *Landscape Planning and Environmental Impact Design.* London; UCL

9 Motloch, John L. (1995) *Introduction to Landscape Design.* ASLA; Lê Bá Tho. (1998) *Vietnam and Geography Areas.* Hanoi magazine; Lê Bá Tho. (2004) *Vietnamese Nature.* Magazine Educational ministry; Lê Phng Tho et. al. (1980,1993) *Plantings in the urban. 1,2.* Construction Magazine, Ministry of Construction Swaffield, S. (2002) *Theory in landscape Architecture: A Reader (Penn Studies in Landscape Architecture).* University of Pennsilvania Press.; Simonds JO. (1998) *Landscape architecture. A manual of site planning and design.* New York: McGraw-Hill

10 Alexander. (1977) *A Pattern Language: Towns, Buildings, Construction.* New York: Oxford University Press; Appleton J. (1975) *The Experience of Landscape.* New York: John Wiley & Sons; Bell, S. (1999) *Landscape. Pattern, Perception and Process.* London, E&FN Spon; Dee, C. (2001) *Form and Fabric in Landscape Architecture – A visual introduction.* London & New York: Spon press – Taylor and Francis group

11 Alexander. (1977) *A Pattern Language: Towns, Buildings, Construction.* New York: Oxford University Press; Bacon, E.N. (1967) *Design of Cities.* New York, Penguin Books.; Ching, F. D. K. (1979) *Architecture: Form, Space and Order.* New York: Van Nostrand Reinhold; Fuller, R. B. (1965) *Conceptuality of Fundamental Structures. In Structure in Art and in Science.* Gyorgy Kepes, editor. New York: Braziller; Haken, H. and Portugali, J. (2003) *The face of the city is its information.* Journal of Environmental Psychology; Jacobs, J. (1992) *The Death and Life of Great American Cities.* Vintage Books; Lynch, K. (1960) *The Image of the City.* Cambridge, MIT Press; Norberg-Schulz, C. (1980) *Genius Loci: Towards A Phenomenology of Architecture.* New York; Rizzoli; Rapoport, A, (1969) *House Form and Culture.* Englewood Cliffs, NJ; Prentice-Hall; Salingaros, N.A. (2005) *Principles of Urban Structure.* Amsterdam, Techne Press

12 Cooper CM, Francis C. (1998) *People places.* New York: Wiley; Eckbo, G. (1969) *The Landscape We See.* New York; McGraw-Hill; Kaplan R. et. al. (1998) *With people in mind. Design and management of everyday nature.* Washington, DC: Island Press; Redfieid, R. (1956) *Peasant Society and Culture: An Anthropological Approach to Civilization.* Chicago; University of Chicago Press; Tuan, Yi-F. (1974) *Topophilia: A Study of Environmental Perception, Attitudes, and Values.* Englewood Cuffs, NJ; Prentice-HaU

13 Bacon, E.N. (1967) *Design of Cities.* New York, Penguin Books.; Bell, S. (1993) *Elements of Visual Design in the Landscape.* London. E&FN Spon.; Dee, C. (2001) *Form and Fabric in Landscape Architecture – A visual introduction.* London & New York: Spon press – Taylor and Francis group; De Sausmarez, M. (1964) *Basic Design: The Dynamics of Visual Form.* New York: Reinhold; Higuchi, T. (1975) *The Visual and Spatial Structure of Landscapes.* Cambridge, The MIT Press.; Snowden, R., Thompson, P. and Troscianko, T. (2006) *Basic Vision. An introduction to visual perception.* Oxford, Oxford University Press; Steffennijhuis. (2011) *Visual research in Landscape architecture.* TUDelf; Valánszki et. al. (2022): *Assessing Relations between Cultural Ecosystem Services, Physical Landscape Features and Accessibility in Central-Eastern Europe: A PPGIS Empirical Study from Hungary.* Sustainability 2022, 14, 754. https://doi.org/10.3390/su14020754

14 Dee, Catherine. (2001) *Form and Fabric in Landscape Architecture – A visual introduction.* London & New York: Spon press – Taylor and Francis group; Cerver FA, ed. (1996) *Landscape architecture.* Barcelona: Atrium International; Ching, F. D. K. (1979) *Architecture: Form, Space and Order.* New York: Van Nostrand Reinhold; DeChiara, J., and Koppelman L. (1982) *Urban Planning and Design Criteria* (Third edition). New York: Van Nostrand Reinhold; Dramstad et. al. (1996) *Landscape Ecology Principles in landscape architecture and land-use plannning.* Havard University and Island Press, Washington D.C; Forman, R. T. T. (1995) *Land Mosaics: The Ecology of Landscapes and Regions.* Cambridge; Gibson, J.J. (1986) *The Ecological Approach to Visual Perception.* London, Lawrence Erlbaum Associates (Original edition 1979); Handley, J. et. al. (1998) *Defining Coherence for Landscape Planning and Management: a regional landscape strategy for North West England.* Landscape Research; Hough M. (1995) *Cities and natural process.* London: Routledge; Mcharg, I. L. (1995) *Design with nature.* John Wiley and Sons, INC. New York. Chichester. Brisbane. Toronto. Singapore; Motloch, J. L. (1995) *Introduction to Landscape Design.* ASLA; Kaplan R. et. al. (1998) *With people in mind. Design and management of everyday nature.* Washington, DC: Island Press; Kaplan, R., and Kaplan, S. (1989) *The Experience of Nature. A Psychological Perspective.* Cambridge, Cambridge University Press; Laurie, M. (1975) *An Introduction to Landscape Architecture.* New York: Elsevier Science Publishing Co., Inc; Simonds JO. (1998) *Landscape architecture. A manual of site planning and design.* New York: McGraw-Hill; Turner, T. (1987, updated 1998) *Landscape Planning and Environmental Impact Design.* London; UCL

15 Dee, C. (2001) *Form and Fabric in Landscape Architecture – A visual introduction.* London & New York: Spon press – Taylor and Francis group; Cerver FA, ed. (1996) *Landscape architecture.* Barcelona: Atrium International; Ching, F. D. K. (1979) *Architecture: Form, Space and Order.* New York: Van Nostrand Reinhold; Motloch, J. L. (1995) *Introduction to Landscape Design.* ASLA; Laurie, M. (1975) *An Introduction to Landscape Architecture.* New York: Elsevier Science Publishing Co., Inc; Swaffield, S. (2002) *Theory in landscape Architecture: A Reader (Penn Studies in Landscape Architecture).* University of Pennsilvania Press; Simonds JO. (1998) *Landscape architecture. A manual of site planning and design.* New York: McGraw-Hill

A VÁROSI ALRENDSZEREK ÖSSZEKAPCSOLÁSÁNAK ÉS KOORDINÁCIÓJÁNAK FELTÁRÁSA LUOHE VÁROS REZILIENCIA VIZSGÁLATÁNAK PÉLDÁJÁN

EXPLORATION OF URBAN SUBSYSTEM COUPLING COORDINATION BASED ON RESILIENCE IN LUOHE CITY

WANG XINYU | SHI ZHEN | KOLLÁNYI LÁSZLÓ | YANG YANG | LIU MANSHU | ZHANG XIAOYAN

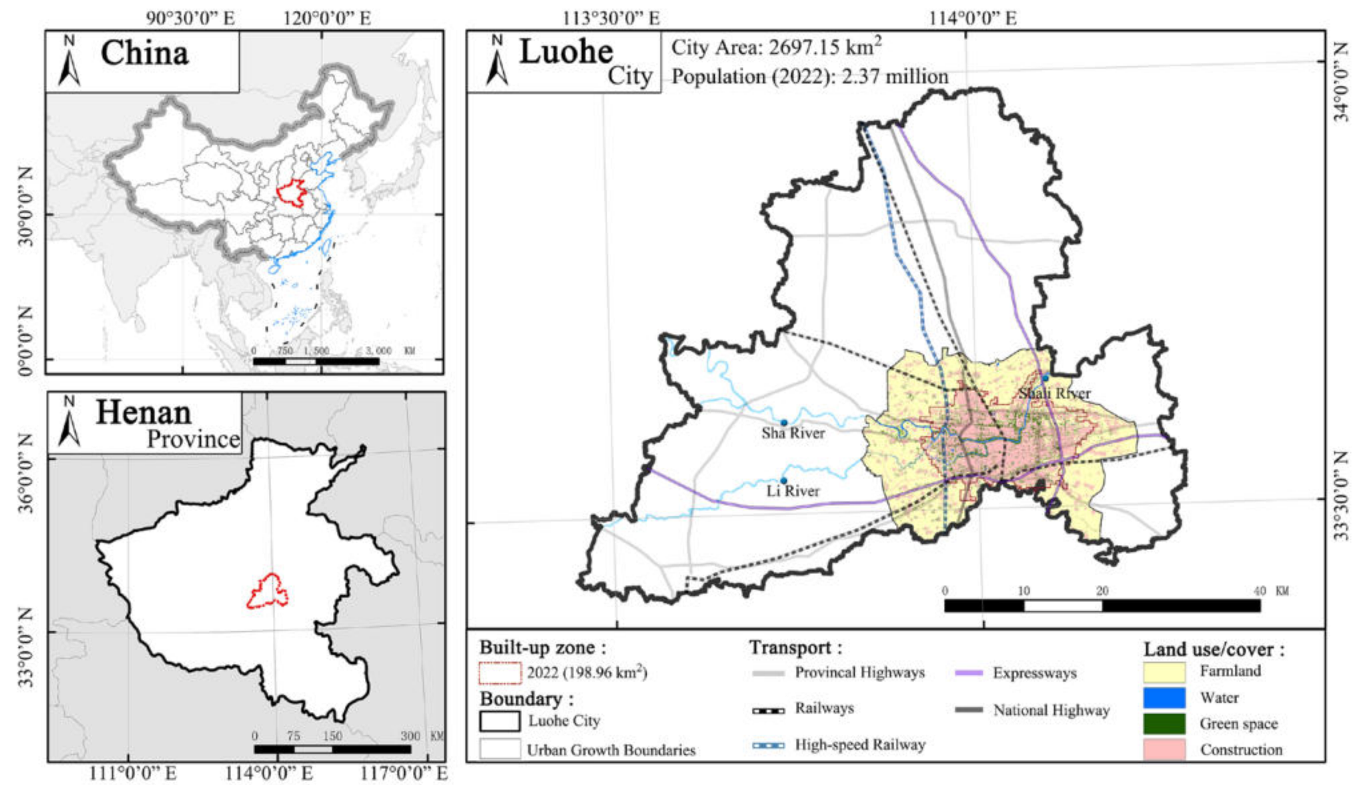
ABSZTRAKT

Az urbanizáció fokozódásával Kínában is nőnek a városi területek területhasználati problémái. A probléma megoldása a mennyiségről a minőségre történő várostervezési módszerek adaptálása. A rendszerszemlélet, a koordináció és az integráció a tervezésben elősegíti, hogy a városi területek ellenállóbbá váljanak a kockázatokkal szemben. Jelen tanulmány Luohe város (Kína) 2022-es adatait használja példaként a rendszerek közötti összekapcsolódás koordinációs fokának (CCD) számításához, az ellenálló-képesség kiépítését akadályozó tényezők megtalálásához, és az azt akadályozó tényezők térbeli heterogenitásának további feltárásához. A módszer három modellezés eredményeit használja ("szintetikus értékelési modell", a "csatolási értékelési modell", "akadálydiagnosztikai modell") az egyes alrendszerek értékelésére és elemzésére. Az eredmények a következők: ① A szintetikus értékelés szerint az átlagos városfejlesztési érték 0,48; a magas értékű régiók a délkeleti beépített övezetben csoportosulnak. ② A városcsatlakozási koordináció átlagos értéke 0,66; a koordinációs szint 7 (mérsékelt koordináció). ③ A városi fejlettségi fok pozitívan korrelál a CCD-vel. ④ Globálisan a gazdaság a legfőbb akadályozó tényező a rugalmas növekedés szempontjából, de az ökoszisztémák, természeti területek korlátozásai nagyobbak és szélesebb körű hatással bírnak. Ez a tanulmány hozzájárul a városi, nagyvárosi területek belső hierarchikus rendszerének megértéséhez, és hozzájárulhat a területek harmonikus fejlesztéséhez, a városi ellenálló képesség, reziliencia növeléséhez. ◉

4D 67, 22–29. (2023)

DOI: HTTPS://DOI.ORG/10.36249/4D.67.3700

Figure 1: Location Map (GS (2020)4619)



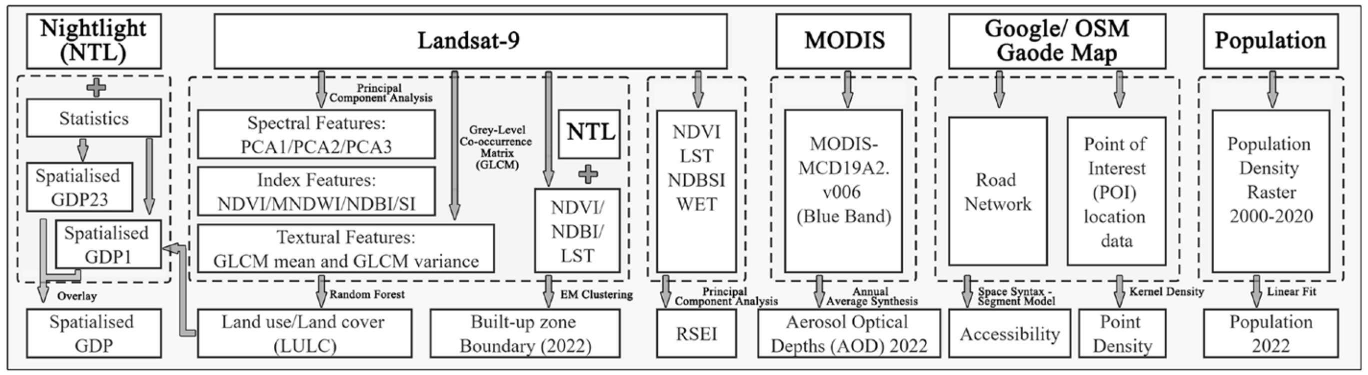
ABSTRACT

With urbanisation, the uncertainties faced by urban areas continue to increase, and in response, China's urban planning is transitioning from a focus on quantity to quality. Promoting system coupling and coordination helps to make urban areas more resilient to risk. This paper uses data from Luohe City (China) in 2022 as an example to calculate the inter-system Coupling Coordination Degree (CCD), to find the factors that obstruct resilience construction and further explore the spatial heterogeneity of the obstacle factors. The synthetic evaluation model, coupling evaluation mode and obstacle diagnosis model are used to evaluate and analyse each subsystem. The results are as follows: ① According to the synthetic evaluation, the mean urban development value is 0.48, with high-value regions clustered in the Southeastern built-up zone. ② The mean value of urban coupling coordination is 0.66, the coordination level is 7 (Moderate Coordination). ③ The urban development degree is positively correlated with the CCD. ④ Globally, the economy is the main factor obstructing resilient growth, but the core obstacle areas of the ecosystem are larger and have a wider impact. This study helps us understand the internal system of urban areas and provides data for balanced development and urban resilience enhancement.

INTRODUCTION

Urban sustainability is increasingly challenged by urban growth. Although no city can completely predict the occurrence of natural/unnatural disasters, the urban system can improve its resilience to external disturbances [1]. Urban resilience (UR) is an emerging concept that can help urban areas adapt to uncertainty and become more resilient to external disturbances to deal with these challenges.

Urban areas are perceived as complex systems, and the interrelationship between the various subsystems dramatically affects overall operational efficiency [2, 3]. As an important attribute of the urban system, UR is also a multi-dimensional system for managing urban risk to adapt to uncertainty by focusing on system integration and coordination [2, 4–6]. Currently, many studies focus on constructing a multi-criteria framework [7, 8] based on single-factor evaluations [9, 10] to provide quantitative measures of UR. The socio-economic-ecological framework is widely used in many fields [11–13]. The interrelationship of



multiple urban subsystems, especially regarding urbanisation, is gradually gaining traction [14, 15]. It can be seen that the degree of development of urban subsystems and their interrelationships are equally important in building UR. The Coupling Degree (CD) is an important indicator of system interactions [16]. Good coupling is known as coordination. The Coupling Coordination Degree considers both the coupling and the coordination relationships [13,17]. It can show the system's robustness, help balance development and reduce internal conflicts. After all, the single pursuit of economy or construction may lead to the decoupling of subsystems, causing potential problems such as industrial structural imbalance, spatial sprawl and ecological degradation [18,19].

This paper uses the classical socio-economic-ecological framework to analyse urban subsystems and their interactions through the Synthetic Evaluation Model, Coupled Evaluation Model and Obstacle Diagnosis Model (ECO model) [20]. In summary, coupled coordination research aims to contribute to UR architecture by exploring the relationships between urban subsystems. Exploring individual systemic obstacle degrees provides policymakers and practitioners with spatial detail, improves development heterogeneity and promotes urban equity.

1. MATERIALS

This section includes an introduction to the study area, the acquisition of basic data and the preliminary processing flow.

1.1 Study Area

Luohe is in the south-central part of Henan Province in central China. It is well connected and is a regional transport hub, and is crossed by the Shali River (Figure 1). Regarding its urban scale and economic level, Luohe is a good representative of most ordinary cities in China. In 2022, there was still a considerable amount of farmland within the Urban Growth Boundary (UGB). Therefore, to exclude the influence of non-urban areas, we needed to screen the boundary of the built-up zone as the study area.

1.2 Data Collection and Processing

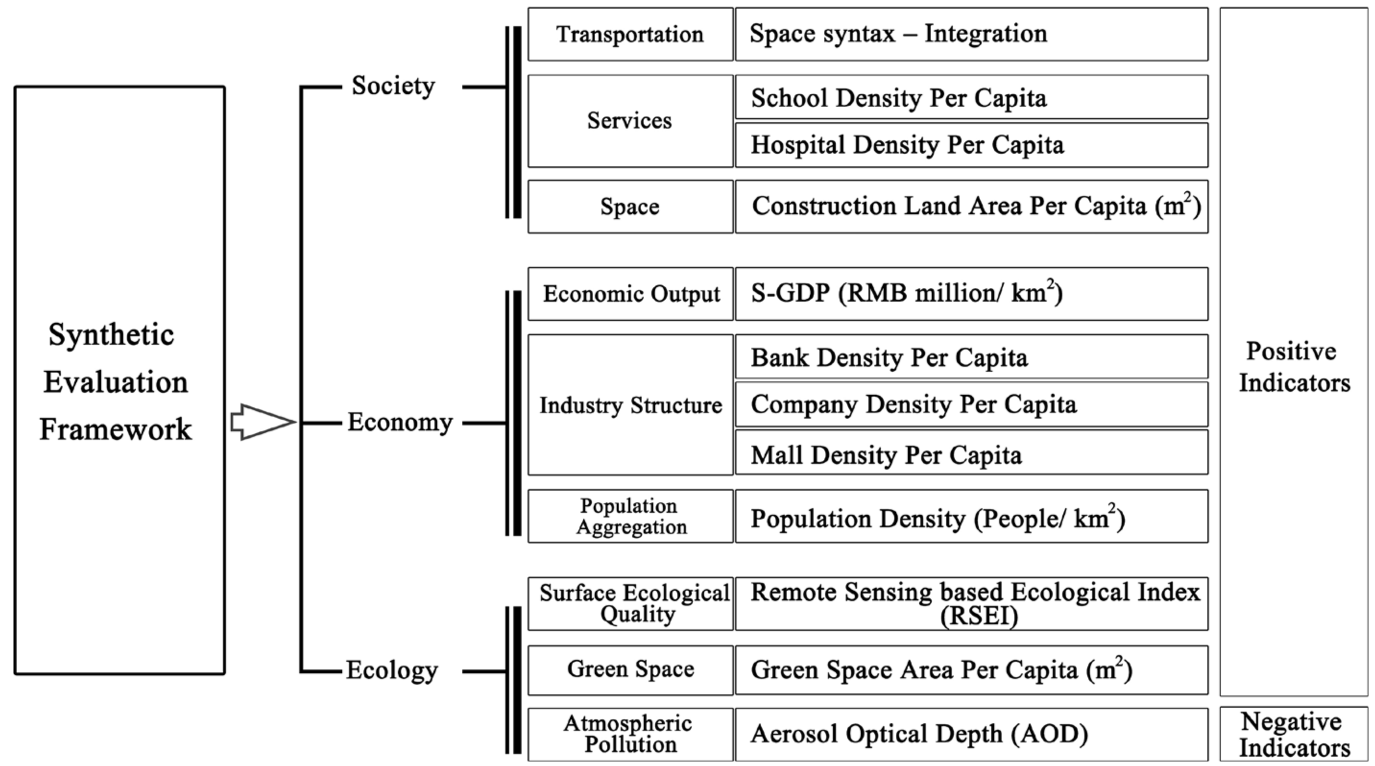
Basic satellite images were derived from Landsat-9. Annual nighttime lights (NTL) are from the NPP-VIIRS. The population was obtained from Google Earth Engine (GEE) – Worldpop collection. The Aerosol Optical Depth (AOD) is derived from the MODIS collections (Figure 2). The above basic data acquired and other indices, such as Land Surface Temperature (LST)[21], are acquired by GEE (https://code.earthengine.google.com/). Point of Interest (POI) is obtained from Gaode Map (https://lbs.amap.com/). Roads were obtained from OpenStreetMap (OSM, https://www.openstreetmap.org/) and Google Maps (Figure 2).

Built-up zone: The identification of the built-up zone drew on previous studies [22, 23]. Based on NTL/ NDBI/ LST, Expectation Maximization Clustering [24] is used to classify the UGB into three clusters (Figure 1). **Land use/ Land cover (LULC):** Based on Landsat-9, NDVI/ NDBI/ MNDWI and texture data as secondary data. Random Forest was used [23, 25]: Farmland, Water, Green space, Construction (Kappa=85.65%). **Integration:** Accessibility can characterise urban infrastructure and resource distribution efficiency. The Segment model of space syntax was chosen, and accessibility is expressed by road integration [23, 26]. **Spatialized GDP (S-GDP):** Farmland&NTL can reflect the primary GDP (GDP1) & secondary tertiary GDP (GDP23) respectively. The correction coefficients are calculated based on the statistical yearbook, spatialized GDP1 and GDP23 separately, then superimposed (Mean Absolute Errors=17.07%). **RSEI calculation:** Remote Sensing based Ecological Index (RSEI) is a more comprehensive ecological indicator. Greenness (NDVI), humidity (WET), dryness (NDBSI) and heat (LST) were synthesised by Principal Component Analysis to obtain it. **POI Density:** The POI density is calculated based on ArcMap10.8 Kernel Density. **Population:** Based on the 2000-2020 raster, a linear fit was performed to obtain population data in 2022 [11].

1.3 Framework and Methods

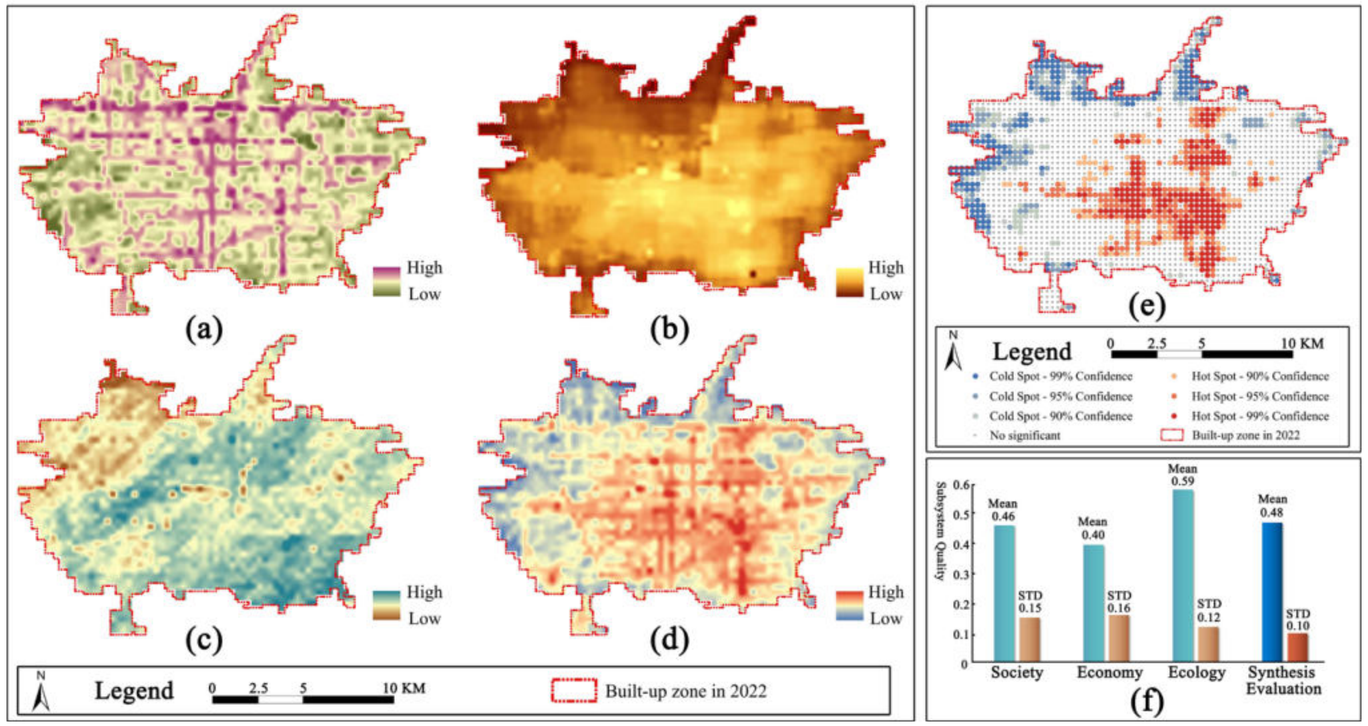
The individual indicators are weighted and overlaid with McHarg's Layer Cake and CRITIC models. The results are

◂◂ **Figure 2** : Data processing flowchart
Figure 3: Synthetic Evaluation Framework
Figure 4: Synthetic Evaluation Framework



Urban Subsystem	Weights (%)	Indicators	Weights (%)
Society	38.23	Space syntax - Integration	60.16
		School Density Per Capita	7.46
		Hospital Density Per Capita	7.81
		Construction Land Area Per Capita (m^2)	24.57
Economy	34.64	S-GDP (RMB million/ km^2)	43.32
		Bank Density Per Capita	5.68
		Company Density Per Capita	17.83
		Mall Density Per Capita	7.31
		Population Density (People/ km^2)	25.86
Ecology	27.13	RSEI	34.91
		Green Space Area Per Capita (m^2)	18.04
		AOD	47.05

Figure 5: Evaluation results. (a)-(b) Social/ Economic/ Ecological subsystem of development degree; (d) Synthesis urban development degree; (e) Cold/Hot spots of urban development degree; (f) Statistic of the subsystem/synthesis development degree
►►Figure 6: Coordination classification based on CCD with corresponding area percentage
►►Figure 7: (a) Coordination classification; (b) Joint coordinate axis of Development Degree - CCD



then analysed regarding their coupling with the Coupling Evaluation/ Obstacle Diagnosis Model.

Synthetic Evaluation Model: the social subsystem considers how to provide the three main needs: transport, education & health, and space. The economic subsystem considers the economic structure (POI density) and output (GDP). Finally, ecosystems also focus on green space quantity and land ecological quality. Atmospheric quality (AOD) is also an important part of the environment. Humans should be the central focus of the urban environment. Some indicators are further weighted by population (Figure 3).

CRITIC model: given the unavoidable multicollinearity between the indicators, we chose the Criteria Importance Through Intercriteria Correlation (CRITIC) model [27] to calculate the weights of each one. This method includes the intensity of the contrast and the conflict in the framework.

Coupling Evaluation Model and Obstacle Diagnosis Model: based on the synthesis evaluation, firstly, the coordination level between the subsystems was analysed using the Coupling Evaluation Model. The Coupling Coordination Degree (CCD) has a higher value, indicating better coordination between subsystems and more resilience within the overall system. At the same time, the Obstacle Diagnosis Model was used to analyse the main obstacle factors of the urban system. A higher O value (O, O= [0.0, 1.0]) indicates that the subsystem is less developed and has greater development needs [12]. The Obstacle Diagnosis Model provides insight into the subsystems that require more resources and effort to overcome obstacles and achieve their maximum potential.

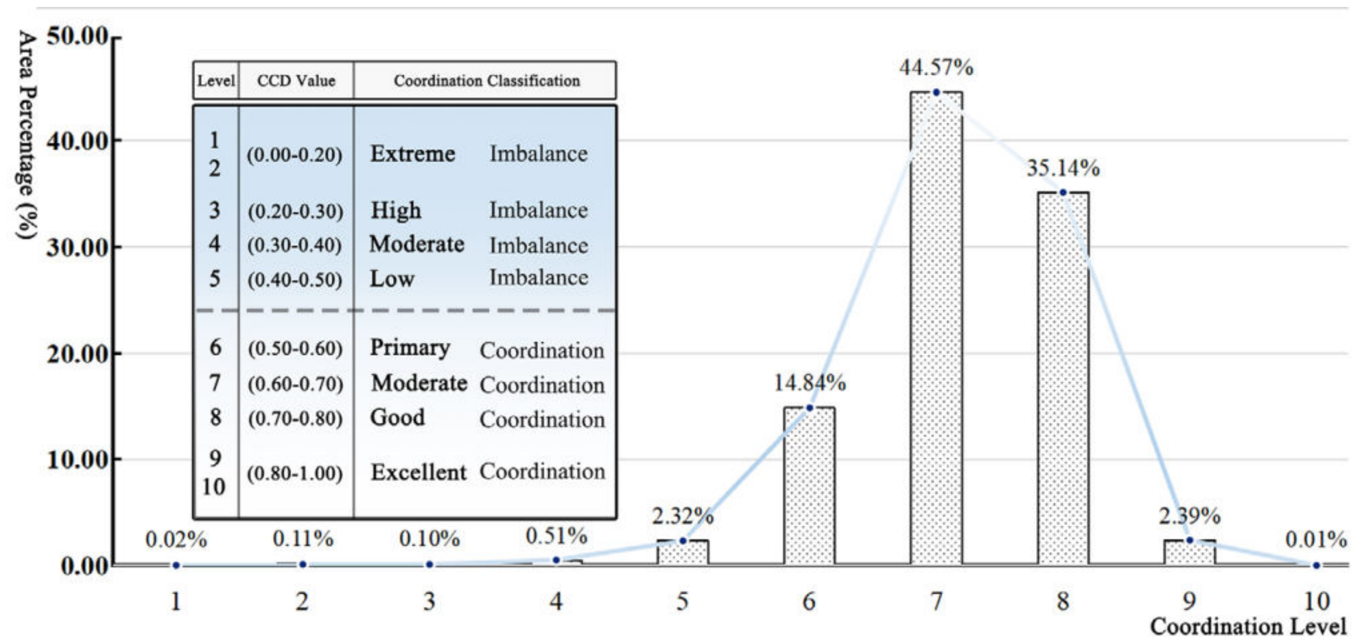
2. RESULTS

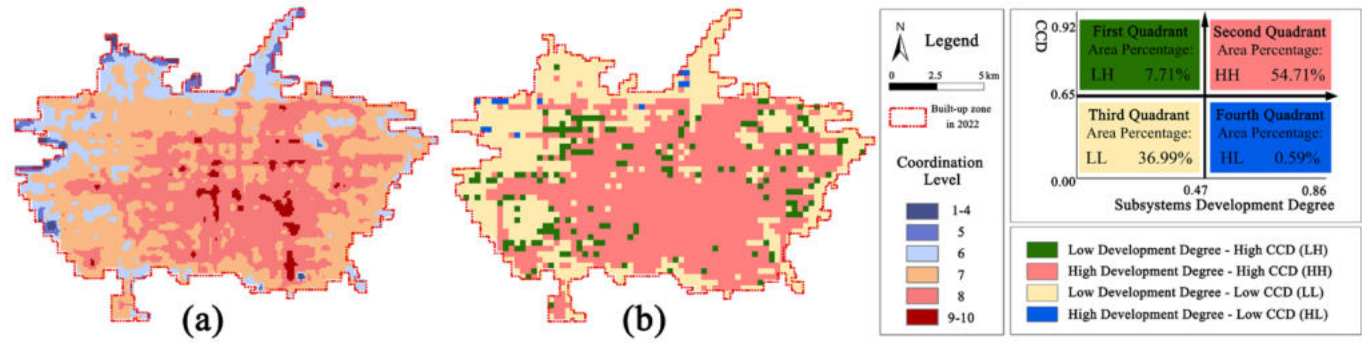
These include the results of the system development assessment, the overall coupling coordination statistics. They also include the correlation between coupling coordination and system development degree, and finally the obstacle degree hotspot analysis.

2.1 Synthetic evaluation results

Weight of each indicator: the weights calculated by CRITIC are shown below (Figure 4). The ranking of the importance of the subsystems shows: Society > Economy > Ecology.

↗





Synthetic evaluation results: based on the mean, we can observe that the development degree of these systems is ranked as follows: Ecology > Society > Economy. The standard deviation (STD) represents the data dispersion degree, i.e. the imbalance and heterogeneity of development (Figure 5 (f)). As a result, the economic system exhibits higher heterogeneity (STD=0.16), while the ecosystem is relatively more balanced (STD = 0.12). Spatial details are equally important, and both ecological and economic systems exhibit an upward trend in the Southeast and a downward trend in the Northwest, except for the social system (Figure 5 (a)-(c)). Furthermore, we visualised the aggregation of the values using the Hot Spot Analysis method. Hot Spots represent areas with high-value aggregation, while Cold Spots represent areas with low-value aggregation. The synthesis evaluation tends to be high in the centre and low in the surroundings, with the Southeast exhibiting high values and the Northwest exhibiting low values (Figure 5 (d-e)).

2.2 Coupling Coordination and Obstacles

Coupling Coordination Degree: CCD statistics are shown in Figure 6 (mean=0.66, STD=0.09). Luohe City belongs to the moderate coordination classification.

Based on the coordination classification levels (Figure 6), we can obtain spatial details (Figure 7 (a)): high in the Southeast and low in the Northwest. In order to visually represent the relationship between development degree and CCD, the two are linked based on the cartesian coordinate (Figure 7 (b)). The pixels were grouped into four categories, with classification thresholds determined by Jenks natural breaks. The highest percentage of High Development Degree – High CCD (HH) region is a trend that needs to be maintained, and the High Development Degree – Low CCD (HL) and Low Development Degree – High CCD (LH) regions are tiny (Figure 7 (b)).

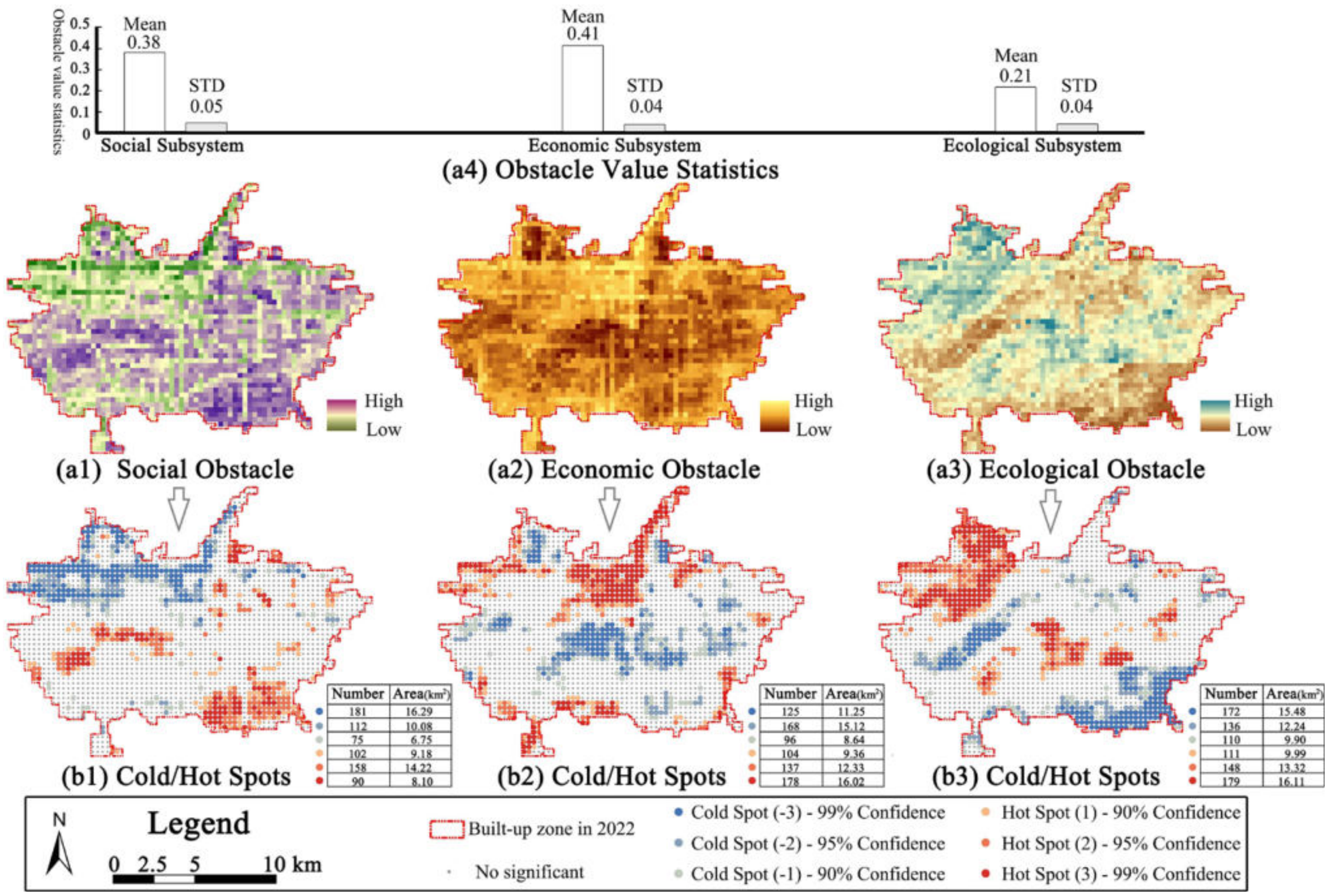
Obstacle Degree: globally (Figure 8 (a4)), the economy is the main obstacle to improving the CCD (Mean=0.41). However, we observe that the core obstacle areas of the ecosystem are much larger (Hot Spot (3)=16.11km²). Therefore, even though the economic system shows a higher obstacle degree on average, the development needs of the landscape, especially in its core obstacle areas, should not be ignored.

3. DISCUSSION AND CONCLUSIONS

This paper's indicators are based on land use (except Atmospheric Pollution). This is primarily because the

↙

Figure 8: Subsystem obstacle statistics/ heterogeneity/ hotspot analysis



land is the physical base for urban activities, is undergoing significant change and is subject to the most dramatic impacts during urbanisation [11]. Society is dominated by accessibility. Transit-oriented Development (TOD) theory considers transport essential for heterogeneous urban expansion. GDP dominates the economy. The AOD dominates the ecosystem.

The urban development degree (Mean) and CCD in Luohe are 0.48 and 0.66 respectively. The proportion of positively correlated regions (HH and LL) between the two is over 90%. With urban development, resilience is becoming a prerequisite for integral construction. Urban growth, which should be seen as systemic change, is the combined effect of all subsystems rather than any individual subsystem [17]. The relationship between the size of obstacle areas and residents' perceptions may be an essential factor. Despite a lower global obstacle degree, larger ecological obstacle areas may substantially impact residents' perceptions due to their more visible and tangible nature. This could amplify the perceived importance of ecological issues within the urban environment, necessitating a more focused approach to ecological development in urban planning strategies. Adjusting development heterogeneity can better help multi-system coordination and balance development. Based on the results of the barrier degree analysis, targeted filling of ecological low-value areas and promoting a balanced development of the landscape will help the coupling and coordination of urban systems.

The different frameworks and indicators may significantly influence the study's results. Conducting multi-temporal studies, refining indicators and maintaining the robustness of the evaluation framework will be the next step [1]. ⦿

1 Ribeiro, P. J. G. – Gonçalves, L. A. P. J. (2019): *Urban resilience: A conceptual framework. SCS, 50,* 101625. https://doi.org/10.1016/j.scs.2019.101625

2 Lhomme, S. – Serre, D. – Diab, Y. – Laganier, R. (2012): Urban technical networks resilience assessment. In: Damien, Serre – Bruno, Barroca – Richard, Laganier. (ed.): *Resilience and Urban Risk Management:* CRC Press, Florida, USA, pp. 109–117.

3 Batty, M. (2002). *Thinking about Cities as Spatial Events. Environment and Planning B: Planning and Design,* 29, 1–2. https://doi.org/10.1068/b2901ed

4 Büyüközkan, G. – Ilıcak, Ö. – Feyzioğlu, O. (2022): *A review of urban resilience literature. SCS, 77,* 103579. https://doi.org/10.1016/j.scs.2021.103579

5 Index C. R. (2014): *City resilience framework.* The Rockefeller Foundation and ARUP: New York.

6 Meerow, S. – Newell, J. P. – Stults, M. (2016): *Defining urban resilience: A review. LANDSCAPE URBAN PLAN, 147,* 38–49. https://doi.org/10.1016/j.landurbplan.2015.11.011

7 Assumma, V. – Bottero, M. – Datola, G. – Pezzoli, A. – Quagliolo, C. (2021): Climate change and urban resilience. Preliminary insights from an integrated evaluation framework. In: Carmelina, Bevilacqua – Francesco, Calabrò– Lucia, D. (ed.): *INTERNATIONAL SYMPOSIUM: New Metropolitan Perspectives:* Springer International Publishing, German, 676–685.

8 Masnavi, M. R – Gharai, F. – Hajibandeh, M. (2019): *Exploring urban resilience thinking for its application in urban planning: A review of literature. INT J ENVIRON SCI TE, 16,* 567–582. https://doi.org/10.1007/s13762-018-1860-2

9 Panahi, R. – Gargari, N. S. – Lau Y. – Ng A. K. (2022). *Developing a resilience assessment model for critical infrastructures: The case of port in tackling the impacts posed by the Covid-19 pandemic. OCEAN COAST MANAGE, 226,* 106240. https://doi.org/10.1016/j.ocecoaman.2022.106240

10 Shutters, S. T. – Muneepeerakul, R. – Lobo, J. (2015). *Quantifying urban economic resilience through labour force interdependence. Palgrave Communications, 1,* 1–7. https://doi.org/10.1057/palcomms.2015.10

11 Wang X. – Yao X. – Shao H. – Bai T. – Xu Y. – Tian G. – Fekete A. – Kollányi L. (2023). *Land Use Quality Assessment and Exploration of the Driving Forces Based on Location: A Case Study in Luohe City, China. Land, 12,* 1–17. https://doi.org/10.3390/land12010257

12 Cui X. – Yang S. – Zhang G. – Liang B. – Li F. (2020). *An Exploration of a Synthetic Construction Land Use Quality Evaluation Based on Economic-Social-Ecological Coupling Perspective: A Case Study in Major Chinese Cities. Int J Environ Health Res, 17*(10). https://doi.org/10.3390/ijerph17103663

13 Dong L. – Longwu L. – Zhenbo W. – Liangkan C. – Faming Z. (2021). *Exploration of coupling effects in the Economy–Society–Environment system in urban areas: Case study of the Yangtze River Delta Urban Agglomeration. Ecological Indicators, 128,* 107858. https://doi.org/10.1016/j.ecolind.2021.107858

14 Yang L. (2019). *Evaluating the urban land use plan with transit accessibility. SCS, 45,* 474–485. https://doi.org/10.1016/j.scs.2018.11.042

15 Ariken, M. – Zhang F. – weng Chan N. (2021). *Coupling coordination analysis and spatio-temporal heterogeneity between urbanization and eco-environment along the Silk Road Economic Belt in China. ECOL INDIC, 121,* 107014. https://doi.org/10.1016/j.ecolind.2020.107014

16 Lin Y. – Peng C. – Chen P. – Zhang M. (2022). *Conflict or synergy? Analysis of economic-social- infrastructure-ecological resilience and their coupling coordination in the Yangtze River economic Belt, China. ECOL INDIC, 142,* 109194. https://doi.org/10.1016/j.ecolind.2022.109194

17 Tian Y. – Zhou D. – Jiang G. (2020). *Conflict or Coordination? Multiscale assessment of the spatio-temporal coupling relationship between urbanization and ecosystem services: The case of the Jingjinji Region, China. ECOL INDIC, 117,* 106543. https://doi.org/10.1016/j.ecolind.2020.106543

18 Liu F. – Zhang Z. – Shi L. – Zhao X. – Xu J. – Yi L. – Liu B. – Wen Q. – Hu S., – Wang X. (2016). *Urban expansion in China and its spatial-temporal differences over the past four decades. J GEOGR SCI, 26,* 1477–1496. https://doi.org/10.1007/s11442-016-1339-3

19 Wang X. – Dong X. – Liu H. – Wei H. – Fan W. – Lu N. – Xu Z. – Ren J. – Xing K. (2017). *Linking land use change, ecosystem services and human well-being: A case study of the Manas River Basin of Xinjiang, China. ECOSYST SERV, 27,* 113–123. https://doi.org/10.1016/j.ecoser.2017.08.013

20 Cong X. (2019). *Expression and mathematical property of coupling model, and its misuse in geographical science. ECONOMIC GEOGRAPHY, 39*(4), 18–25.

21 Ermida, S. L. – Soares, P. – Mantas, V. – Göttsche, F. M. – Trigo, I. F. (2020). *Google earth engine open-source code for land surface temperature estimation from the landsat series. Remote Sensing, 12,* 1471. https://doi.org/10.3390/rs12091471

22 Li Z. – Yang X. M. – Meng F. – Chen X. – Yang F. S. (2017). *The Method of Multi-source Remote Sensing Synergy Extraction in Urban Built-up Area. Journal of Geo-Information Science, 19,* 1522. https://doi.org/10.3724/SP.J.1047.2017.01522

23 Wang X. – Kollányi L. – Shi Z. – Liu M. – Yang Y. (2022). *Study On Land Use Aggregation Pattern of Luohe City Based On Spatial Heterogeneity. Proceedings of the Fábos Conference on Landscape and Greenway Planning: Vol. 7: Iss. 1, Article 56.* https://doi.org/10.7275/oj3n-x734

24 LUO J. – ZHOU C. – LEUNG Y. – MA J. (2002). *Finite mixture model and its EM clustering algorithm for remote sensing data. Journal of Image and Graphic, 7,* 336–340. https://doi.org/10.11834/jig.200204119

25 Zhou L. – Dang X. – Sun Q. – Wang S. (2020). *Multi-scenario simulation of urban land change in Shanghai by random forest and CA-Markov model. SUSTAIN CITIES SOC, 55,* 102045. https://doi.org/10.1016/j.scs.2020.102045

26 SHENG Q. – YANG T. – HOU J. (2015). *Continuous Movement and Hyper-link Spatial Mechanisms——A Large-scale Space Syntax Analysis on Chongqing's Vehicle and Metro Flow Data. Journal of Human Settlements in West China, 30,* 16–21. https://doi.org/10.13791/j.cnki.hsfwest.20150503

27 Diakoulaki, D. – Mavrotas, G. – Papayannakis, L. (1995). *Determining objective weights in multiple criteria problems: The critic method. COMPUT OPER RES, 22,* 763–770. https://doi.org/10.1016/0305-0548(94)00059-h

ZÖLDFELÜLET-INTENZITÁS VÁLTOZÁSAI BUDAPEST XIV. KERÜLETÉBEN

CHANGES IN GREEN SPACE INTENSITY IN BUDAPEST'S 14TH DISTRICT

JOMBACH SÁNDOR | ÜSZTÖKE LAURA | YASEEN N. HASSAN

ABSZTRAKT

Kutatásunk a "Zöldfelület-Intenzitás" (ZFI) mutatót alkalmazta annak érdekében, hogy jellemezze Zugló, Budapest XIV. kerületének 1992 és 2020 közötti zöldfelület-változásait. A ZFI mutató az NDVI indexre (Normalizált Vegetiációs Index) épül, de az értékei orthofotóhoz igazítottak, és több nagyon nagy felbontású űrfelvétel felhasználásával ellenőrzöttek. A mutatót az elmúlt két évtizedben fejlesztettük, közismertté tettük, és gyakran került alkalmazásra magyarországi városok zöldfelületeinek elemzésére az elmúlt tíz év kutatásaiban. A zöldfelületek változásának elemzése egy döntés-támogató tevékenység a település-tervezésben és -fejlesztésben. Segít meghatározni a változások mozgatórugóit és a változások hatását a városklímára, a beépített és burkolt felületekre, a városi élővilág fajaira, a honos, az inváziós és a dísznövényfajok szerepére a városi zöldinfrastruktúrában. Városökológiai szempontból ez a kutatás jobb és fenntarthatóbb tervezési megoldások megválasztását is támogatja.

Kulcsszavak: zöldfelület, növekedés, csökkenés, fejlesztés, átalakulás, felhagyás, változás, változás-foltok

BEVEZETÉS ÉS HÁTTÉR

A zöldfelületek felmérésére és elemzésére használt módszerek egyike a zöldfelület-intenzitás (ZFI) számítása, amely űrfelvételek és légifelvételek kombinált feldolgozásával segíti a zöldfelület térképezését és térinformatikai elemzését, értékelését. A módszer kifejezetten térségi vagy települési szinteken történő hasznosításra került kifejlesztésre, de alkalmazható településrészek, sőt egyes tömbök zöldfelület-intenzitásának jellemzésére is.

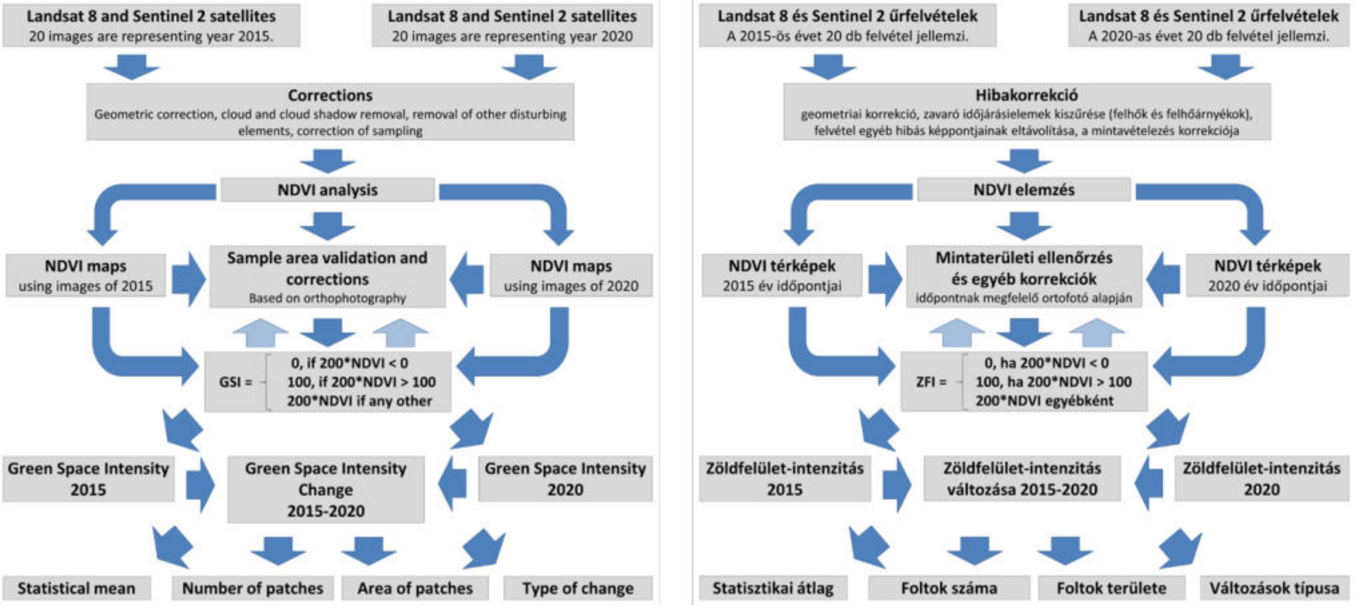
A ZFI módszer első változata 2006-ban a "Pro Verde" projektben [1] került alkalmazására, amely térinformatikai módszerekkel célozta meg a zöldfelületek térképezését, értékelését és monitorozási módszerének kidolgozását a főváros területére és annak várostervezési zónáira. A fővárosról és agglomerációjáról szóló zöldfelületi elemzési tanulmány – a projekt megalapozó tanulmánya [2], – elsőként használta az NDVI alapú úgynevezett "elméleti zöldfelület-számítási módszert".

A korábbi zöldfelület-térképezési és elemzési munkák számos tapasztalattal gazdagították a felmérést, térinformatikai és vizuális képértelmezési, képinterpretációs tevékenységükkel [3], vagy „zöldfelületi arány" és „biológiailag aktív felületek" kulcsszavak használatával [4] nyújtottak támpontokat az NDVI vegetációs index települési alkalmazásához. Az NDVI index a vegetáció felszínének biológiai aktivitását mutatja ki, ezért a módszerrel készülő publikációk 2006-ban és 2007-ben még a „zöldfelület biológiai aktivitása" címszóval kerültek nyomdába [5, 6, 7]. Mivel ezzel egy időben elkészült a területek biológiai aktivitásértékének számításáról szóló ÖTM rendelet [8], ezért a későbbiek során célszerűbbé vált egy ettől eltérő, ám a módszer lényegét is jobban visszaadó „zöldfelület-intenzitás" kulcsszó bevezetése és használata [9].

A zöldfelület-intenzitás (ZFI) elemzésének módszere számos tekintetben megújult, teszteken és mintaterületi

4D 67, 30–43. (2023)

DOI: HTTPS://DOI.ORG/10.36249/4D.67.4188



1. ábra/Fig. 1: Budapest XIV. kerülete és kerületrészei, tipikus madártávlati képekkel / *Budapest's 14th district and its sub-divisions with names and typical bird's eye-view images*
2. ábra/Fig. 2: Az űrfelvételektől a Zöldfelület-intenzitás területi statisztikai elemzéséig tartó adatfeldolgozási folyamat / *Data processing from satellite images to territorial statistic analysis of Green Space Intensity*

ABSTRACT

This research used the "Green Space Intensity" (GSI) index to describe the changes of green space within Zugló, Budapest's 14th district, from 1992 to 2020. The GSI index is based on the NDVI (Normalized Difference Vegetation Index), but the values have been revised and adjusted to high-resolution orthoimagery and validated by VHR satellite images. It has been developed over the last two decades, it is well known and has been used in the last ten years in research to analyse green spaces within the towns and cities of Hungary. Analysis of green space changes provides reasonable decision-support in urban planning and city development. It helps to define the drivers of change and the effects of changes on the urban climate, paved and built-up areas, the urban habitat of wildlife species and the role of endemic, invasive and ornamental plant species in the city's green infrastructure. From an urban ecology perspective, this research supports better and more sustainable planning and design solutions.

Keywords: green space, growth, decrease, development, transformation, abandonment, change, change patches

INTRODUCTION AND BACKGROUND

Green Space Intensity (GSI) is one of the methods used for green space survey and analysis. It is applied to help mapping, geospatial analysis and assessment of green space, by using satellite images and aerial photographs. The method is developed for regional or urban scales, but can be applied to characterise green infrastructure within districts or blocks.

The first applied version of the GSI method was used in 2006 in the "Pro Verde" project [1], which aimed to map, assess and develop the monitoring method for green

3. ábra/Fig. 3: Zöldfelület-intenzitás (ZFI) térképek és változás-térképek Budapest XIV. kerületéből / *Green Space Intensity (GSI) maps and Change maps for Budapest's 14th district*

ellenőrzéseken finomodott, visszajelzések alapján került felülvizsgálatra. A zöldfelület-intenzitás (ZFI) megmutatja, hogy mekkora az adott területrészre eső zöldfelület síkbeli kiterjedésének aránya és egészségi állapotának mértéke. A módszer alapján űrfelvételek és ortofotók feldolgozásával készített adatbázis a zöldfelület kiterjedéséről és állapotáról egyaránt szolgáltat információt azzal, hogy egy nullától száz százalékig terjedő skálán megmutatja, milyen arányú a zöldfelület intenzitása egy adott területen. Elsősorban települési szintű fejlesztési vagy tervezési munkák megalapozására, döntés-támogatásra, a zöldfelületek állapotának és változásának monitorozására kívánja a legtöbb felhasználó alkalmazni. A felhasználási példák között szerepel a rekreációs igények kiszolgálása is [10].

ANYAG ÉS MÓDSZER

A kutatás a Zöldfelület-intenzitás (ZFI) és a Zöldfelület-intenzitás változásának térbeli elemzésén alapult. Az elemzéshez mind a 2015-ös, mind a 2020-as év jellemzésére 20-20 űrfelvételt használtunk fel (Landsat 8 és Sentinel 2 felvételek), továbbá felhasználtuk korábbi kutatások 8-8 felvételre (Landsat 4, 5, 8) épülő elemzési eredményeit 1992 és 2015 közötti időszakból. A Zöldfelület-intenzitás (ZFI) meghatározásához alapvetően a 2011-ben Jombach által publikált módszert alkalmaztuk [11]. A módszer a vegetáció biológiai aktivitásának kimutatására használt NDVI indexre épül [12], de azt mintaterületi tesztek során jelentősen átalakítja. A "Zöldfelület-intenzitás" (ZFI) a vegetáció jelenlétének és egészségi állapotának egyesített indikátora, amely százalékos értékeivel (0-100%-ig) egyetlen számértékkel mutatja meg milyen területi aránnyal és milyen vitalitással bír a növényzet egy adott területrészen. Kutatásunk fókuszterülete Budapest XIV. kerülete, amely a főváros átmeneti zónájában található, de sok kertvárosi területe, kertes családi házas övezete, zöldterülete és barnamezős területe is van. A kerületet hivatalosan nyolc kerületrészre bontja a kerületi szabályozás (1. Ábra).

A ZFI változás-elemzések 1992, 2005, 2010, 2015 évekre készültek kizárólag a 30 méteres térbeli felbontású Landsat felvételek felhasználásával [13] [14]. A jelenlegi kutatás többnyire 10 méteres felbontású Sentinel felvételeket használt fel, és a 2015-ös évet tekintette bázis évnek [15]. A feldolgozási folyamat lépéseit a 2. ábra szemlélteti. A módszer korlátja, hogy a vertikális zöldfelületeket (pl. zöldfalakat, zöld homlokzatokat) jelentőségüknél alacsonyabb igényességgel dokumentálja. Mindemellett a cikk nem terjed ki az összes lehetséges területhasználat-változásra.

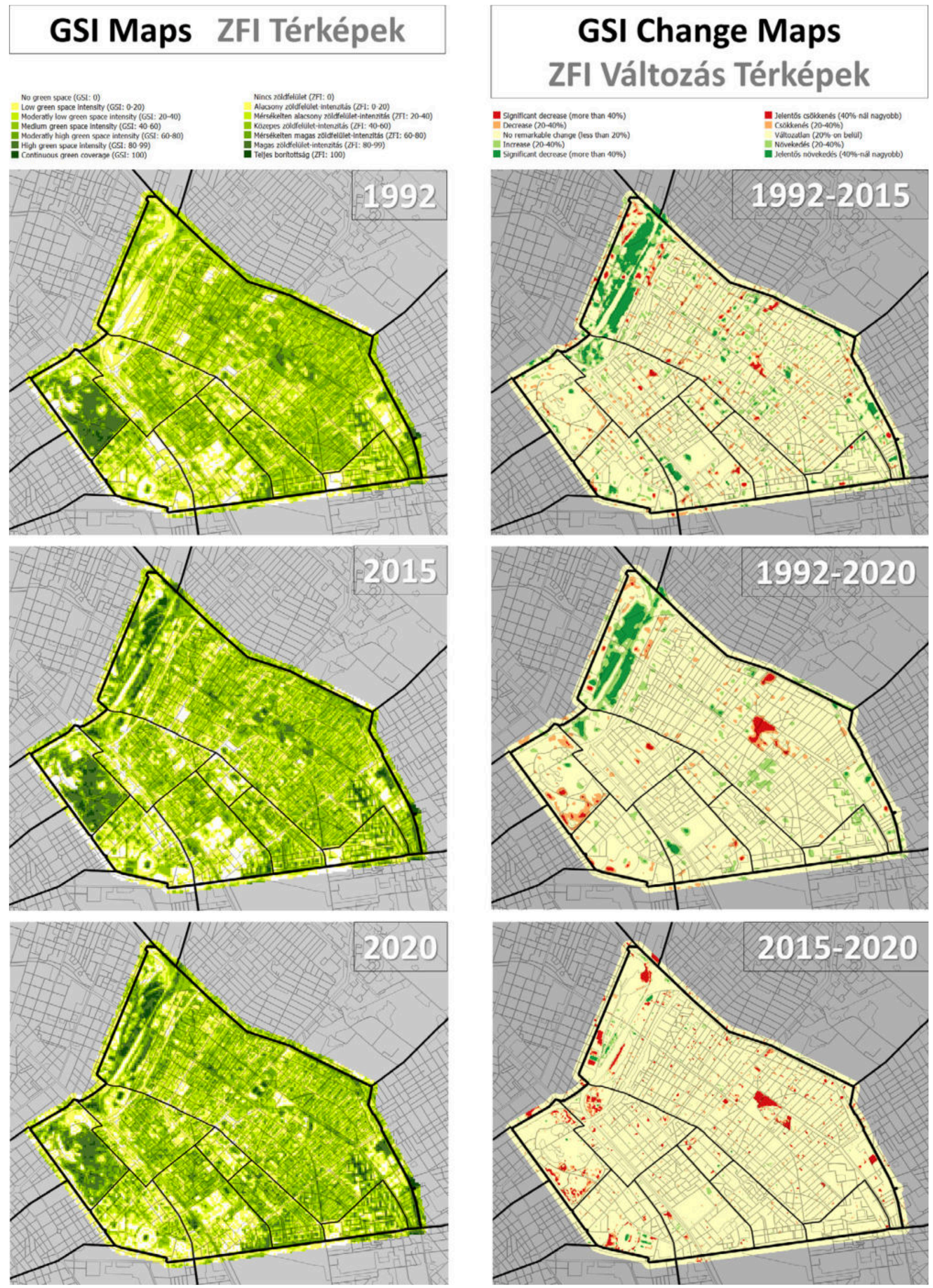
Az elemzés során a következő mutatókat vettük figyelembe:

- **Zöldfelület-intenzitás (ZFI) értékek statisztikai átlaga** (a zöldfelület-intenzitás értékek átlagértéke)
- **ZFI változás statisztikai átlaga** (a zöldfelület-intenzitás változásának átlagértéke)
- **A ZFI változás-foltok száma** (a 20%-os mértéket meghaladó változás-foltok száma)
- **A ZFI változás-foltok területe** (a 20%-os mértéket meghaladó változás-foltok területe)
- **A ZFI növekedés-foltok száma** (a 20%-os mértéket meghaladó növekedés-foltok száma)
- **A ZFI csökkenés-foltok száma** (a 20%-os mértéket meghaladó csökkenés-foltok száma)
- **A ZFI) növekedés-foltok területe** (a 20%-os mértéket meghaladó növekedés-foltok területe)
- **A ZFI csökkenés-foltok területe** (a 20%-os mértéket meghaladó csökkenés-foltok területe)
- **A változást kiváltó jelenség típusa** (A használat, kezelés megváltozásából következtethető)

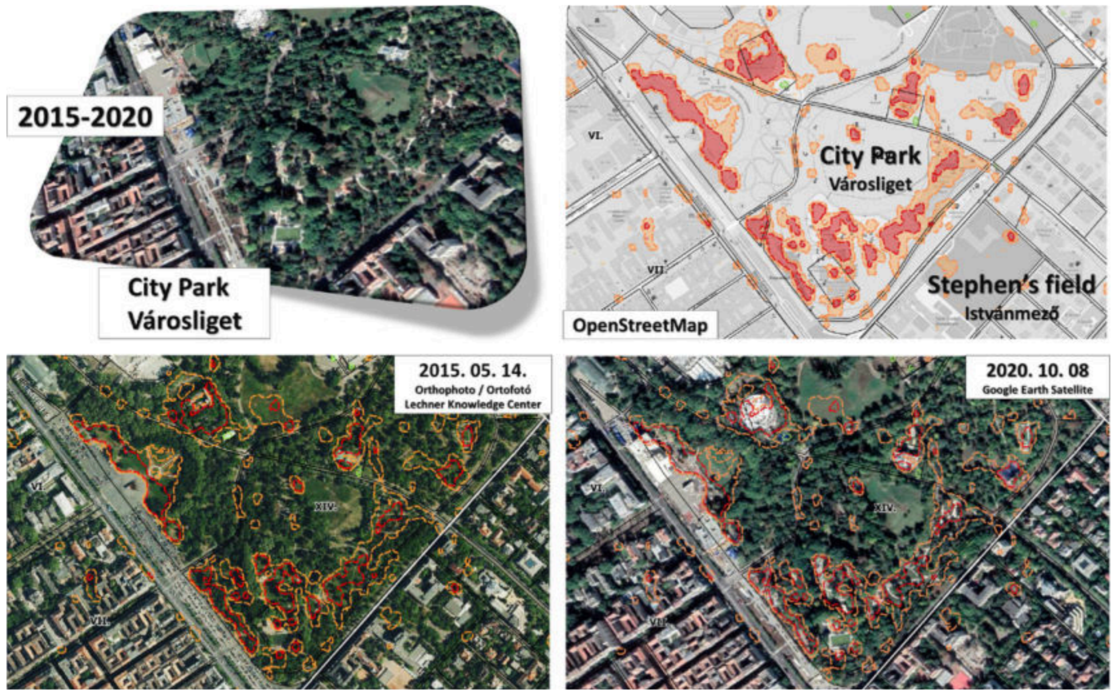
EREDMÉNYEK

A Zöldfelület-intenzitás (ZFI) változásának átlaga egy statisztikai számérték, ami megmutatja a változás-értékek átlagát, amit egy konkrét időszakban a felvételek alapján érzékeltünk. Ez a típusú elemzés a kerületben azt mutatta, hogy a ZFI 3%-kal növekedett (34%-ról 37%-ra) az 1992-2020 időszakban. A 28 évet tekintve ez a negyedik legmagasabb érték a főváros 23 kerülete közül. A 2015-2020 időszakban a ZFI változása azonban épp ellenkező tendenciát mutat. A zöldfelület-intenzitás 3,1%-kal csökkent. A puszta statisztikai értékek alapján azt mondhatnánk hogy 28 év alatt összességében inkább növekedés történt, de a vizsgált időszak utolsó öt éve inkább erőteljes csökkenést hozott a zöldfelület-intenzitásban.

A kerületrészeket figyelembe véve a legmagasabb ZFI-változás Alsórákoson történt (átlag: +8,4%) 28 év alatt, köszönhetően a Rákosrendező vasútállomás felhagyott területein a növényzet spontán növekedésének. A legalacsonyabb változásérték a Városliget városrészben volt (átlag 1992 és 2020 között: –5,7%) köszönhetően azoknak az építési munkálatoknak (4. ábra), amelyek az utolsó öt évben történtek (2015-2020 átlagos változása itt: –6,5%). Az egész kerületet és a kerületrészeket is tekintve a két időszak összehasonlításából is az 2015-2020 időszak a



4. ábra/Fig. 4: Változások a Városligetben a park átalakításának időszakában / *Changes in City Park due to park reconstruction*



kedvezőtleneb zöldfelület-intenzitás vonatkozásában. Ez a térképeken is tisztán látható (3. ábra).

A változás átaga – mint mutató – a térbeli elemzés során kevésbé tűnt relevánsnak, mint a változás-foltok száma és területe. "Változás-foltoknak" azokat a sokszöggel lehatárolható foltokat tekintettük, ahol a ZFI 20%-nál nagyobb növekedést vagy csökkenést jelzett. A továbbiakban a területi elemzések a 20%-nál nagyobb mértékű "változás-foltokra" koncentráltak. A legkisebb méretű "változás-foltot" úgy lehet elképzelni mint egy nagyobb lombkoronájú fa kivágását, vagy egy intenzív zöldtető telepítését egy családi ház tetején (5. ábra).

A 2020-as év összevetése az 1992-es évvel azt mutatja, hogy a változás-foltok területe 2,37 km^2 volt, ami a kerület 13,1%-a. Amennyiben a 2020-as évet a 2015-ös évvel hasonlítjuk össze a változás-foltokkal érintett terület 1,17 km^2, ami a kerület 6,5%-a. A változás-foltok száma 994 volt az 1992-2015 időszakban, de a 2015-2020 időszakban már 2052 darabot ért el. Ez a növekedés lehet a jele az apróbb területű változások szaporodásának is, de részben a 2015 utáni képek nagyobb felbontásának köszönhető (Sentinel műhold, 10 m-es felbontással).

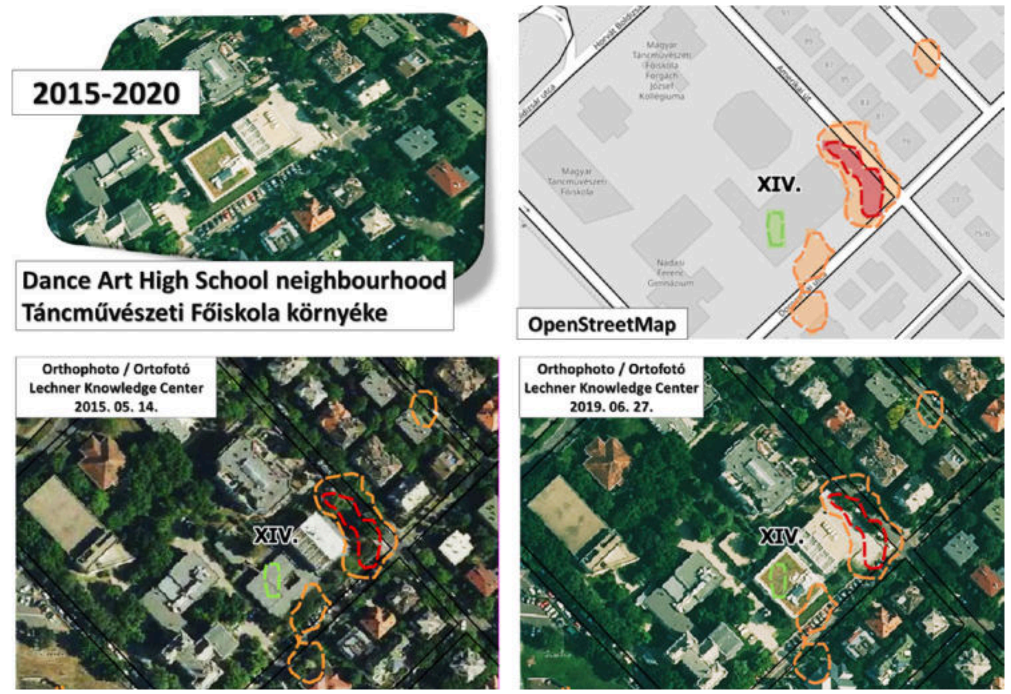
Az eredmények azt mutatják, hogy az időről-időre készülő változás-elemzések változás-foltjai átfednek egymással. Ez azt jelenti, hogy néhány terület, ami a zöldfelület csökkenését mutatta 1992-2015 időszakban, lehetséges, hogy a 2015-2020 időszakban már növekedést mutat és más területeken hasonló dolog történhet épp fordított irányban. Megjegyzendő, hogy a felhagyott Rákosrendező vasútállomás jelentős területét teszi ki az összes változás-foltnak valamennyi időszakban (12%-tól 30%-ig). Ez azt jelzi, hogy a korábbi vasútállomás és környezete kifejezetten "változásra hajlamos" része a kerületnek (6. ábra).

A 2015-2020 közötti változás-foltok átlagos kiterjedése 0,057 hektár (570 m^2), és a legnagyobb foltok Alsórákos és Herminamező kerületrészekben találhatók (6,6 hektáros területtel). A legjelentősebb változás Alsórákoson történt, ahol a Paskál lakóparkok épültek fel (9. ábra). Itt egy öt hektáros területű folt majdnem teljesen elveszítette zöldfelület-intenzitását 2020-ra.

A 2015-2020 közötti csökkenés-foltok száma (1521) majdnem háromszor akkora, mint a növekedés-foltok száma (531), míg a korábbi 23 év alatt ez a két szám nagyjából egyenlő volt (474 és 520). Ez azt jelenti, hogy az utolsó öt évben háromszor több csökkenés-folt keletkezett, mint növekedés-folt. Amennyiben a változás-foltok kiterjedését nézzük meg a 2015-2020 időszakra a mérleg még rosszabb. A csökkenés-foltok területe ötször nagyobb (0,99 km^2), mint a növekedés-foltok területe (0,19 km^2).

A 2015-2020 közötti időszakban Istvánmező kerületrésznek volt a legnagyobb területi arányú növekedés-foltja a kerületrész összterületéhez viszonyítva (2,1%). A növekedés 45 foltban történt meg, főként a a Puskás Ferenc Stadion környékén, ahol 2015-ben az átépítés már elkezdődött, és 2020 nyarára már majdnem teljesen kész állapotba került az új zöldfelületek egy része tekintetében (7. Ábra) Ugyanakkor a 2015-2020 időszakban a csökkenő változás-foltok területe a Városligetben elérte a kerületrész

5. ábra/Fig. 5: A változás-foltok példái fakivágás és zöldtető-építés esetén / *Examples of change patches for tree felling and green roof construction*



space in Hungary's capital city. The preliminary study of the project [2] about Budapest and its agglomeration used the so-called "theoretical green space" calculation method based on NDVI values.

Previous green space mapping studies supported this research with numerous lessons learned, either through GIS application and visual interpretation activity [3] or using the keywords of "green space ratio" and "biologically active areas" [4], prompting researchers to adapt the NDVI to urban green space analysis. The NDVI and the method developed on the basis of NDVI show the biological activity of the green coverage. Accordingly, the publications of 2006 and 2007 used the term "biological activity of green space" [5, 6, 7]. At the same time, a ministerial decree [8] announced the "biological activity value" calculation method, and it then became more appropriate to introduce and use the term "Green Space Intensity" for satellite image-based green space mapping and calculations [9].

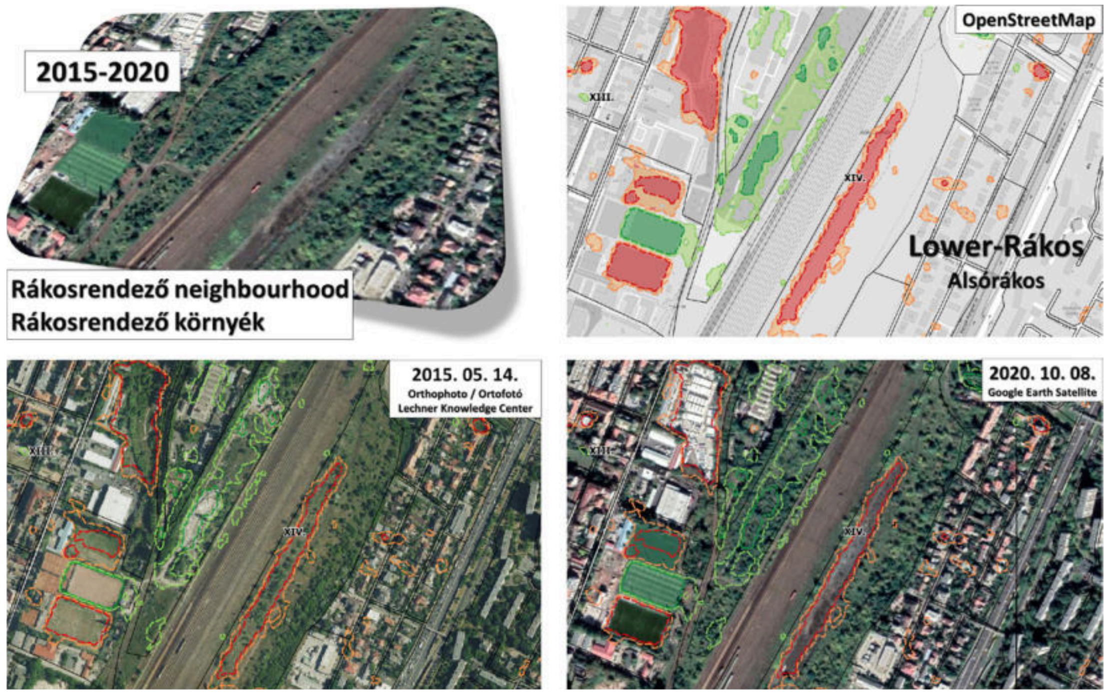
The Green Space Intensity (GSI) method has been developed and revised through sample area validations, tests and feedback. UAs an index, GSI shows the spatial ratio and health of vegetation within territorial units. The database generated from satellite images and orthophotos provides information about the territory and the vital condition of vegetation with one combined value. It ranges from zero to one hundred, and shows the intensity of the green space within the analysed territory. The method is generally used for decision-support regarding urban development plans, as a tool for green space analysis and mapping, change mapping and spatial assessment of green spaces e.g. serving recreational needs [10].

MATERIALS AND METHODS

The research is based on the spatial analysis of Green Space Intensity (GSI) and the change in Green Space Intensity. The analysis used 20 satellite images (Landsat 8 and Sentinel 2) from 2015 and 2020, and it used the data and the results of the previous studies, which were using eight Landsat images (Landsat 4, 5 and 8) from the years 1992 and 2015. In order to define GSI, we used the method published by Jombach in 2011 [11]. The method is based on NDVI [12], which is widely used to indicate the biological activity of vegetation, but is revised through sample area tests. Green Space Intensity is a combined indicator of the presence and the health of vegetation. It shows the ratio and vitality of vegetation with one single value (ranging from 0 to 100%). The study focuses on Budapest's 14^{th} district, which is in the capital's transitional zone, but it has many garden city areas, family houses with gardens, green areas and brownfield sites. The district is officially divided into eight sub-divisions (Figure 1).

The GSI change analysis was conducted for the years 1992, 2005, 2010 and 2015, using only Landsat images with 30 m spatial resolution [13] [14]. In the current study, we used Sentinel images with 10m resolution and considered 2015 as a base year [15]. The data processing steps are shown in Figure 2. The limitation of the method is that vertical green surfaces (green walls, green facades) cannot

6. ábra/Fig. 6: Rákosrendező vasútállomás: A változékony környék / *A change-prone neighbourhood: Rákosrendező railway station*



11,8%-át. A legtöbb változás a középső, a déli és az északi részein történt. A növekedés-foltok (20% feletti ZFI növekedés) összesen egy hektárt értintettek, míg a csökkenés-folttal érintett területek (20% feletti ZFI-csökkenés) majdnem 16 hektárt is elértek 2020-ig (4. Ábra).

Az átalakulás alatt álló területek általában veszélyeztetik a szomszédos területek zöldfelületeit is, köszönhetően annak, hogy munkaterületként funkcionálnak. Még akkor is, ha a fejlesztési munkálatok célja, hogy végeredményben növeljék a zöldfelületet, az építési munkálatok befejezése után közvetlenül általában csökken a zöldfelület nemcsak a területen belül, hanem a környező területeken is (6. ábra). A zöldfelület növekedése csak nagyon kis számú befejezett projekt esetében figyelhető meg azonnal. A zöldfelület-intenzitás növekedését csak akkor lehet tapasztalni és dokumentálni, amennyiben a növényzetnek időt adunk, és éveken át gondját viseljük. Felmerül a kérdés, hogy mit jelent az "éveken át"? A gyepek és gyomos zöldfelületek esetében lehet akár csak egy-két év, de fák esetében általában több mint öt évre van szükség, amíg a lombkorona növekedése érzékelhető az ültetést követően. Jelentős növekedés pedig általában 10 év után következik be, de ez sok tényezőtől függ (faj, helyi adottságok, fenntartás stb.).

A zöldfelület-intenzitást növelő "projektek" némelyike barnamezős beruházásból induló megújulás, mint a Dorozsmai utcai példa, ahol korábbi ipari terület alakult át két évtized alatt apartmanházas lakóterületté (Levendula Apartman) és kapcsolódó zöldfelületeivé. Hasonló történt a Zöldváros Lakópark és a Porcelán Lakópark területén. A Levendula Apartman zöldfelületei kicsik ugyan, de legalább nagyobbnak nevezhetők, mint korábban (8. árba). Sok esetben elmondható, hogy – amíg az építkezési lendület alábbhagyott 2008 táján – a növényzet elfoglalta a területek egy részét, és adódhatott volna lehetőség arra is, hogy az ilyen területeken közcélú, minőségi zöldterület-fejlesztés induljon el, de nem volt elég erőteljes helyi érdek és szándék a zöldfelületek fejlesztésére. Szerencsére a közelben egy óvoda és egy irodaház is zöldtetővel rendelkezik – összesen 2250 m^2 területen. A zöldtető majdnem fele a 2015-2020 időszakban készült el, de mindkettő használata korlátozott.

Sajnálatosan több és nagyobb területen történt zöldmezős beruházás a kerületben. Ezek többnyire olyan beépítetlen zöldfelületeken valósultak meg, amelyek jó közlekedési kapcsolatokkal rendelkeznek, és például a Rákos-patak és a Paskál Termálfürdő vonzó környezetéhez tartoztak. Zöldinfrastruktúra-fejlesztési szempontból sajnálatos, hogy ezek a lakónegyedek az utolsó hektárnyi zöldfelületeket élik fel a kerület egyetlen kisvízfolyása mellett, aminek a legerősebbek a kapcsolatai a főváros ökológiai hálózatához. Ezek a zöldfelületek rendelkeznek a legnagyobb pontenciállal, hogy jó minőségű multifunkciós zöldfelületté fejlesszük őket. A legtöbb adódó lehetőséget már elszalasztottuk, és csupán néhány ilyen maradt meg.

A lakópark típusú lakóterületi fejlesztések több, mint 20 hektárnyi területet értek el a vizsgált 28 évben. A legjelentősebb példák ezek közül a Hermina Lakópark, a

7. ábra/Fig. 7: Sok változás-folt, kis nyereség a Puskás stadion környékén / *Many change patches, limited gain of green spaces around Puskás Stadium*

be mapped with the same significance as these surfaces appear in the cityscape. Of course, the type of change does not cover all possible land use change options.

In the analysis, we considered and used the following metrics to obtain results:

- **Satistical mean of Green Space Intensity (GSI)** (Average value of Green Space Intensity)
- **Statistical mean of GSI change** (Average of change values)
- **Number of GSI change patches** (Number of polygons with more than 20% GSI change)
- **Area of GSI change patches** (Area of polygons with more than 20% GSI change)
- **Number of patches with GSI increase** (Number of polygons with more than 20% GSI growth)
- **Number of patches with GSI decrease** (Number of polygons with more than 20% GSI loss)
- **Area of patches with GSI increase** (Area of polygons with more than 20% GSI growth)
- **Area of patches with GSI decrease** (Area of polygons with more than 20% GSI loss)
- **Type of phenomenon causing GSI change** (Based on the change in land use, maintenance)

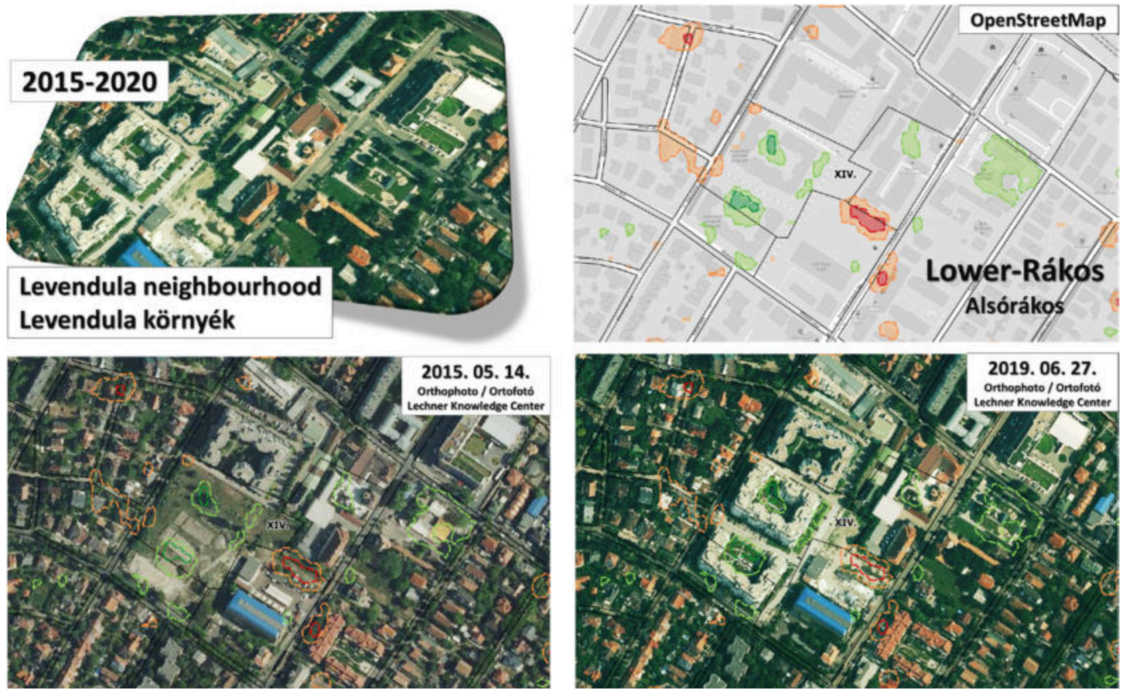
RESULTS

The mean value of Green Space Intensity (GSI) changes is a statistical value that shows the **average of all GSI changes** detected over a given time period. This analysis shows that Green Space Intensity grew by 3% (from 34% to 37%) in the 14^{th} district in the 1992-2020 period. This is the fourth best value among Budapest's 23 districts over the 28 years. In the 2015-2020 period, the GSI change mean value trended in quite the opposite direction. Green Space Intensity decreased by 3.1%. These numbers show that the mean of 28 years of change was mostly growth, but the last five of these 28 years predominantly registered a decrease in the mean GSI value.

Looking at **district areas,** the highest GSI change was in Lower Rákos (mean value: +8.4%) over 28 years, thanks to spontaneous vegetation growth in the abandoned railway station of Rákosrendező. The lowest change value in 28 years was in the City Park (mean value of 1992-2020: –5.7%), due to the construction works (Figure 4.) that occurred mostly in the last five years before 2020 (mean value reaching –6.5% in 2015-2020). Comparing the 1992-2020 period as a whole to 2015-2020, we can see that the latter certainly fared worse in terms of the GSI change for the whole district. This is shown in the maps (Figure 3.).

As an indicator, the statistical average (mean) seemed to have less relevance in the spatial analysis than the **area and number of change patches.** Change patches were considered the "polygons with changes of more than **20%**", either an increase or decrease. The following analysis focuses on the territorial analysis of these change spots. The smallest "change patch" (more than 20%) can be explained or visualised as a big tree being felled or the development of an intensive green roof on the rooftop of a family house (Figure 5).

8. ábra/Fig. 8: Lakópark-fejlesztés az egykori barnamezős területen a Dorozsmai utcában / *Development of a housing estate on a former brownfield site in Dorozsmai street*



Paskál Lakópark és a Cordia Thermal Lakópark (9. Ábra). Az elmúlt években bejelentett "Zugló Városközpont" egy több, mint 6,5 hektáros fejlesztési terület. Jelenleg a terület "zöldfelület", és a beruházás a kerület új lakóterületi és irodaházas központjaként került beharangozásra sétálóutcával, szokatlanul magas épületekkel. Ezzel a fejlesztéssel a kerület elveszíti a lehetőséget, hogy növelje a zöldfelület-intenzitást a központi kerületrészen.

A változás-foltokat 24 típusba soroltuk annak megfelelően, hogy milyen jelenség váltotta ki a zöldfelület-intenzitás változását. Az osztályozás a területhasználat-változásának, fejlesztésnek, esetleg felhagyásnak, vagy a zöldfelület használatában vagy kezelésében bekövetkezett változásnak megfelelően történt. A típusokat fényképes példákon keresztül sikerült összefoglalni és illusztrálni (1. és 2. táblázat). A leggyakoribb növekedés-típusok közé tartoztak a terület használatának felhagyása következtében fellépő spontán növekedés és a fák lombkoronájának növekedése. Előbbiek érintették a legnagyobb területet is, különösen az 1992-2015 és az 1992-2020 időszakban. A legkevesebb foltban a zöldtető-létesítése és a sportpályák új gyepterülete jelent meg a kerületben.

Az intenzitás-csökkenés foltjai közül a leggyakoribbak a parkolók létesítéséhez tartoztak. Sok kisebb foltban, sok helyen jelentek meg a kerületben közterületen is, de leginkább intézményi vagy magántulajdonban lévő telkeken belül. A legnagyobb kiterjedésű csökkenés-területet a zöldmezős lakóterületi beruházások és az összefüggő fás zöldfelületek megszűnése (kivágása) jelentette.

ÖSSZEFOGLALÁS

A kutatás célja az volt, hogy a nagy változási mértéket mutató XIV. kerületben úgy elemezzük a zöldfelület-intenzitás változásait, hogy meghatározzuk:

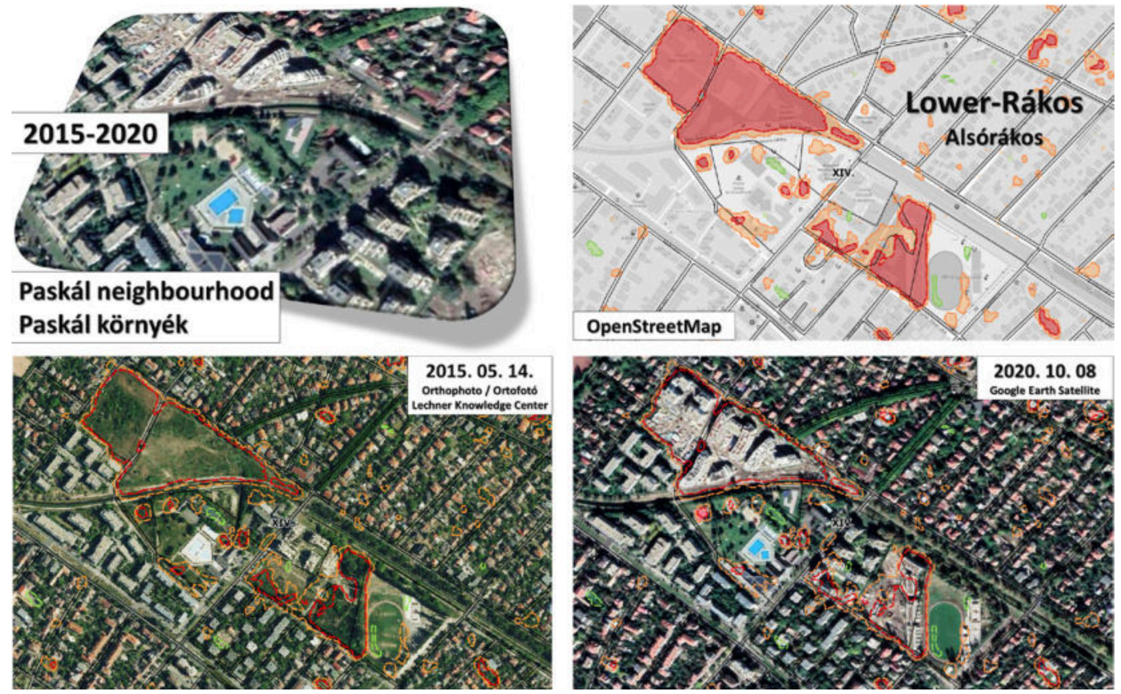
- a változás domináns irányát (statisztikai és területi statisztikai módszerekkel),
- a változások térbeli sajátosságait (a változás-foltok számának és területének felhasználásával),
- a változások jellegét (egyedi, használatra épülő tipizálással).

A kutatás eredményei két csoportban foglalhatók össze. A módszertani következtetések az eredményeket technikai szempontból mutatják be, a zöldfelület-intenzitás változásából fakadó következtetések a térképezési eredményeket a kerületi zöldinfrastruktúra-fejlesztés szempontjából értelmezik.

Módszertani eredmények és következtetések:

- A változás-foltok száma és területe gondosabban mutatja be a változások sajátosságait, mint a pusztán az átlaggal jellemzett zöldfelület-intenzitás értékek.
- A változások típusa több tanulsággal szolgál a tervezőknek és a beruházóknak, mint a zöldfelület-intenzitás változásának (GSI) összegzett statisztikai jellemzése egyetlen számértékkel.
- Az űrfelvételek felbontásának növekedése több megfigyelhető változási foltot ad, ezért a foltok száma magasabb a 10 méteres felbontású elemzésnél,

9. ábra/Fig. 9: Zöldmezős beruházás a Paskál Thermál Fürdő környéki lakóparkok építésekor / *Greenfield investment of housing estates in the Paskál Thermal Spa neighbourhood*



The results for 2020 compared to 1992 show that the **area of change patches** was 2.37 km², around **13.1% of the district.** If we compare **2020 to 2015,** the territory affected by change was 1.17 km², approximately **6.5% of the district.** There were 994 change patches in the 1992-2015 period, but 2,052 polygons in the 2015-2020 period. This increase could also be a sign of more small changes in the last few years, but is partly the result of higher resolution images after 2015 (Sentinel satellite, 10 m spatial resolution).

The analysis shows that some of the change patches **overlap** with each other from time to time. This means that some areas that saw a decrease in greenery from 1992 to 2015 then saw an increase in the following period (2015-2020), and vice versa. It is remarkable that the area around the **abandoned railway station of Rákosrendező** accounts for a significant ratio in area terms of all the change patches (from 12% to 30%) in each time period. This means that the former railway station and its surroundings are a particularly"change-prone" part of the district (Figure 6).

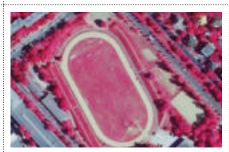
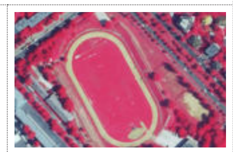
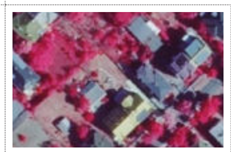
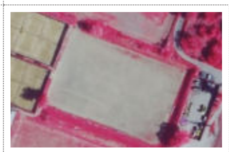
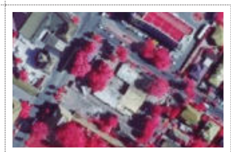
The mean area of change patches in the 2015-2020 period was 0.057 hectares (570 m2), and the **biggest change patches** are found in the Lower-Rákos and Hermina-field sub-districts (covering a size of 6.6 hectares). **The most intensive decrease** occurred in Lower-Rákos, where the Paskál residential area was under construction (Figure 9). Here, a patch covering five hectares lost almost the entirety of its Green Space Intensity.

The **number** of land patches with a decreasing GSI (1,521) were almost three times higher than the number with an increasing GSI (531) in the 2015-2020 period, while in the previous 23 years, these numbers were approximately equal (474 and 520). This means that in the last five years, there were three times as many sites recording a decrease than an increase. If we compare the **territory** covered by change patches in the 2015-2020 period, the situation is even worse. The land area with falling GSI was five times bigger (0.99 km²) than the area with rising GSI (0.19 km²).

In 2015-2020, the **Stephen's field** district part had the highest ratio of positive change patches as a percentage (2.1%) of the sub-division's area. Growth occurred in 45 patches mostly dominated by the neighbourhood of the **Puskás Ferenc Stadium,** which was under construction in 2015 and was almost complete with new green areas by 2020. (Figure 7) At the same time, in 2015-2020, the area of negative change patches reached 11.8% of the territory covered by the **City Park.** The most changes occurred in the central, southern and northern parts of the City Park. The area of patches affected by an increase in GSI (more than 20%) was approximately one hectare, and the area affected by a decrease in GSI (more than 20%) within the park totalled almost 16 hectares up to 2020 (Figure 4).

Sites under tansformation usually endanger the neighbouring area's green spaces, owing to the fact that they are used as work areas. Even if the development project is intended to increase the area of green spaces, the construction works usually ruin the green space not just within the sites but in the neighbourhood more generally

1. táblázat/Table 1: Zöldfelület-intenzitás növekedés-típusok a XIV. kerületben / *Types of growth in Green Space Intensity in the 14th District*
A KÉPEK FORRÁSA: ORTOFOTÓ, LECHNER TUDÁSKÖZPONT / *IMAGE SOURCE: LECHNER KNOWLEDGE CENTRE*

Zöldfelület-intenzitás növekedését kiváltó jelenségek / Phenomena causing growth in Green Space Intensity		**Zöldfelület-intenzitás növekedését kiváltó jelenségek / Phenomena causing growth in Green Space Intensity**		**Zöldfelület-intenzitás növekedését kiváltó jelenségek / Phenomena causing growth in Green Space Intensity**	
Korábban / *Earlier* (2015)	**Később / *Later* (2019)**	**Korábban / *Earlier* (2015)**	**Később / *Later* (2019)**	**Korábban / *Earlier* (2015)**	**Később / *Later* (2019)**
1. Lombkorona növekedése / *Canopy growth*		2. Épület-bontás / *Building demolition*		3. Terület-használat felhagyása / *Land abandonment*	
					
4. Bolygatott terület spontán gyepesedése gyomosodása / *Spontaneous grass and weed growth on disturbed area*		5. Zöldfelület minőségi javulása / *Improvement of green space quality*		6. Zöldfelület minőségi javulása lakóterületen / *Improvement of green space quality in residential areas*	
					
7. Közhasználatú zöldfelület megújítás / *Renewal of public green space*		8. Sportpálya gyepesítése (kép forrása: Google Earth, 2020) / *Lawn installation on sports fields (image source: Google Earth, 2020)*		9. Zöldtető létrehozása / *Creation of a green roof*	
					

mint a 30 méteres felbontású elemzés esetén. Ezért a foltok számának növekedéséből nem feltétlenül kell következtetést levonni. A növekedés- és csökkenés-foltok egymáshoz viszonyított arányából azonban már indokolt és lehetséges is érdekes tanulságokat levonni.

A zöldfelület-intenzitás változásához kapcsolódó következtetések:

- Eltekintve az elhagyatott Rákosrendező pályaudvar területétől – ami spontán gyomosodást, cserjésedést, erdősülést produkált, és ezáltal alacsony minőségű zöldfelületeket hozott inváziós fajokkal – **mindkét vizsgált időszakban** (1992-2015 és 2015-2020) **zöldfelület-intenzitás csökkenés** történt. Ezt a területi statisztika eszközeivel és a változás-foltok területével is igazoltuk.
- A zöldfelület-intenzitás **csökkenés-foltok számaránya** az összes változási folt között jóval **magasabb** volt a 2015 és 2020 közötti években, mint az 1992-2015 közötti időszakban. A 2020-ig tartó időszakban a **csökkenés-foltok területe is nagyobb,** mint a növekedés-foltok területe. Ez azt jelenti, hogy az utolsó vizsgált öt évben a kerületben a korábbinál intenzívebb és egyértelműbb zöldfelület-intenzitás-csökkenés volt tapasztalható, mint korábban.
- A **változások típusai** azt mutatják, hogy a változásokat nagymértékben meghatározza a zöldfelület-használat, továbbá befolyásolja az erős **beruházási potenciál és a zöldfelületek alkalmassága** a lakossági vagy közlekedési fejlesztések kiszolgálására. A zöldmezős beruházások esetében nagy a kockázata a zöldfelület-intenzitás csökkenésének, de a barnamezős beruházásoknál van lehetőség a zöldfelület-intenzitás növelésére. ⦿

(Figure 6). Only a very limited number of completed projects show an immediate increase in green space. This is especially true since growth in Green Space Intensity can only occur and be documented if vegetation is allowed to grow or is specially taken care of for many years. The following question may therefore arise: What does "many" years mean? In the case of grassy or even weedy vegetation, it may be only one or two years, but in the case of trees, it usually takes more than five years until canopy growth can be detected after plantation. Significant growth usually comes after ten years, but it depends on many factors (species, local conditions, maintenance etc.).

Some of the **"projects" aimed at increasing GSI** may be brownfield regeneration projects, as is the case with Dorozsmai street where a former industrial site was transformed over two decades into a residential site comprising apartment buildings (Levendula Apartments) and related green sites. A similar process occurred in the Zöldváros and Porcelán housing estates over a longer period. The green spaces in and around Levendula Apartments are small, but they are at least bigger than before (Figure 8). In many cases, we could mention that vegetation took over the sites when construction work stopped around 2008, and quality green areas could have been developed for public use, but there was not sufficiently strong local interest or will to enhance green spaces. Luckily, a kindergarten and an office building nearby have green roofs covering an area of 2,250 m^2. Almost half of this was completed in the 2015-2020 period, but its use is restricted.

Unfortunately, there are more and larger examples of greenfield investments in the district. These mostly used open green spaces in the district close to good transport links and the appealing Rákos Creek and Paskál Thermal Spa neighbourhood. Sadly, in terms of urban green infrastructure development, these residential areas occupy the last remaining hectares of green spaces along the only watercourse in the district, which has the strongest links to the capital's ecological network. These green spaces have the strongest potential in the district to be developed into a multifunctional and high-quality green area. Most of these opportunities have been missed, and only a few remain.

The "housing estate" model of residential investments covered more than 20 hectares in the 28 years analysed. The most significant examples are the Hermina, Paskál and Cordia Thermal housing estates (Figure 9.). The "Zugló City Centre" development site, announced recently, covers more than 6.5 hectares. The land was previously "greenfield" site, at present it is a construction site, and the investment has been heralded as the district's new residential and office centre, with a pedestrianised area and unusually high buildings. With this development, the district will lose the opportunity to increase Green Space Intensity in its centre.

We classified the change patches into 24 types. The classification was based on the phenomena that caused the changes. These are related to land use changes due to development or abandonment, or to the change in the use or the maintenance of the green space. A summary and illustration of change types using orthophotos are provided in table 1 and table 2. The most frequent types of increase were spontaneous green growth due to the abandonment of areas and tree canopy growth. The abandonment type affected the largest areas in particular in the 1992-2015 and 1992-2020 periods. Growth changes relating to green roofs and sports fields appeared in the lowest number in the district.

Development of parking lots was the most frequent cause of a decrease in GSI. These appeared in many patches in various locations in public spaces, but particularly on private or institutional plots. The biggest area to register a decrease was affected by greenfield investments for residential use (housing estate development), and the felling of woodland.

SUMMARY

The **goal** of the research was to analyse the changes in Green Space Intensity based on satellite images in Zugló, Budapest's 14th district, and the areas making up the district. Specifically, this means that the **objectives** were:

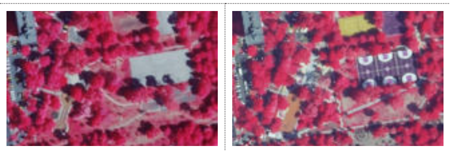
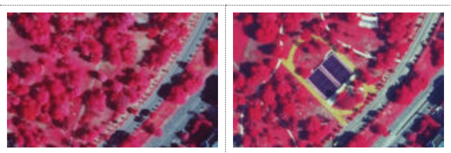
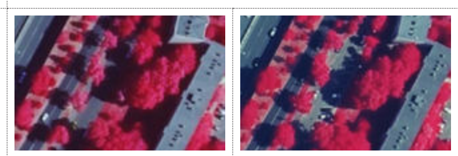
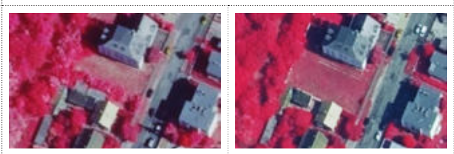
- to determine the dominant direction of change (using statistical and territorial statistical methods)
- to describe the spatial characteristics of changes (by number and by territory of change patches)
- to categorise the changes in types (using a special classification by use of the area).

The results of the study can be summed up in two groups. The methodological conclusions show the results from a technical viewpoint, and the Green Space Intensity conclusions interpret the green infrastructure development of the district.

Methodological results and conclusions:

- The number and area of patches give more insight into the nature of changes than simply the mean of the Green Space Intensity (GSI) change.
- The change types provide more lessons to planners and developers than simply the summed statistical value of change in Green Space Intensity (GSI).
- The increase in satellite image resolution generated more change patches to be observed, which is why the number of patches is higher with the 10m resolution analysis than with the 30m resolution analysis. It is not therefore necessary to draw any conclusions from

2. táblázat/Table 2: Zöldfelület-intenzitás csökkenés-típusok a XIV. kerületben / *Types of decrease in Green Space Intensity in the 14th District*
A KÉPEK FORRÁSA: ORTOFOTÓ, LECHNER TUDÁSKÖZPONT / *IMAGE SOURCE: LECHNER KNOWLEDGE CENTRE*

Zöldfelület-intenzitás csökkenését kiváltó jelenségek / Phenomena causing decrease in Green Space Intensity		**Zöldfelület-intenzitás csökkenését kiváltó jelenségek / Phenomena causing decrease in Green Space Intensity**		**Zöldfelület-intenzitás csökkenését kiváltó jelenségek / Phenomena causing decrease in Green Space Intensity**	
Korábban / *Earlier* (2015)	**Később / *Later* (2019)**	**Korábban / *Earlier* (2015)**	**Később / *Later* (2019)**	**Korábban / *Earlier* (2015)**	**Később / *Later* (2019)**
10. Lakópark létesítése zöldmezős beruházásként / *Construction of a residential area in greenfield investment*		11. Parkoló kialakítása / *Construction of a parking lot*		12. Fás zöldfelület megszűnése / *Felling of woodland area*	
					
13. Rekreációs célú fejlesztés / *Recreational development*		14. Zöldfelület-fejlesztés túlnyomóan épített elemekkel / *Green space development with pre-dominantly built elements*		15. Ideiglenes zöldfelület-csökkenés / *Temporary reduction of green space*	
					
16. Sportcélú fejlesztés / *Development for sports purposes*		17. Műfüves vagy burkolt sportpálya létesítése / *Construction of an artificial turf or paved sports field*		18. Közterületi fakivágás / *Felling of trees in public areas*	
					
19. Lakóterületi építkezés / *Residential construction*		20. Korlátozottan látogatható intézmény parkoló-fejlesztése / *Parking lot development for a restricted access facility*		21. Közterületi parkoló területigénye / *Area for public parking*	
					
22. Fák ifjítása, visszametszése / *Rejuvenation and pruning of trees*		23. Erőteljes zöldfelület kezelés, visszavágás / *Intensive green space management*		24. Ipari, gazdasági v. kereskedelmi terület létesítése / *Industrial, economic or commercial development*	
					

the increase in the number of patches. However, it is worth drawing conclusions from the relative ratio of patches showing an increase or decrease.

Conclusions related to changes in Green Space Intensity:

- If we do not consider the area around the abandoned railway station of Rákosrendező, which provided spontaneous green growth and thus low quality green spaces with invasive species, in both analysed time periods (1992-2015 and 2015-2020), **a loss in Green Space Intensity occurred.** This was proven by territorial statistics tools and calculations regarding the area of change patches in the district.
- The ratio of **patches showing a decrease** in green space intensity among all change spots was much **higher** in the years from 2015 to 2020, than in the 1992-2015 period. In the later period, the **area of spots showing a decrease** was **also larger** than those showing an increase. This means that in these five years, the district experienced more intensive loss in Green Space Intensity than previously.
- The **types** of changes show that the changes are driven predominantly by the use of green spaces and influenced by their strong **investment potential and suitability** especially for residential or transport developments. There is a high risk that greenfield investments lead to a decrease in Green Space Intensity, but brownfield investments have the potential to increase Green Space Intensity. ◉

1 Studio Metropolitatna (2006): Pro Verde! Budapest Zöldfelületi Rendszerének Fejlesztési Koncepciója és Programja (egyeztetett dokumentáció), *(in English: Development Concept of Budapest's Green Space System)* Studio Metropolitana Urbanisztiaki Kutató Központ Kht. Budapest

2 Studio Metropolitatna (2006): A zöldfelületi rendszer állapota és változása Budapest éa Budapesti Agglomeráció területén 1990-2005, *(in English: The status and changes of green space system in Budapest and in the Budapest Agglomeration)* Studio Metropolitana Urbanisztiaki Kutató Központ Kht. Budapest

3 Ökoplan Kft (1994): Budapest Digitális Zöldfelületi Kataszter, *(in English: Green Space Cadastre of Budapest)* Budapest Főváros Főpolgármesteri Hivatala Környezetvédelmi Ügyosztálya, Budapest

4 M. Szilágyi Kinga (1993): Település zöldfelületi rendszerének vizsgálati és értékelési módszerei *(in English: Analysis and assesment methods of municipal green space system)*, Kertészeti és Élelmiszeripari Egyetem, Kert és Településépítészeti Tanszék, Budapest, Kandidátusi értekezés

5 Gábor Péter, Jombach Sándor, Ongjerth Richárd (2006): Budapest zöldfelületi állapotfelmérése űrfelvételek feldolgozásával *(in English: Green space surwey of Budapest with satellite image processing)*, 4D Tájépítészeti és Kertművészeti Folyóirat, Budapesti Corvinus Egyetem, Tájépítészeti Kar, Budapest, 4. szám, pp.15-22.

6 Gábor Péter, Jombach Sándor, Ongjerth Richárd (2007): A biológiai aktivitás változása Budapesten és a Budapesti Agglomerációban 1990 és 2005 között, *(in English: Green space change surwey of Budapest with satellite image processing)*, 4D Tájépítészeti és Kertművészeti Folyóirat, Budapesti Corvinus Egyetem, Tájépítészeti Kar, Budapest, 5. szám, pp.21-28.

7 Jombach Sandor (2007): Landsat image utilisation in Green Surface intensity Survey of Budapest, microCAD 2007 International Scientific Conference, Miskolci Egyetem Innovációs és Technológia Transzfer Centruma, Miskolc, pp 105-110

8 9/2007. (IV. 3.) ÖTM rendelet: a területek biológiai aktivitásértékének számításáról *(in English: decree about the calculation of biological activity value of areas)*

9 Péter Gábor, Sándor Jombach (2008): Zöldfelület Intenzitás és a városi hősziget jelenségének összefüggései Budapesten, *(in English: Relations of Green Space Intensity and Urban Heat Island phenomenon in Budapest)*, Falu Város Régió, Budapest, 2008/1. szám Váti Kht. pp 31-36

10 M. Szilágyi Kinga, Báthoryné Nagy Ildikó Réka (2017): Urban Landscape Architecture – Green network research on recreational needs and social care, Városi Tájépítészet – Zöldhálóazt kutatások a rekreációs igények és a szociális ellátás tükrében, Journal of Landscape Architecture and Garden Art – 4D Tájépítészeti és Kertművészeti Folyóirat. No. 46. 2017, 2-31

11 Jombach Sándor (2012): Térségi vagy települési szintű zöldfelület-intenzitás távérzékelési elemzésének módszere. *(in English: Regional or municipal analysis methods of Green Space Intensity with remote sensing)*, 4D: Tájépítészeti és Kertművészeti Folyóirat Különszám, 219-232.

12 Gibson, Paul J. Power Clare H. (2000): Indroductory Remote Sensing, Digital Image Processing and Applications, Routledge, London, 2000, pp117-118.

13 Jombach Sándor (2011): A 2010. évi Budapesti Zöldfelületi Intenzitás (ZFI) adatbázis leírása, *(in English: Description of the Green Space Intensity dataset of Budapest in 2010)*, BCE, Tájtervezési és Területfejlesztési Tanszék, Budapest

14 Jombach Sándor (2011): Zöldfelület-intenzitás elemzése távérzékeléssel a Budapesti Agglomerációban, *(in English: Analysis of Green Space Intensity with Remote Sensing in Budapest Agglomeration)* Élhető Települési Táj Kutatási Program, BCE Tájtervezési és Területfejlesztési Tanszék

15 Budapest Főváros Önkormányzata (2017): Budapest Zöldinfrastruktúra Koncepciója I. és II. kötetek Helyzetelemzés és értékelés, koncepció. *(in English: Green Infrastructure Concept of Budapest, Volume 1. and 2. Status report and assessment, Concept)* Budapest, Budapest Főváros Önkormányzata

ÉLŐHELYMINŐSÉG-ÉRTÉKELÉS AZ INVEST MODELL ALAPJÁN – ZHENGZHOU, KÍNA

HABITAT QUALITY ASSESSMENT BASED ON INVEST MODEL – ZHENGZHOU, CHINA

LIU MANSHU | KOLLÁNYI LÁSZLÓ | WANG XINYU | SHI ZHEN

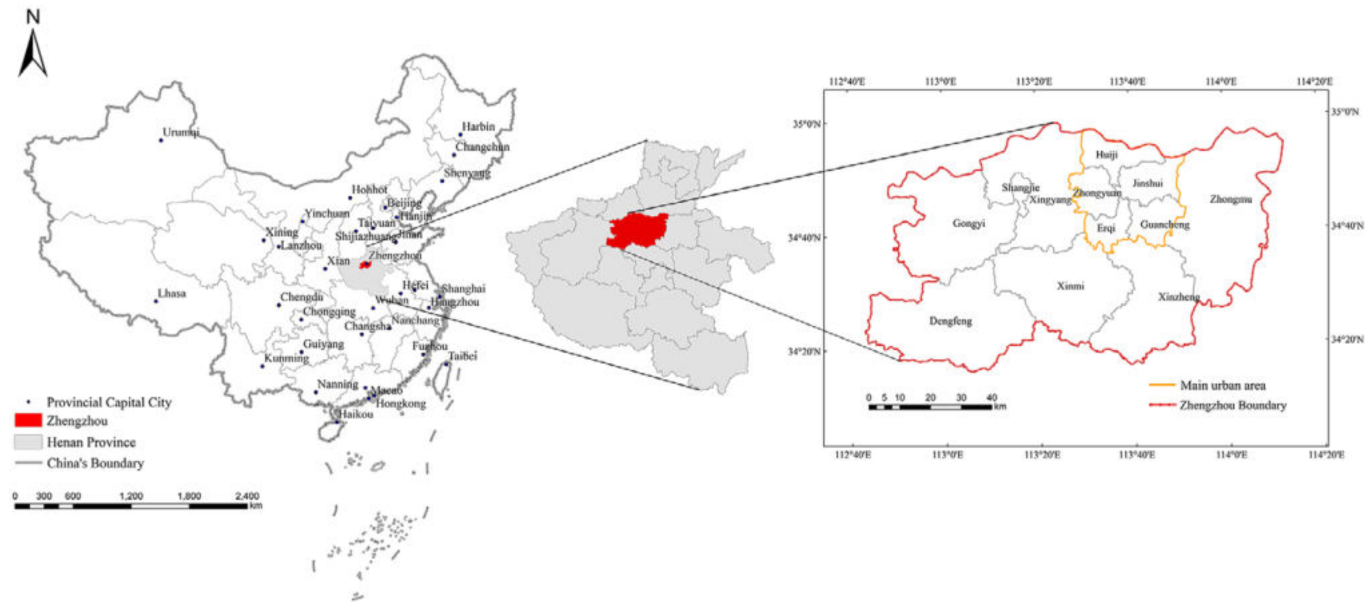
ABSZTRAKT

Az emberi tevékenységek és az urbanizáció globálisan befolyásolják a földterületek ökológiai integritását, az ökológiai hálózatok folyamatosságát és a természetes élőhelyek feldarabolódását okozva. A folyamatok világszerte ökológiai kockázati problémákat eredményeznek. Az egyes tájfoltok ökológiai funkciói leromlanak vagy akár el is tűnhetnek. Vizsgálni kell ezért az urbanizáció földhasználati változásokra, természetes élőhelyekre gyakorolt hatását. A kutatási terület Zhengzhou város, amely a 21. század eleji gyors urbanizáció mintapéldája Közép-Kínában. Az InVEST-élőhelyminőségi modell és az ArcGIS térinformatikai szoftver segítségével értékeltük Zhengzhou földhasználatának és élőhelyminőségének változásait 2000 és 2020-es évek között. Az eredmények azt mutatják, hogy: ① Az építési terület nagysága 2000 és 2010 között 806,76 km²-rel ugrásszerűen megnőtt, míg 2010-2020 között a növekedés üteme évi 33 km²-re lassult. A beépített területek nagy része korábban szántóföld volt. Az erdő és a gyepterület is jelentősen csökkent a térségben 2000-2010 között, de 2010-2020 között a csökkenés nem volt ennyire látványos. Ez azt jelzi, hogy a városi terjeszkedés a 2000-2010 közötti felgyorsult időszakból fokozatosan egy lassuló tendenciába fordult 2010-2020 között. A beépítések nagy része ebben az időszakban elsősorban a szántóterületeket érintették. ② A nyugati és déli hegyvidéki erdők élőhelyminősége magasabb volt, míg a keleti síkságon az alacsony élőhelyminőségű területek a városépítés fejlődésével fokozatosan bővültek. A Sárga-folyót, amely Kína legfontosabb folyója, szintén negatívan érintette az urbanizáció Zhengzhou északi részén. 2010-2020 között viszont fokozatosan javult az élőhelyek minősége. ③ Az elmúlt években a város központi területein az élőhely minősége néhány helyen javult a zöldterületek és a mesterséges tavak megjelenésének köszönhetően és a zöldterületek karbantartásának javulásával is. Azt azonban, hogy a mesterséges tavak és a nagy kiterjedésű zöldfelületek jelentik-e az optimális megoldást az élőhely minőségének javítására, érdemes tovább vizsgálni. A jövőben a gazdasági beruházások és az ökológiai előnyök szempontjából a legjobb költséghatékony ökológiai védelmi módszereket lehet keresni. ⦿

4D 67 44–55. (2023)

DOI: HTTPS://DOI.ORG/10.36249/4D.67.3699

Fig. 1: Geographical location of Zhengzhou



ABSTRACT

Human activities and global urbanisation have affected the integrity and continuity of ecological land, and resulted in the fragmentation of natural habitats and worldwide ecological security issues. Some ecological functions of landscape patches have been degraded or even lost. We need to study the impact of land use changes on natural habitats that are caused by urbanisation. As the research area, we selected Zhengzhou, a city in central China that has undergone rapid urbanisation in the early 21st century. By using the InVEST-habitat quality model and ArcGIS geographical analysis, we evaluated changes in land use and habitat quality in Zhengzhou from 2000 to 2020. The results show that: ① The area of construction land increased sharply by 806.76 km² from 2000 to 2010, while during 2010-2020 the growth rate slowed to 33 km² per year, and most of it was converted from arable land. The area of forest and grassland was also greatly reduced in 2000-2010, but did not change significantly in 2010-2020. This indicates that urban expansion gradually shifted from the acceleration of 2000-2010 to a period of stability in 2010-2020, and construction land has taken over a large amount of arable land. ② Habitat quality was higher in the mountain forests to the west and the south, while the low habitat quality areas in the eastern plain gradually expanded with the development of urban construction. The Yellow River, the most important river in China, was also negatively affected by urbanisation in the north of Zhengzhou, but its habitat quality gradually improved during 2010-2020. ③ In the central urban area, habitat quality was improved in some places due to the creation of green spaces and artificial lakes in recent years, and also through with the improved maintenance of green spaces. However, it is worth continuing to explore whether artificial lakes and large-scale green spaces are the optimal solutions to improve habitat quality. In the future, we will be able to seek the best cost-effective ecological protection methods in terms of economic investment and ecological benefits.

Keywords: land use, habitat quality, urbanisation, Zhengzhou, China

1. INTRODUCTION

The Earth's biosphere and its ecosystem services are important conditions for human survival [1]. In the current Anthropocene era dominated by human activities,

Table 1: Weight and maximum distance impacted by threat factors
Table 2: Habitat suitability of different land use types and the sensitivity to each source of threat
►►**Table 3:** Land use transfer matrix in Zhengzhou between 2000, 2010 and 2020 (km²)

THREAT	WEIGHT	MAX_DIST(km)	Spatial attenuation types
Urban area	1	10	exponential
Village area	0.6	5	linear
Arable land	0.7	8	linear
Highway	1	8	exponential
Railways	1	7	exponential
National roads	1	3	exponential

LULC	NAME	Habitat suitability	Sensitivity					
			Urban area	Village area	Arable land	Highways	Railways	National road
1	Arable land	0.6	0.5	0.35	0.3	0.7	0.55	0.8
2	Forest	1	1	0.85	0.8	0.95	0.8	1
3	Grassland	0.8	0.6	0.45	0.4	0.8	0.7	0.8
4	Water	1	0.85	0.8	0.7	0.5	0.5	0.6
5	Construction land	0	0	0	0	0	0	0
6	Unused land	0.6	0.5	0.2	0.4	0.4	0.4	0.5

global urbanisation has resulted in a variety of landscapes with significant human influence. The artificial land use pattern and the natural environment are superimposed, which to a certain extent has broken the continuity and ecology of the originally natural landscape [2]. Changes in land use patterns with human intervention have led to a series of ecological problems such as global warming, extreme weather, air pollution and geological disasters [3-4], which also have fragmented ecological landscapes, reduced species diversity and affected the functions of ecosystem services [5].

Ecosystem services are defined in the Millennium Ecosystem Assessment (MEA) as "the benefits people obtain from ecosystems" and are divided into four service functions: supporting services, provisioning services, regulating services and cultural services [1]. Biodiversity is closely related to ecosystem "provisioning services", and habitat quality directly affects the service function of biodiversity. Habitat quality means the suitable ecological environment that the ecosystem can provide for various organisms and populations to survive and continue to develop, which can reflect the ability of an area to provide good conditions for species continuation and biodiversity development [6]. Good habitat patches are key to promoting the improvement of regional biodiversity, and are the most important source of ensuring regional ecological security and maintaining ecosystem service functions. In recent years, more and more researchers have focused on the evaluation and analysis of habitat quality. There are generally two methods: constructing an index system and model assessment. Bazelet established a dataset evaluation system by selecting some habitat species indicators [7]; Nelson simulated regional biodiversity conservation levels with habitat quality assessment [8]; Dresit assessed the impact of hydrology changes on regional habitat quality [9]; Bhagabati selected tigers as an example to explore the relationship between ecosystem services and habitat quality [10]; Baral identified the key areas for conservation and mapped regional conservation priorities through habitat quality assessment [11]. This shows that the assessment of habitat quality has gradually become the focus of related research fields, but most of them just pay attention to a single period, and the spatial-temporal impacts of land use on habitat quality have not been fully explored. This study employs model assessment methods to compare the habitat quality of different periods and to

Year	Land use type	Arable land	Forest	Grassland	Water	Construction land	Unused land
2000–2010	Arable land	3869.48	121.24	27.14	131.45	788.09	0.00
	Forest	253.12	484.76	17.13	6.06	113.91	0.00
	Grassland	200.23	45.42	351.10	1.04	91.45	0.00
	Water	48.58	5.50	0.51	119.87	19.54	0.00
	Construction land	184.39	16.54	0.96	4.34	660.23	0.00
	Unused land	0.80	1.73	0.00	0.09	0.00	0.00
	Net inflow	687.13	190.44	45.75	142.98	1012.99	0.00
	Net outflow	1067.92	390.22	338.14	74.14	206.23	2.62
	Net change	−380.80	−199.78	−292.39	68.83	806.76	−2.62
2010–2020	Arable land	3928.97	79.62	21.63	68.02	458.43	0.00
	Forest	61.36	554.93	5.89	3.40	49.64	0.00
	Grassland	20.26	7.16	356.43	1.44	11.59	0.00
	Water	26.24	9.69	0.13	204.58	22.12	0.00
	Construction land	151.73	46.95	6.00	7.09	1461.55	0.00
	Unused land	0.00	0.00	0.00	0.00	0.00	0.00
	Net inflow	259.59	143.43	33.65	79.94	541.78	0.00
	Net outflow	627.70	120.29	40.45	58.18	211.78	0.00
	Net change	−368.10	23.14	−6.80	21.76	330.01	0.00

explore the impact of land use changes on habitat quality during rapid urbanisation in China.

China is a developing country with a vast territory and a large population. Since the establishment of the People's Republic of China in 1949, urbanisation has gradually been accelerating. Especially in the past 30 years, the achievements of urban construction have been remarkable [12]. The current urbanisation rate in China increased from 17.92% in 1978 to 64.72% in 2021. Rapid urbanisation has also brought more urban ecological problems. In 2000, the concept of "maintaining national ecological environment security" was put forward in the "National Ecological Environmental Protection Outline" policy for the first time [13], highlighting that solving ecological problems had become an important task of urban development in China.

Our research area was the city of Zhengzhou in central China, where the urbanisation rate increased from 32.4% in 1978 to 79.1% in 2021, [14] and urban expansion was obvious. The study on the evolution of habitat quality in Zhengzhou during the urbanisation process is representative in the formulation and implementation of ecosystem protection policies in China.

2. METHODS AND DATA

This chapter introduces the basic information about the research area, including geographical location, topographic features, administrative divisions and socio-economic development. In addition, we detail the data sources used in this study, data pre-processing, research methods and the introduction of the related tools.

2.1 Study area

Zhengzhou is the capital city of Henan Province in central China (34°16–34°58 North Latitude, 112°42–114°14 East Longitude), which has five prefecture-level cities, one county and six districts. Zhengzhou covers a total area of approximately 7,567 km², of which the main urban area is 1,010 km². The overall terrain of Zhengzhou is relatively flat. The Song and Fuxi Mountains are to the south-west, the loess hilly area along the Yellow River in the north-west, and the alluvial plain formed by the Yellow River system to the east. The Yellow River is the most famous river in China and one of important ecological sources in Zhengzhou.

Zhengzhou has a large population, with around 12 million in 2021. It is an important transportation hub in

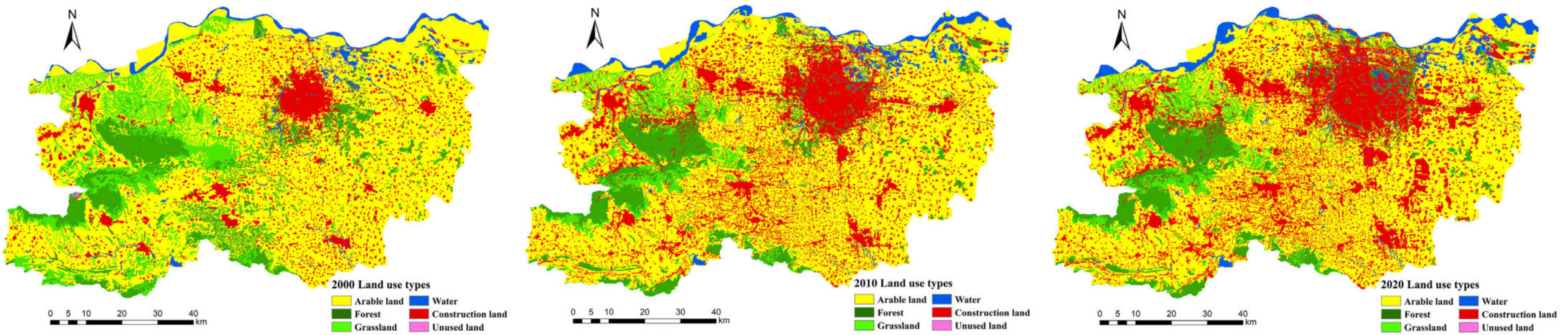


Fig. 2: Zhengzhou land use classification in 2000, 2010 and 2020

China because of its advantageous geographical location, which also makes it the core city of the "Belt and Road". The first Zhengzhou-Europe International block train started running from 2013, strengthening the connection between China and Europe. All of the points above are reflected in the fact that Zhengzhou is heavily impacted by urbanisation.

2.2 Data resource

The basic data used in this paper include Zhengzhou Landsat-8TM and Landsat-7 remote sensing image data (30m×30m resolution), Zhengzhou 2000/2010/2020 land classification data (30m×30m resolution), Zhengzhou Statistical Yearbook data, and road data. These are taken respectively from the United States Geological Survey (http://earthexplorer.usgs.gov/), Chinese Academy of Sciences (http://www.resdc.cn/), Zhengzhou Municipal Bureau of Statistics, and Baidu Map Data.

The land use data of this study is classified by combining the classification data of the Chinese Academy of Sciences (CAS) and the supervised classification data of Landsat image data. Since the CAS data unified all types of the land inside the main urban area as construction land, there is no accurate classification of the main urban area. We used ArcGIS to collect supervised samples by visual interpretation and employed the random forest supervised classification method to classify the land use of the main urban area. Then we tested the Kappa accuracy of the three years' classification results and all of them were more than 80%, which means the data can be used for research and analysis. Finally, we compared and combined the data from supervised classification with the CAS data to get the final and more accurate land classification results.

2.3 Transfer matrix of land use types

The land use pattern is an important factor affecting ecosystem services and one of the important factors in assessing habitat quality. Therefore, a clear evolution of land use is a prerequisite for exploring the evolution of habitat quality. Based on land use data, we superimposed the data in 2000/2010/2020 year with the raster calculator tool in ArcGIS 10.2, then obtained the changes and transfer of land use types in the study area between 2000-2010 and 2010-2020. The transfer matrix of land use types is shown in Chapter three (Table 3).

2.4 Habitat Quality Analysis

We analysed the habitat quality of Zhengzhou using the InVEST-Habitat Quality model tool. The InVEST model is a comprehensive model for ecosystem assessment and trade-offs jointly developed by Stanford University, the Nature Conservancy (TNC) and the World Wide Fund for Nature (WWF) [6]. It defines habitat as the area which has the resources and conditions to provide a suitable living environment for a given organism. The sources of threat to habitat are the lands affected by human activities. Habitat quality depends on the suitability of habitat patches and the sensitivity of a habitat patch to these threats.

The InVEST-Habitat quality model requires three main factors: the relative weight of the various sources of threat, the maximum distance impacted by the source of the threat, and the sensitivity of different habitats to each threat factor (the anti-interference ability of the habitat). In this study, we set urban areas, rural settlements, arable land, important traffic routes (highways, railways, national roads) as sources of threat. The relative weights are set according to the software instruction manual and related research, and are between 0 and 1 (Table 1). The habitat suitability and the sensitivity values to threats are set between 0 and 1: the closer to 1, the better the habitat suitability and the higher the sensitivity, as shown in Table 2.

3. RESULTS

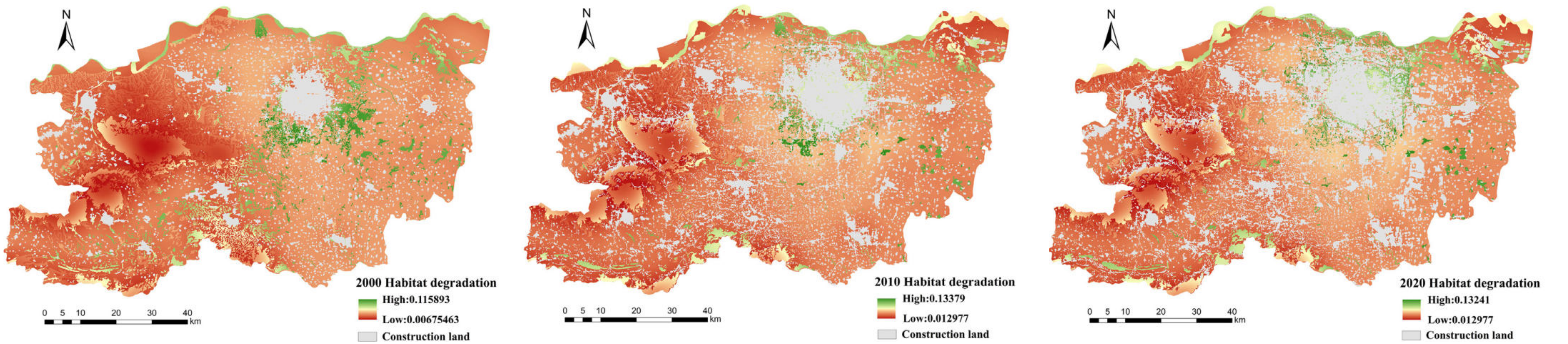
Through the data processing and analysis as set out above, we obtained the land use classification results of Zhengzhou in 2000, 2010 and 2020, as shown in Figure 2. This chapter shows the transfer matrix between these six land use types from 2000 to 2020, and the spatial-temporal changes of habitat degradation and habitat quality.

3.1 Changes in land use pattern

By superimposing the raster data of land use classification in 2000, 2010 and 2020, we obtained the land transfer results as shown in Table 3. Overall, the transfer in 2000-2010 was more significant than in 2010-2020. It mainly occurred between arable land and construction land. The water area continued to increase.

From 2000 to 2010, the area of arable land, forest and grassland decreased, while the area of construction land increased significantly. Arable land decreased

Fig. 3: Degree of habitat degradation in 2000, 2010, and 2020



by 380.80 km^2, which was mainly converted into construction land. The forest decreased by 199.78 km^2 and the grassland area decreased by 292.39 km^2. Both were mainly replaced by arable land, followed by construction land. The growth of construction land was particularly obvious, with net growth of 806.76 km^2. Most of this came from arable land, up to 788.09 km^2. During this period, the water area increased by 68.83 km^2, which was mainly converted from arable land, and part of it was also in the meantime converted into arable land. That's because some rivers in rural regions became dry and were replaced by arable land. However, arable land occupied by new urban areas developed with various artificial lakes, such as Longzi Lake and Long Lake in the Jinshui District, resulting in an increase of the water area in the city.

From 2010 to 2020, the transfer of arable land and construction land was similar to that of the previous period. But the change in forest was wholly different from 2000-2010, increasing by 23.14 km^2, mainly from arable land. The main reason is that the "Returning Farmland to Forest" policy had achieved some results in certain areas during 2010-2020. It also reflects that government calls and increased ecological awareness are having an important influence on environment change. Construction land increased by 330.01 km^2. Compared with 2000-2010, the growth rate decreased by 59.10%. Although the urban construction area continued to expand, the urbanisation of Zhengzhou gradually slowed down and reached a relatively stable state.

Looking at land use changes in 2000-2020, it is clear that a lot of arable land was occupied by urban expansion, and that arable land suffered a considerable degree of loss. It also caused problems in agricultural production and food security. Therefore, some forest and grassland continued to be occupied and developed into arable land. This is a vicious circle caused by socio-economic development and the expansion of the area covered by human activities, which also has a negative influence on the ecological environment and agricultural security.

3.2 Dynamic evolution of Habitat degradation

The degree of habitat degradation indicates the impact of the degradation sources (threats) on the surrounding habitat. The greater the impact, the higher the degradation (Figure 3). It can reflect suitability for the development of natural communities. The urban area and rural settlements belong to construction land and there is no more degradation, so we extracted the other landscape types to analyse the degradation.

In terms of spatial distribution, the degree of habitat degradation in Zhengzhou is highest around the main urban area, and gradually decreases with increasing distance from the main urban area. In the mountainous areas, the degree of habitat degradation was lower, and reached a low in the Song-Fuxi Mountains in the west, an area with high ecological value and protection needs.

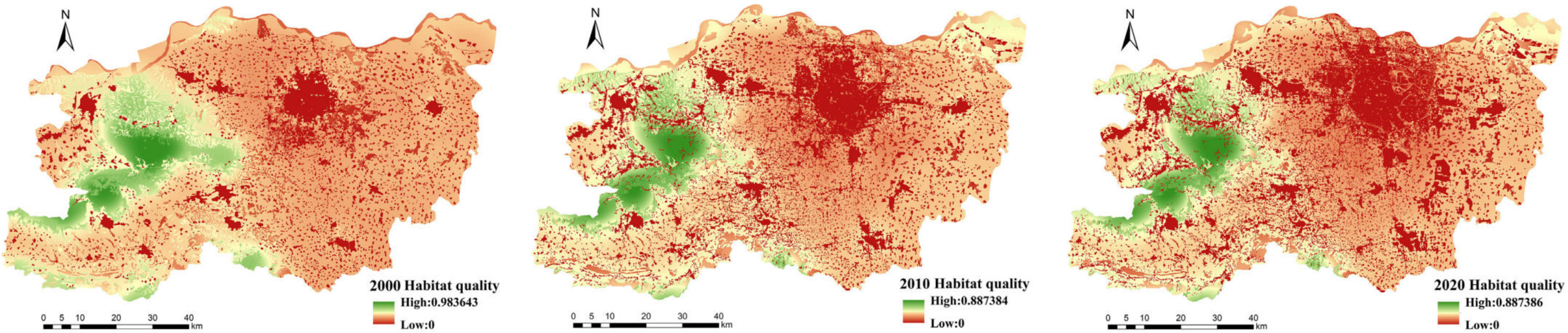
From the temporal perspective, we compared the degree of habitat degradation in 2000, 2010 and 2020. It was clear that the value attributed to the degree of habitat degradation continued to increase from 2000 to 2020. In 2000, the value was in the range of 0.00675-0.11589, while in 2010, the range increased to 0.01298-0.13379. This means the impact from sources of degradation increased, with even the lowest value doubled. The value of habitat degradation in 2020 didn't change much compared with 2010. However, with the expansion of urban construction land, the area of high habitat degradation spread outwards, which apparently affected the habitat quality of surrounding arable land.

In 2000, the main urban area was small, there were not too many artificial threat factors like highways, railways or paved roads, so the negative impact on the surrounding habitat was limited. In 2020, the construction area greatly expanded, and the impact had spread to the three prefecture-level cities: Gongyi, Dengfeng and Xinmi in the mountain area to the west. This reduced the habitat quality of the mountain forest areas compared to before, and particularly affected the habitats near the foot of mountains. Although there were no significant changes in the habitat degradation value during 2010-2020, the areas with low habitat quality expanded and the distribution was more even.

3.3 Changes in habitat quality

The evolution in the trend of habitat quality is like the degree of habitat degradation, as shown in Figure 4. The habitat quality value is between 0 and 1. The closer to 1, the better the habitat quality is. To display the temporal and spatial changes of habitat quality more clearly, we used the ArcGIS reclassification tool to divide habitat

Fig. 4: Habitat quality map in 2000, 2010 and 2020



quality results into five grades: 1 is the worst (0-0.2), 2 is bad (0.2-0.4), 3 is medium (0.4-0.6), 4 is good (0.6-0.8), 5 is the best (0.8-1), and calculated the area changes of different habitat quality grades as shown in Figure 5.

The habitat quality was best in 2000, with 6147.93 km^2 of medium and above grades, accounting for 81.3% of the whole area. From 2000 to 2010, the quality of the habitat decreased significantly. The area of good and best grades even decreased by 43.1%. From 2010 to 2020, the area of habitat quality within each grade changed little, and the overall habitat quality decreased slightly. Grades 4 and 5 remained basically unchanged, indicating that the protection of important habitat areas was achieved. Compared with the land use transfer matrix, the growth area of construction land continued to increase but the annual growth rate decreased, which is the main factor leading to the gradual stabilisation of habitat quality after the deterioration.

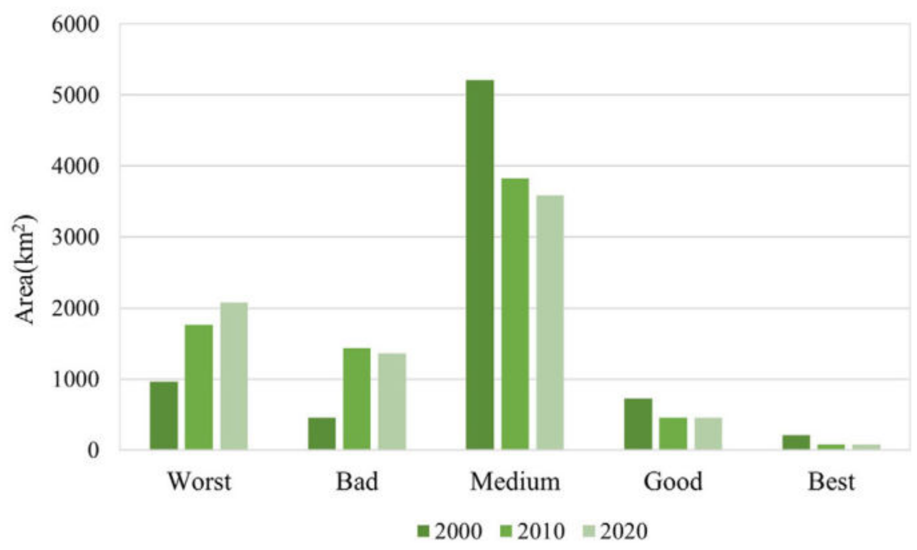
To further explore the distribution characteristics in the spatial dimension, we analysed the change in habitat quality in 2000-2020, as shown in Figure 6. The colour from red to green represents the change in habitat quality from decline to improvement, and yellow indicates the areas with no change. The major decrease was mainly distributed near the new construction land. For example: the expansion of the urban area to the north had led to the deterioration of the habitat quality of the Yellow River; the new industrial zone and airport in Xinzheng in the south had caused the deterioration of the nearby agricultural habitat. The western mountainous area was far from the main urban area, and transportation was not as convenient as in the eastern region, habitat quality was higher in 2000. With the development of transportation and urbanisation, the habitat quality of the Song-Fuxi Mountain in the west decreased slightly, and the habitat quality of western counties and towns also declined. Although the decline in the western area was greater than in the eastern area, it's still higher than in the eastern area in terms of the spatial dimension.

While the overall habitat quality deteriorated, some areas improved a little (Figure 6). In the main urban area, there were some new large-scale green spaces and lakes in the Jinshui District in the east, such as Zhengzhou Zhilin Park, Ruyi Lake, Longzi Lake, etc., which reflected the positive effect of urban green spaces and parks on habitat improvement. The protection and maintenance of rivers also improved the quality of the river habitat in the urban area. There was some improvement in habitat quality in certain sections of the Yellow River in the north-east, showing that the government has sought to protect the ecology of the Yellow River habitat. The ecological level of the surrounding environment was improved and prevented urban development from damaging the habitat of the Yellow River.

4. DISCUSSION

There is a game relation between construction land, arable land and ecological land. How to balance the three effectively to achieve unified and coordinated development is one of the important issues to be considered in future urban development. Taking this study area as an example, urban development and expansion occupied a large area of arable land in the eastern plains. To ensure the food supply, some forest and grassland in the western mountainous area have been developed into arable land, and the ecological environment of the whole city has been severely impacted. Therefore, for cities with growth in their population and economy, we should consider how to improve the quality of the living environment and people's sense of happiness, rather than blindly expanding and pursuing an increase in the urban construction area.

Ecological protection policies and urban green spaces can effectively improve habitat quality. By comparing the urban habitat quality in Zhengzhou from 2000 to 2020, the habitat quality in some urban areas has improved significantly because of the newly-built urban green spaces, including a number of small street green spaces, open parks, residential green space, etc. Encouraged by the policies such as "the Construction of Ecological Civilization", "National Forest City", and "National Ecological Garden City" launched by the Chinese government, many local governments have responded with a series of green space protection regulations. This has been effective in improving the ecological environment. At present, when the protection of the ecological environment is taken as an important development task, all regions in China are paying attention to the protection of natural habitats and the construction of urban green spaces, and habitat quality has gradually stabilised and improved. However, whether new large-scale artificial lakes and green spaces are the most cost-effective way to improve habitat quality still needs to be explored.



5. CONCLUSIONS

The land use changes and ecological problems that emerged during the urbanisation of Zhengzhou are representative of the situation in most cities in China. This study explores the spatial and temporal evolution of land use patterns and habitat quality under the influence of urbanisation. Its conclusions are as follows:

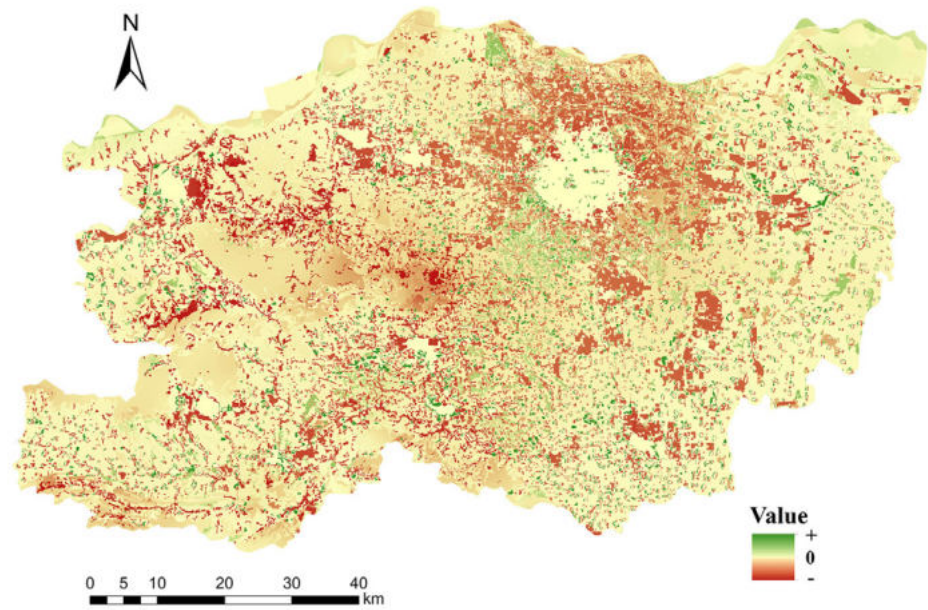
① In 2000-2010, the area of forest and grassland was significantly reduced, and mainly converted into arable land and construction land. In 2010-2020, the construction area continued to increase, but the growth rate decreased, and the forest area increased slightly. This shows that urbanisation in Zhengzhou accelerated from 2000 to 2010, and then was relatively stable in 2010-2020. Urbanisation has a significant impact on the land use pattern.

② Habitat quality in the city of Zhengzhou is not very good. The Song-Fuxi Mountains in the west and the Daxiong Mountains in the south have higher habitat quality. The northern Yellow River habitat was affected by urban expansion, but gradually improved in 2010-2020. In 2000-2010, the low habitat quality area increased considerably with the expansion of the main urban area. In 2010-2020, habitat quality decreased slightly, and there were some small improvements in the areas such as the north-eastern section of the Yellow River, some reservoirs and the areas surrounding the Song-Fuxi Mountains.

③ Habitat quality in the Jinshui District in the main urban area improved in 2000-2020 because of some new large-scale parks and lakes created there, such as Zhengzhou Zhilin Park, Ruyi Lake and Longzi Lake. This reflects the positive effect of urban green and blue spaces on habitat improvement. Government policies and local response also play a crucial role in maintaining and improving the ecological environment.

④ The InVEST model can effectively simulate habitat quality and display it visually. It has a powerful auxiliary function for people to conduct ecological environment research, identify important habitat areas, and analyse changes in habitat quality. Moreover, it could be used in large-scale regional planning and small-scale ecological design in the future. ⦿

◂◂**Fig. 5:** Area of different habitat quality grades in 2000, 2010 and 2020
Fig. 6: Changes in habitat quality from 2000 to 2020



1 Alcamo, Joseph – Bennett, Elena M. – Millennium Ecosystem Assessment (Program) (2003): *Ecosystems and human well-being: a framework for assessment.* Island Press: Washington, DC.

2 Tscharntke, Teja – Tylianakis, Jason M. – Rand, Tatyana A. – Didham, Raphael K. – Fahrig, Lenore – Batáry Péter – Bengtsson, Janne – Clough Yann – Crist, Thomas O. – Dormann, Carsten F. – Ewers, Robert M. – Fründ, Jochen – Holt, Robert D. – Holzschuh, Andrea – Klein, Alexandra M. – Kleijn, David – Kremen, Claire – Landis, Doug A. – Laurance, William – Lindenmayer, David – Scherber, Christoph – Sodhi, Navjot – Steffan-Dewenter, Ingolf – Thies, Carsten – van der Putten, Wim H. – Westphal, Catrin (2012): Landscape moderation of biodiversity patterns and processes – eight hypotheses. *Biol. Rev,* (87), 661–685. DOI: https://doi.org/10.1111/j.1469-185X.2011.00216.x

3 Zhai Xiaohui – Yan Changzhen – Xing Xuegang – Jia Haowei – Wei Xiaoxu – Feng Kun (2021): Spatial-temporal changes and driving forces of aeolian desertification of grassland in the Sanjiangyuan region from 1975 to 2015 based on the analysis of Landsat images. *Environ. Monit. Assess,* (193), 2. DOI: https://doi.org/10.1007/s10661-020-08763-8

4 Walther, Gian-Reto (2010): Community and ecosystem responses to recent climate change. *Philos. Trans. R. Soc. B-Biol. Sci,* (365), 2019–2024. DOI: https://doi.org/10.1098/rstb.2010.0021

5 McKinney, Michael L. (2002): Urbanization, biodiversity, and conservation. *Bioscience,* (52), 883–890. DOI: https://doi.org/10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2

6 Natural Capital Project (2022): *InVEST 3.13.0 User's Guide.* [online] Stanford University, University of Minnesota, Chinese Academy of Sciences, The Nature Conservancy, World Wildlife Fund, Stockholm Resilience Centre and the Royal Swedish Academy of Sciences. URL: https://storage.googleapis.com/releases.naturalcapitalproject.org/invest-userguide/latest/index.html [2022. 04. 06].

7 Bazelet, Corinna S. – Samways Micheal J. (2011): Identifying grasshopper bioindicators for habitat quality assessment of ecological networks. *Ecol. Indic,* (11), 1259–1269. DOI: https://doi.org/10.1016/j.ecolind.2011.01.005

8 Nelson, Erik – Mendoza, Guillermo – Regetz, James – Polasky, Stephen – Tallis, Heather – Cameron, D Richard – Chan Kai MA – Daily, Gretchen C. – Goldstein, Joshua – Kareiva, Peter M. – Lonsdorf, Eric – Naidoo, Robin – Ricketts, Taylor H. – Shaw, M. Rebecca (2009): Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Front. Ecol. Environ,* (7), 4–11. DOI: https://doi.org/10.1890/080023

9 Dresti, Claudia – Becciu, Gianfranco – Saidi, Helmi – Ciampittiello, Marzia (2016): The hydromorphological state in mountain rivers subject to human impacts: a case study in the North-West of Italy. *Environ. Earth Sci,* (75), 495. DOI: https://doi.org/10.1007/s12665-015-5102-3

10 Bhagabati, Nirmal K. – Ricketts, Taylor – Sulistyawan, Thomas Barano Siswa – Conte, Marc – Ennaanay, Driss – Hadian, Oki – McKenzie, Emily – Olwero, Nasser – Rosenthal, Amy – Tallis, Heather – Wolny, Stacie (2014): Ecosystem services reinforce Sumatran tiger conservation in land use plans. *Biol. Conserv,* (169), 147–156. DOI: https://doi.org/10.1016/j.biocon.2013.11.010

11 Baral, Himlal – Keenan, Rodney J. – Sharma, Sunil K. – Stork, Nigel E. – Kasel, Sabine (2014): Spatial assessment and mapping of biodiversity and conservation priorities in a heavily modified and fragmented production landscape in north-central Victoria, Australia. *Ecol. Indic,* (36), 552–562. DOI: https://doi.org/10.1016/j.ecolind.2013.09.022

12 Gu Chaolin – Hu Lingqian – Cook Ian G. (2017): China's urbanization in 1949-2015: Processes and driving forces. *Chin. Geogr. Sci,* (27), 847–859. DOI: https://doi.org/10.1007/s11769-017-0911-9

13 without author (2000): *Notice on the thorough implementation of the "National Ecological Environmental Protection Outline".* Ministry of Ecology and Environment of the People's Republic of China. URL: https://www.mee.gov.cn/gkml/zj/wj/200910/t20091022_172001.htm [2022. 02. 06].

14 without author (2022): *Population over the years.* Zhengzhou Municipal Bureau of Statistics. URL: http://tjj.zhengzhou.gov.cn/ndsj/3134558.jhtml [2022. 05. 23].

DOI: HTTPS://DOI.ORG/10.36249/4D.67.3721

A TERVEZETT M2 GYORSFORGALMÚ ÚT HATÁSAI

A SaveGREEN INTERREG projekt eredményei a magyarországi vizsgálati területen

THE EFFECTS OF THE PLANNED M2 MOTORWAY

Results of the SaveGREEN INTERREG project in the Hungarian pilot area

FILEPNÉ KOVÁCS KRISZTINA | DANCSOKNÉ FÓRIS EDINA | BÁNYAI ZSOMBOR | HUBAYNÉ HORVÁTH NÓRA | MÓDOSNÉ BUGYI ILDIKÓ | VARGA DALMA | WEIPERTH ANDRÁS | SALLAY ÁGNES | SZILVÁCSKU MIKLÓS ZSOLT | KOLLÁNYI LÁSZLÓ

ABSZTRAKT

A SaveGREEN INTERREG projekt célja, hogy segítse az ökológiai folyosók integrált tervezéssel történő megőrzését, továbbá felhívja a figyelmet a megfelelő kárenyhítési intézkedések különböző módjaira. A SaveGREEN projekthez kapcsolódóan és tájépítész hallgatók egyetemi képzése keretében készítettük el a tervezett M2 autópálya határmenti térségének komplex tájértékelési, tájfejlesztési tervét. A SaveGREEN projekt a TRANSGREEN, a ConnectGREEN és a HARMON DTP-projektek szerves folytatásaként indult. A projekt középpontjában a partnerországok vizsgálati területei állnak: az Alpok-Kárpátok folyosó, a Délnyugat-Kárpátok, a Zakarpatszka, Beskidek, Ljulin és Balkán hegység és Magyarországon a tervezett M2 térségének kritikus ökológiai folyosói, amelyeket a közlekedési infrastruktúra és a nem fenntartható területhasználat befolyásol leginkább. Tanulmányunkban a hazai vizsgálati terület komplex értékelését mutatjuk be, kiemelt figyelmet fordítva a tervezett M2 autópálya nyomvonalát keresztező ökológiai folyosók értékelésére. ⦿

Figure 1: Partner countries and pilot areas of SaveGreen project marked with numbers [8]

ABSTRACT

The SaveGREEN INTERREG project aims to help conserve or improve ecological corridors through integrated planning and to raise awareness of the different types of appropriate mitigation measures. In connection with the SaveGREEN project and within the framework of the university educational programme of landscape architecture students, we prepared a complex landscape assessment and landscape development plan for the planned M2 border area. The SaveGREEN project builds on the results of the TRANSGREEN, ConnectGREEN and HARMON DTP projects. The project focuses on the study areas of the partner countries: the Alpine-Carpathian corridor, the South-Western Carpathians, the Zakarpattya, Beskid, Lyulin and Balkan Mountains and the critical ecological corridors of the planned M2 area in Hungary, which are most affected by transport infrastructure and unsustainable land use. In our study, we present a complex assessment of the Hungarian study area, with a special focus on the assessment of ecological corridors crossing the route of the planned M2 motorway.

INTRODUCTION

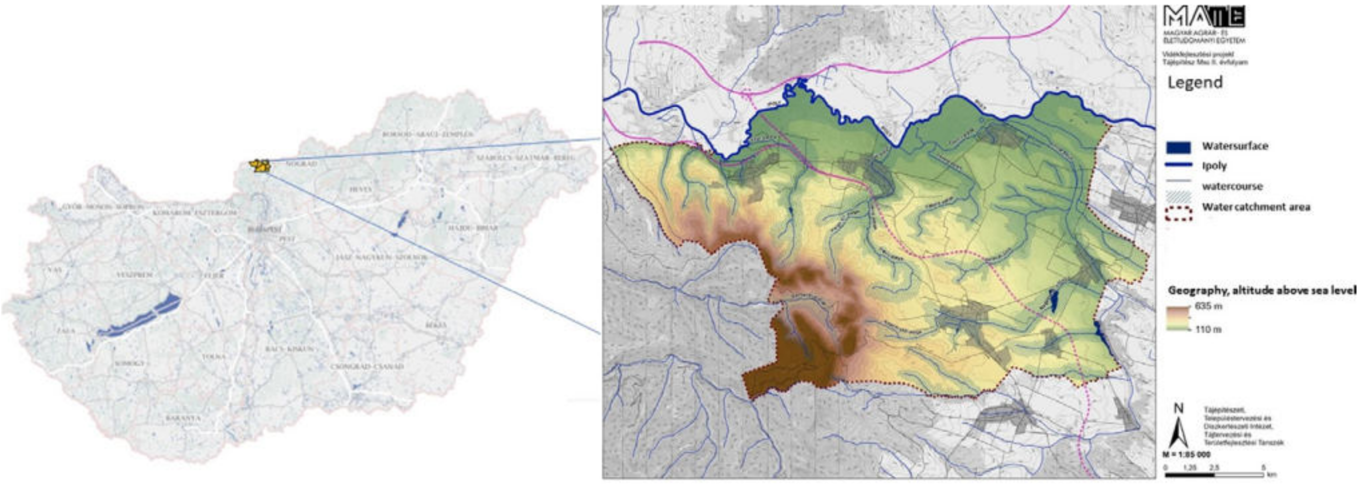
In the long term, the construction of motorways and railways disrupts ecological networks and animal migration routes, and separates natural habitats in a way that is very difficult to mitigate [1]. Roads affect wildlife in a wide range of ways [2,3], including destruction of habitats by road construction or later mortality of specimens by fumigation; changes in behaviour; physical and chemical environmental changes; the introduction of exotic species; fragmentation and isolation of populations and ecosystem disruption. On the basis of further publications [4-7], the literature distinguishes between two broad categories of direct and indirect impact. Direct impacts include habitat loss and degradation, pollution, disturbance and road fumigation due to road construction. Indirect impacts are considered to be environmental changes caused by the negative environmental effects of roads.

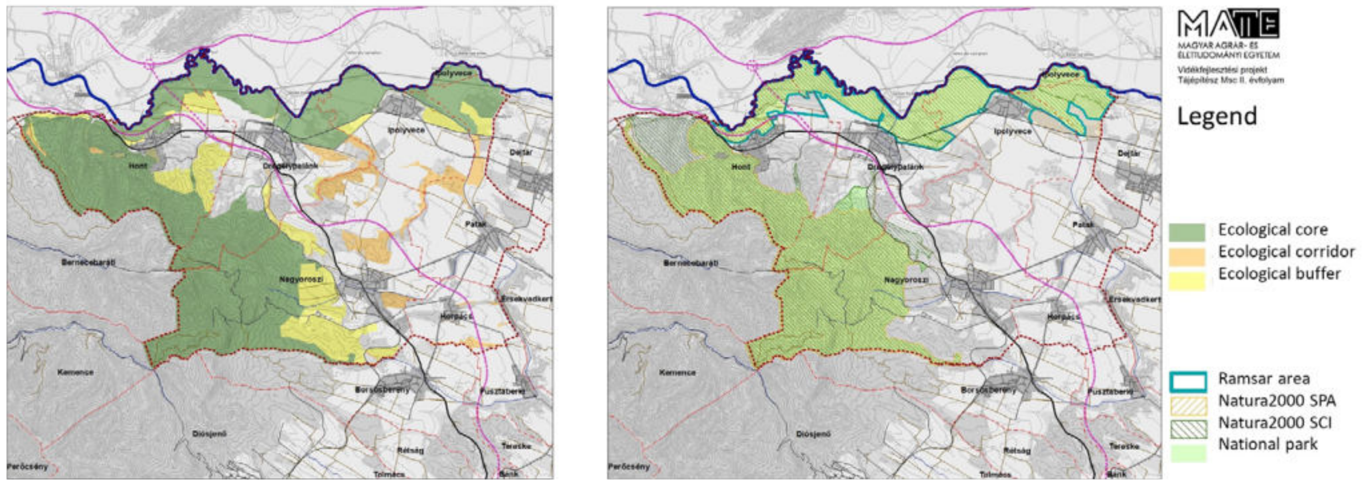
The SaveGREEN project, funded by the Interreg Danube Transnational Programme, and integrating experts from ten countries, focused on the identification, collection and promotion of the best solutions for safeguarding ecological corridors in the Carpathians and further mountain ranges in the Danube region. The SaveGREEN project focused on pilot areas in several Central and Eastern European countries (Fig. 1), with the aim of monitoring and mitigating the negative effects of infrastructure on ecological corridors.

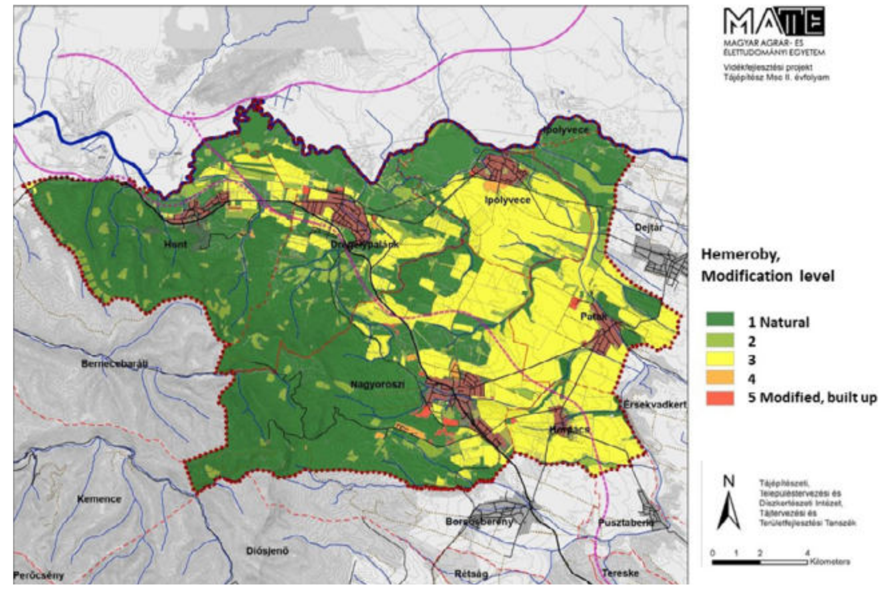
METHODS AND MATERIALS

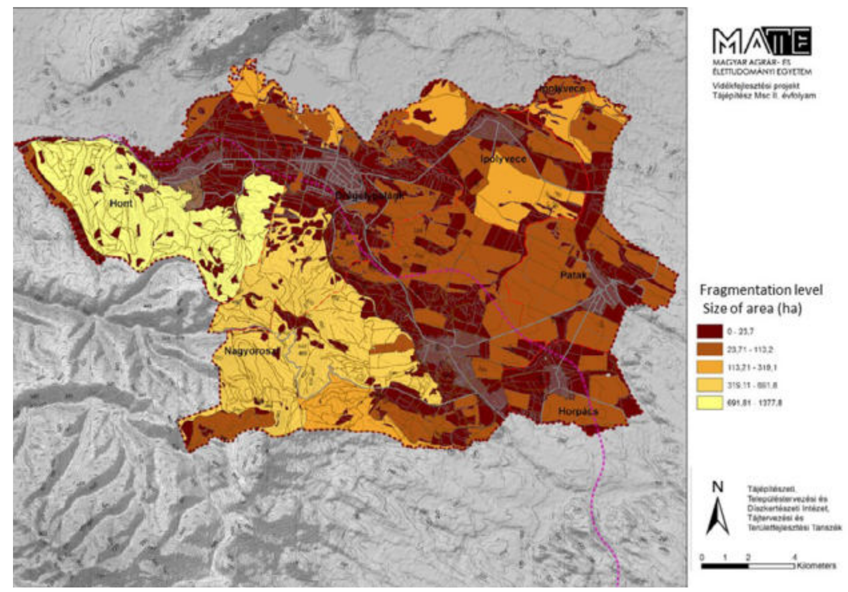
In Hungary, the project assessed the landscape-level impacts of the planned M2 motorway. The aim of the motorway is to improve transit connections in the Hont-Parassapuszta border region between Hungary and Slovakia and to reduce the environmental impact of transit traffic on the hinterland of settlements. The new motorway project is expected to have a positive effect on cross-border cooperation (e.g. connecting the Nitra region with the Budapest agglomeration), helping to develop the economic potential of the border regions and to improve the environmental quality of the settlements. However, it also has very serious negative impacts, as it drastically increases landscape fragmentation and eliminates or negatively affects habitats of high ecological value. The planned M2 motorway will pass through varied landscapes between the Nógrád Basin and the periphery of the Börzsöny mountains, crossing the valley of the River Ipoly (Fig. 2).

The planned route of the M2 motorway and the existing main road No. 2 form the backbone of the study









◂◂**Figure 2:** Location and the geography and watercourses of the study area
◂◂**Figure 3a-b:** Protected areas, a, National park, and Natura 2000 areas, b, National Ecological Network areas: green-Core area, yellow-Buffer zone, orange-Corridor zone
Figure 4: Hemeroby level of the pilot site, the green colour represents the highest level of naturalness, the yellow the modified agricultural areas, and the red is for the built-up areas as heavily altered
Figure 5: Fragmentation level of the pilot site, brown colour highlights the more fragmented landscape. The area is categorized by the extent to which current land uses are divided by linear features, we found that the smallest land use "fragments" range from 0 to 23.7 hectares, while the largest, most untouched land uses, such as the forests in the Börzsöny, range from 691.81 to 1377.8 hectares

area, along with the areas bordering them, Börzsöny and Ipolymente, covering approximately 165 km². The study area is located in the North Hungarian Mountains and covers several small landscape character areas, such as the Nógrád Basin, the western region of the Börzsöny Mountains and the Ipoly Valley, which forms the northern border. In the central part of the area, the most typical zonal associations are oak forests. The valley bottoms of the gently rolling hills are characterised by marshes and wet meadows (Fig. 3.). Most of the area is now ploughed and fallow. Due to the high forest cover and the valuable watercourses, the surrounding extensive grasslands and the natural floodplain of the Ipoly, the area has a high proportion of protected areas. Natura 2000 sites cover the Börzsöny and the Ipoly Valley. The Ipoly and its floodplain are also a Ramsar site, and also contain protected areas of national importance, the areas of the Danube-Ipoly National Park and elements of the National Ecological Network, which are present in the area as core and buffer areas and ecological corridors (Fig. 3).

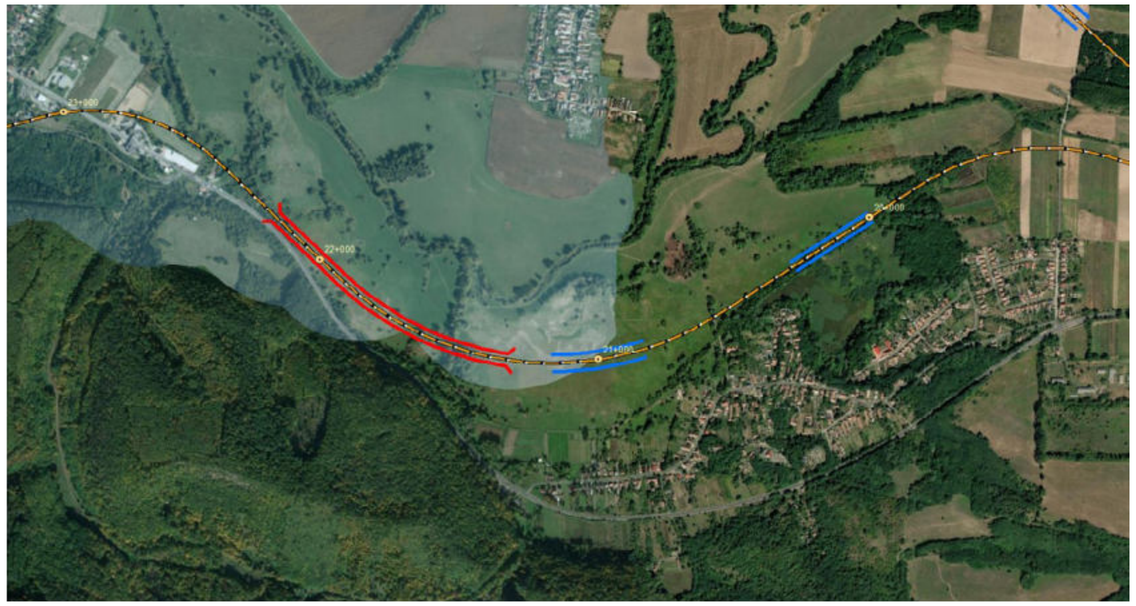
The methodology of the SaveGreen project included the preparation of a general overview, a Logframe about the main conflicts, objectives, measures of infrastructure causing landscape fragmentation with a specific outlook on the study area. The Hungarian study area of the project was integrated into several courses during the MSc in Landscape Architecture at the university. A landscape-level survey and assessment was developed using QGIS software. We assessed landscape heritage, landscape character types, hemeroby and landscape fragmentation levels, quality of green infrastructure, ecological corridors, agricultural structure and land use patterns. The ecological corridors formed by watercourses were assessed according to vegetation, length, disturbance and surrounding land use, as well as their suitability for selected animal species (categories S1-S5, where S1 is very suitable: corridor with little or no restrictions on animal movement). The target species selected were: roe deer, wild boar, common lynx, eastern hedgehog, otter, red fox, brown toad, newt, green lizard, wood sandpiper, bush vulture, hill fox, cutthroat trout. Based on the multi-level assessment, critical sections of the planned infrastructure were identified.

Several watercourses cross the landscape, connecting core areas and representing the most important ecological corridors. The most prominent feature of the hydrography is the River Ipoly. Our assessment identified the critical sections of the proposed M2, the crossing zones of the watercourses. Based on this complex analysis, we developed cross-sectoral proposals to mitigate negative environmental impacts. Our recommendations were compared with the mitigation measures envisaged in the EIA study of the M2 motorway provided by the National Infrastructure Development Ltd (NIF). The subject of our analysis was the version of the Trail C between Rétság and the national border, which received an environmental permit from the Pest County Government Office in 2018.

RESULTS

One of the core parts of the cross-sectoral analysis was a Logframe that provided an overview of the major conflicts and objectives related to the barrier effect of the new and existing infrastructure lines, including the changes in land management. The Logframe provides country-specific suggestions for the mitigation of negative effects. The most important measures concerning the new infrastructure lines, among others:

- During route selection, ecological aspects should be considered, but the track is often decided before ecologists/biologists have examined a trail in detail.
- Avoid sensitive areas.
- Gather data on relevant species using camera traps, tracking and telemetry. For watercourses, continuous sampling is required.
- SEA and EIA legislation should be complemented by provisions for specific roads; for example, the direct and indirect impact area of different roads.
- Specific, well-measured indicators such as the fragmentation analysis (e.g. minimum net size)



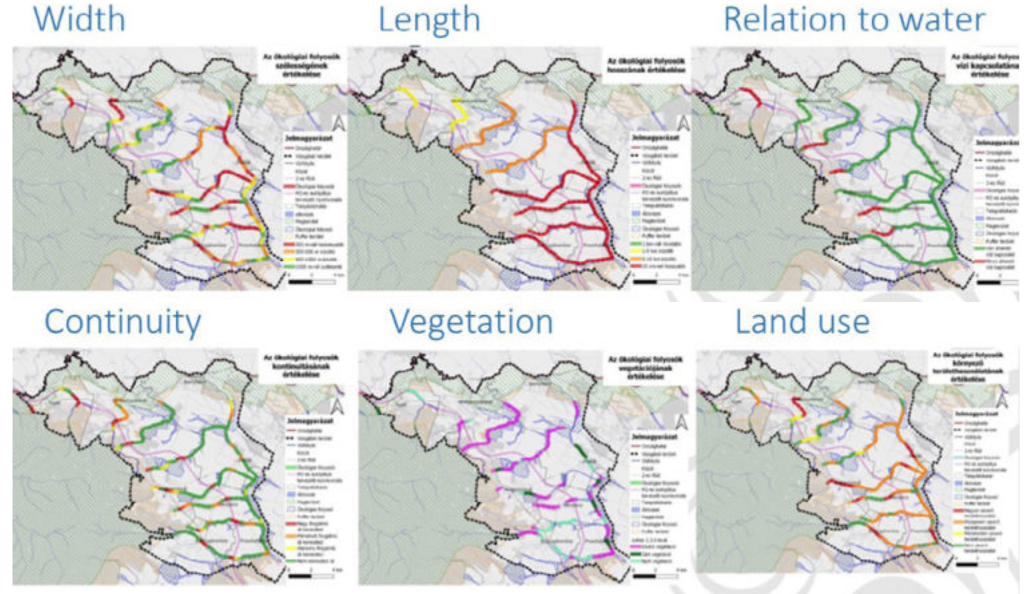


Figure 6: The planned M2 motorway line in the Ipoly Valley
Figure 7: The River Ipoly in this region represents the most natural river section in Hungary
Figure 8: Assessment of ecological corridors crossing the study area based on width, length, relation to water, continuity, vegetation and surrounding land use

or biological activation value calculations should be incorporated into the SEA process and spatial planning.
- A minimum percentage of the entry-level costs of a given project that must be spent on the road's ecological protection facilities (e.g. under- and overpasses, fences), including the provision of areas required for planting and implementing these facilities, should be stipulated in legislation. In addition, a minimum size of an area intended for planting also requires further specification within the legislation, because planting can influence the effectiveness of ecoducts, among other things. (The exact size should depend on the road category.)
- Set up a systematic monitoring plan for new linear infrastructure (before baseline, during the construction and after the construction is completed).
- The term "ecological corridor" or "ecological connectivity" should be cited in Gov. Decree 314/2005 (XII.25.), requiring that the impact of the railway/road project on ecological corridors is evaluated in EIAs.
- Review of national and international practice and adaptation to domestic conditions.
- Advocacy for development of a new small infrastructure project to create a defragmentation facility (overpass).

The most important general objectives for the **existing infrastructure lines,** among others, based on our results:

- Safeguard the permeability of existing transport infrastructure (including the enhancement of permeability of existing features, when possible)
- Safeguard the transversal permeability of riverbanks (including the enhancement of permeability of existing features, when possible)
- Safeguard the longitudinal permeability of rivers (including the enhancement of permeability of existing features, when possible)

Beside focusing on the planned motorway, within the framework of a complex landscape study, we explored the major land use problems in the region. The arable land is characterised by the presence of large monocultures of cropland. Another problem is a frequent absence of forest strips, which reduces ecological connectivity. The main problem with grasslands is that they are no longer grazed or mowed when traditional land use ceases and are often cleared and then turned to ploughland. This conflict can be solved by planting forest belts and bushes by farmers which could be fostered by awareness raising among farmers and incentives of the Common Agricultural Policy. The vast forest block of Börzsöny enhances ecological connectivity, however in order to increase the ecological diversity of forests, the main professional objective is to change from cutting to "Forest wilderness" management and increase the non-timber production mode.

The planned route of the M2 runs in the transition zone between the more natural, more varied vegetation and topography of the Börzsöny and the cultivated, more fragmented cultural landscape (Fig. 4-5.). The assessments clearly show that the areas along the Ipoly River, the Börzsöny marshes and the small watercourses are the most vulnerable and ecologically valuable areas, and are therefore at increased risk from anthropogenic impacts.

Considering the planned route of the M2 motorway, the most critical zone, where the route will cross core habitat areas, is the Ipoly Valley. The Ipoly Valley (Figure 8.) represents an important bio-corridor and core habitat. The planned section of the M2 motorway between Rétság and the border may affect the Ipoly Valley Special Nature Conservation Area (HUDI20026) and the Ipoly Valley Special Birds Protection Area (HUDI10008). The impact area zone of the proposed project (125-125 m from the axis) overlaps with the western edge of the two Natura 2000 sites on the outskirts of Hont, between sections 19+000-23+363 km of the Rétság-Border section.

Natura 2000 sites in the Hungarian region
1. Birds protection Directive Site,
Ipoly Valley, (SPA) (HUDI10008)

The site is composed of various habitats: the most important parts are the unregulated section of the River Ipoly and the floodplain area with different riverside terrains and diverse birdlife. Species that prefer wet meadows are present in significant numbers in the area. The corncrake population (Crex crex) is of global importance, with similar numbers (20-40 pairs) on the Slovak side of the river [9].

2. Habitats Directive Site,
Ipoly Valley (HUDI20026)

Habitat types of Community importance:
- 6440 *Cnidion dubii* river valley marshes,

Habitat types of Special Community importance:
- 6260 *Pannonian* sand grasslands,
- 91E0 Mild alder *(Alnus glutinosa)* and tall ash *(Fraxinus excelsior)* woodland *(Alno-Padion, Alnion incanae, Salicion albae)*

In order to minimise barrier effects in the valley, several underpasses are planned, even lifting the route on pillars, but unfortunately not along the whole sensitive section. Along the River Ipoly, the complexity of the problem requires complex habitat rehabilitation. To preserve and maintain sensitive grassland and biodiverse habitat communities, a viaduct would be the most appropriate on the whole sensitive section, with the potential for a landscape bridge underneath. The construction will still cause major damage to the habitat, so ecologically the most optimal option would be to modify the track.

The ecological corridors along the small watercourses (considered as natural linear elements with a minimum width of 300 m covered by permanent vegetation connecting two core areas) were assessed at several levels. The ecological corridors were evaluated in terms of length and width, continuity, vegetation quality, type of passage, surrounding land use, and presence of water (Fig. 8.), and compared with the needs of animal species.

Table 1: Assessment of ecological corridors based on width, length, vegetation type, relation to water, continuity, surrounding landscape and animal group for which the ecological corridor is the most suitable

Name of ecological corridor	Width	Length	Vegetation type	Relation to water	Continuity	Surrounding land use	Preferred animal group
Honti- stream	excellent	excellent	closed	excellent	excellent	excellent	Amphibian/ Small and mediumsized mammals
Csitári-stream	good	good	open	poor	sufficient	good	Small and mediumsized mammals
Hévíz-stream	sufficient	good	diverse	poor	sufficient	good	Fish
Fekete-stream	sufficient	sufficient	diverse	good	good	good	Reptiles/ Small and mediumsized mammals / Large mammals
Haraszti-creek	sufficient	sufficient	diverse	good	sufficient	sufficient	Large mammals
Nagyoroszi-stream	sufficient	poor	diverse	good	poor	sufficient	Fish
Horpács- stream	sufficient/ good	poor	diverse	good	poor	sufficient	Large mammals
Almás-puszta-stream	sufficient	poor	open	good	poor	sufficient	Fish/ Small and mediumsized mammals
Derék-stream	sufficient/ good	poor	diverse	outstanding	poor	sufficient	Fish

The assessments (Table 1.) indicated the Hont creek as the ecological corridor with the best potential, mainly due to its shortness and closed vegetation cover, with amphibians and small and medium-sized mammals being the preferred fauna groups. The next corridors in order of value are the Hévíz stream, the Fekete stream ecological corridor, followed by the Csitári stream and the Haraszti ditch ecological corridors, where serious problems can be identified (e.g. no permanent water connection, high proportion of ploughs bordering the corridor). The Derék stream provides the longest connection, with a permanent water connection. The ecological corridors of the Nagyoroszi stream, Horpács stream and Almáspusztai stream are in the worst category. Basically, due to the high level of disturbance, these are characterised by poor aquatic connectivity and technical barriers.

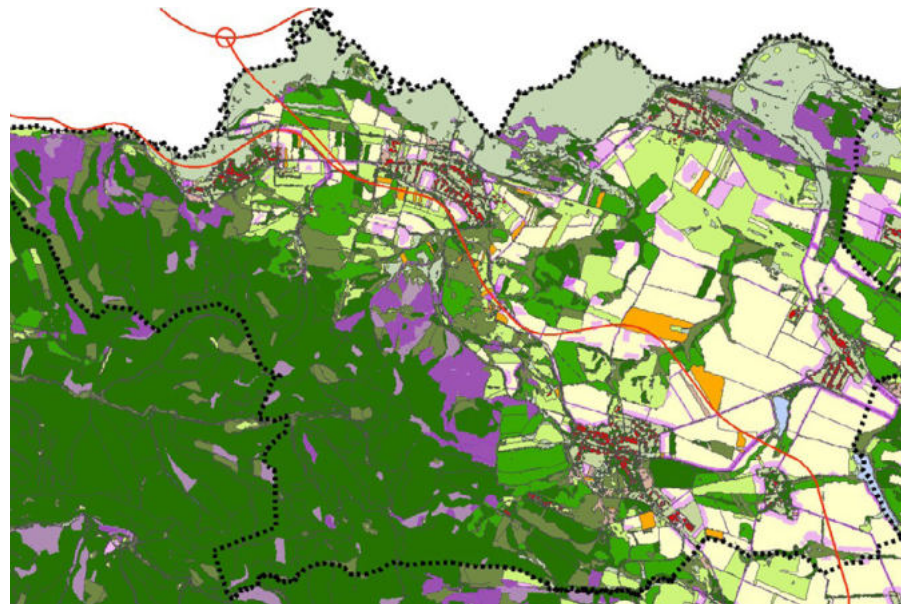
We elaborated proposals for the type of ecological crossings based on the needs of the animal groups. Comparing our results with the environmental permit, it can be seen that although the permit proposes ecological crossings in several places and even a viaduct in the Ipoly Valley, some watercourses lack crossings (e.g. the Hévíz stream). The most sensitive section is the Honti ditch area, where two core areas – Börzsöny and the Ipoly Valley – meet, where the permit also proposes a habitat bridge, although not along the entire length.

In addition to identifying the most critical sections, we have developed a complex set of landscape development proposals to improve green infrastructure and resolve land use conflicts. One of the main groups of our proposals is to link fragmented areas, such as improving and maintaining the functionality of culverts that reduce the barrier effect of transport infrastructure (the amphibian guidance (wall) system), or to install linear elements such as tree lines, strips of woodland or shrubs that reduce the barrier effect of fields and settlements. The other main group of proposals is the preservation of ecologically valuable areas such as grasslands, wetlands and watercourses.

Watercourse buffer strips should be widened to prevent fertiliser run-off and to create new habitats (Fig. 9.). The third group of proposals relates to arable land and forests. It is proposed to reclassify low-cropped arable land as pasture, mowing or orchard land appropriate to the production area. In particular, ploughland located on the floodplain of the River Ipoly, threatened by inland water and with a greater difference in level. Conflicts with forests can be reduced through forest close to natural/non-harvesting management and the use of native species. The restoration of former fruit-growing areas, which were once a strong feature of the landscape character of the area, would also have landscape diversity benefit.

ACKNOWLEDGEMENTS
The study was elaborated within the framework of the SaveGREEN project, Safeguarding the functionality of transnationally important ecological corridors in the Danube basin, INTERREG Danube Transnational Programme, (https://www.interreg-danube.eu/approved-projects/savegreen).

Figure 9: Green infrastructure development possibilities in the area, in two groups – GI development with land use change (from field to grassland, marked in light purple) and GI development without land use change (e.g. plantation forests, poor quality grassland, marked in dark purple)



The study used the results of the following publications:

- Nóra Horváth Hubayné, Zsolt Szilvácsku, Edina Dancsokné Fóris, László Kollányi, Krisztina Filepné Kovács, Ildikó Módosné Bugyi, Dalma Varga Dalma and Ágnes Sallay (Szerk.) (2021): A tervezett M2 autópálya határmenti térségének tájvédelmi és tájfejlesztési tanulmányterve. MATE, Tájépítészeti, Településtervezési és Díszkertészeti Intézet, Budapest, 2021.
- Zsombor Bányai (2021): Ökológiai folyosók értékelési módszertanának kidolgozása és alkalmazása az M2-es autópálya tervezett szakaszán, Diplomamunka, Magyar Agrár- és Élettudományi Egyetem
- Filepné Kovács. K., Bányai, Zs., Dancsokné Fóris, E., Weiperth, A., Urbányi, B., Valánszki, I., Kollányi, L. (2022): Local Cross-Sectoral Operational Plan: Landscape protection and development in the area of the planned M2 motorway in Hungary: Part of Output T2.2 "Local Cross-Sectoral Operational Plans" Gödöllő, Hungary: Hungarian University of Agriculture and Life Sciences ⦿

1 Tari, Tamás (2010): Autópálya vadátjárók kialakítása és használatuk értékelése. PhD értekezés, Nyugat-Magyarországi Egyetem Erdőmérnöki Kar. Sopron
2 Stephen, C. Trombulak – Christopher, A. Frissell (2000): Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14: 18-30. DOI: https://doi.org/10.1046/j.1523-1739.2000.99084.x
3 Scott, D. Jackson (2000): Overview of transportation impacts on wildlife movement and populations. In Messmer, T. A. and West, B. (eds): Wildlife and highways: seeking solutions to an ecological and a socio-economic dilemma. The Wildlife Society, Nashville. pp. 7-20.
4 Denim M. Jochimsen – Charles, R. Peterson – Kimberly M. Andrews – J. Whitfield, Gibbons (2006): Literature Synthesis of the Effects of Roads and Vehicles on Amphibians and Reptiles. Federal Highway Administration (FHWA), U.S. Department of 75 Transportation, Report No. FHWAHEP-08-005. Washington, D.C. pp: 151.
5 Carlo, Scoccianti (2001): Amphibia: aspetti di ecologia della conservazione lAmphibia: Aspects of Conservation Ecology]. WWF Italia, Sez. Toscana. Guido Persichino Grafica, Firenze
6 Andreas, Seiler (2003): Effects of infrastructure on nature. In Trocmé, M., Cahill, S., de Vries, H. J. G., Farral, H., Folkeson, L., Fry, G., Hicks, C. and Peymen, J. (eds): Habitat fragmentation due to train
7 Miklós, Puky (2005): Amphibian road kills: a global perspective. UC Davis: Road Ecology Center. Retrieved from https://escholarship.org/uc/item/7j7546qv
8 SaveGreen project website: https://www.interreg-danube.eu/approved-projects/savegreen
9 VIBROCOMP – BOKÚT-TERV Konzorcium (2015): M2 Gyorsforgalmi út Vác-Országhatár közötti szakasz, NATURA 2000 hatásbecslés; Ipoly völgye SPA(HUDI10008), Ipoly-völgy SCI (HUDI20026) Projekt szám: A002.02; Megbízó: NIF Nemzeti Infrastruktúra Fejlesztő zártkörűen működő Részvénytársaság

4D 67, 64–71. (2023)

DOI: HTTPS://DOI.ORG/10.36249/4D.67.3728

AZ ÖKOLÓGIAI HÁLÓZAT HASZNÁLATI ÉS KITERJEDÉSI KÉRDÉSEI MAGYARORSZÁGON

DILEMMAS IN THE USE AND LAYOUT OF THE ECOLOGICAL NETWORK IN HUNGARY

KUTNYÁNSZKY VIRÁG | SZILVÁCSKU MIKLÓS ZSOLT

ABSZTRAKT

2022 nyarán Magyarországon szélsőséges aszályt tapasztalhattunk, amely különösen az Alföldet sújtotta. Sok helyi gazdálkodó változást szorgalmazott, ám a változáshoz mindannyiukra egységesen szükség van, és a jelenlegi földhasználati módok újragondolására elengedhetetlen. A kutatásunkban az ökológiai hálózat eredeti keleti európai koncepcióját használjuk a kulcsterületek feltárására, biodiverzitás, konnektivitás és vízgazdálkodás szempontjából, meghatározva azokat a területeket, ahol a tájhasználat-váltások bekövetkezhetnek. Megvizsgáltuk a területet regionális léptékben konnektivitás-analízissel, és helyi léptékben, a területhasználatot és élőhelyeket figyelembe véve, valamint a víz természetes körforgását a tájban is beépítettük a módszertanba. Megállapítottuk, hogy a regionális léptékű modell eredményei enyhén más képet mutattak a helyi eredményekhez képest a mintaterületen, ez pedig nagyban kötődik a terület nem megfelelő műveléséhez a potenciális ártéri területeken. ⦿

ABSTRACT

Hungary faced an extreme drought in the summer of 2022, especially in the Great Hungarian Plain. Many local farmers called for change – only to find that change requires all of them to rethink the way they use their land. Our research aims to use the original Eastern European Ecological Network concept to locate key areas of biodiversity, connectivity and water management – where the necessary changes in land use can be implemented. We examined the area on a regional scale, using connectivity analyses, and on a local scale, analysing land use, habitats and aspects of the landscape's natural water cycle. We found that the regional-scale model gave slightly different results to the local-scale research, and the difference is strongly related to the inadequate use of potential flood plain areas.

Keywords: ecological network, sustainable land use, biodiversity, nature conservation

INTRODUCTION

The ecological network (EN) consists of natural and semi-natural habitats [1]. Its main function is to maintain biodiversity with increasing connectivity and to help perpetuate natural processes, such as the circulation of matter and energy [2]. The EN is a coherent, graph-like spatial system where nodes (the core habitats or source areas) are connected through corridors (links) in a network system [3]. The ecological network usually consists of four types of areas: core areas, ecological corridors, buffer zones and restoration areas. Ecological corridors can be 3 different types: linear corridors (usually alongside waterways or roads), landscape corridors (consisting of multiple patches), and stepping stones (where the habitat patches are not contiguous) [1, 4, 5, 6].

The concept originated in the Baltic countries in the 1970s and spread to Western Europe where it became a tool for biodiversity conservation. Though it has proven to be an effective system for improving species diversity, the original theory was to create a sustainably-used environment, balancing intensive and extensive land use according to the landscape's attributes and valuable natural habitats [7]. The EN also provides recreational, socio-economic and visual benefits for the community alongside ecological benefits [5] and can also help moderate the effects of climate change as part of green infrastructure.

The EN can be interpreted according to many different spatial scales [8], from entire continents, to countries and regions, to a single municipality. Studies have shown that the most effective way to map ENs is on the "meso-scale" or "landscape scale" [5, 9, 10, 11] which equates to the regional/national mapping size with core areas of 10-1,000 km² [5]. Although this scale has proven to be effective, research shows that it is beneficial to investigate more than one scale (especially zooming into the local scale) to complement and revise the mapping method or add details to the network [11].

The EN is often evaluated by measuring and modelling connectivity. Functional and structural connectivity can be determined, former with monitoring the actual routes of species movement, the latter can be designated with GIS modelling. For example, the least-cost-path analysis, used in this study, is a widely accepted GIS method regarding the evaluation of structural connectivity [12].

In our opinion, by combining the original Eastern and Western European concepts (sustainable land use and species conservation), an efficient and feasible network can be created that is more resilient and integrates both conservation concerns and the interests of local stakeholders. This requires two different perspectives and methodologies, which we aim to present in this paper. The main goal of our research was to combine these two concepts, experimenting with the scale of the EN and identifying the advantages and limitations of both. This resulted in two approaches: the larger-scale network for species conservation and the smaller-scale network for land use that takes into account the natural characteristics of the area.

DATA AND METHODS

The Hungarian National Ecological Network (NECONET) was planned in 2000 within the framework of the Pan European Ecological Network (PEEN) [13]. It was enacted into law by OTrT (National Spatial Plan) in 2002, and although it is revised every six years when a new National Spatial Plan is prepared, the scope of NECONET has not changed much since it was first established. It was last amended by legislation in 2018 in the MaTrT (Spatial Plan of Hungary) [14]. The NECONET comprises three categories: core areas, ecological corridors and buffer zones, while the concept of restoration areas is completely absent from the network. The NECONET was planned by the National Parks on a regional scale, using different approaches and methods, and then merged into a country-sized network.

As mentioned before, we conducted our research on two different scales, regional and local, using two different areas to test our methods (Fig. 1). The **"regional-scale"** study area contained the catchment area of the River Tisza, located in Eastern Hungary. To specify the area, we used the Hungarian National River Basin Management Plan with smaller modifications. The research area is 32,275 km^2 along the 597 km river. The Tisza was heavily regulated in the 19^{th} century, resulting in a simpler riverbed and creating backwaters all along the river, while also heavily modifying the flooding system and natural floodplains. The consequences of the intervention are highly sensitive right now because of climate change. In the summer of 2022, Hungary experienced an extreme lack of water and drought on the Great Hungarian Plain, which caused serious problems for local farmers.

The **"local-scale"** research area was located in Nagykörű, which is a smaller settlement along the river, between Szolnok and Lake Tisza. The study area contains parts of the administrative areas of the Nagykörű, Csataszög, Hunyadfalva and Kőtelek municipalities, and extends just under 90 km^2. The shoreline of the river is part of the Middle-Tisza Protected Area, which belongs to Hortobágy National Park. The main reason for choosing this area was to include the land use of floodplains (and potential floodplain areas) in the research to help create the network that fits into the Eastern EN approach. During our site visit, we discussed problematic land use and landscape conflicts with a local professional and farmer, Péter Balogh, who has long spoken out in favour of sustainable land use along the river. He helped us understand the river's natural water cycle, and we are also grateful for his advice.

For GIS calculations, we used the Linkage Pathways tool (Linkage Mapper 2.0.0.) in Arcmap 10.4.1. In addition, QGIS 3.0. Landsat DEM data was downloaded from the EarthExplorer's site [15]. For land cover data, we used CORINE 2018 and NÖSZTÉP (National Ecosystem Map [16].

METHOD 1 – REGIONAL EN

For the river-scale EN, we focused on biodiversity conservation and improving connectivity. The regional-scale network of the River Tisza was determined by using the least cost path method, which models the paths of the chosen indicator species or species groups between core habitats. This method is often used to model ENs because it models species movement and migration [3, 11], and the results can help identify missing links, key patches and stepping stones.

For indicator species, we wanted to take a horizontal approach, so we chose to use three indicator groups based on the most common natural habitats in the area: 1) forest-preferring species, 2) grassland-preferring species and 3) water- or wetland-preferring species. When determining the ecological preferences of these species groups, we had mainly bird species in mind, because their movement is less directly affected by the road network, and the scale of the research area is also suitable for migrating birds.

As mentioned before, to model the EN, we used the least cost path method, which requires three input layers: 1) core areas, 2) the Euclidean distances between the cores and 3) resistance rasters. For the **core areas,** we chose to use the same layer for all three indicator groups, which contained the cores from the already established NECONET. These areas have proven to be valuable natural or semi-natural habitats, containing key or endangered species by definition [14]. To reduce the number of cores and to get a more accurate result in this scale, we merged cores that were closer than 50 metres and then eliminated patches under 5 km^2, resulting in 85 core areas. According to the literature [5], the meso-scale network has cores of at least 10km^2, but this way, only 20 patches would be large enough to consider, which is why we chose to lower the minimum area to 5 km^2.

The Conefor plugin was used to calculate the **Euclidean distances** between the 85 cores. We set a threshold of 50 km between patches, because above this distance, it is unlikely that these patches would have a direct connection for any kind of species.

We used CORINE land cover as a base map for our **resistance rasters.** The three species groups each had different resistance rasters, where each set of land cover data had a specific resistance value for the group from 1-100 (with 1 the most suitable habitat for our indicator group). Then, the vector layer was converted into a raster with a pixel resolution of 50x50 metres, which is estimated to be accurate enough for our research area.

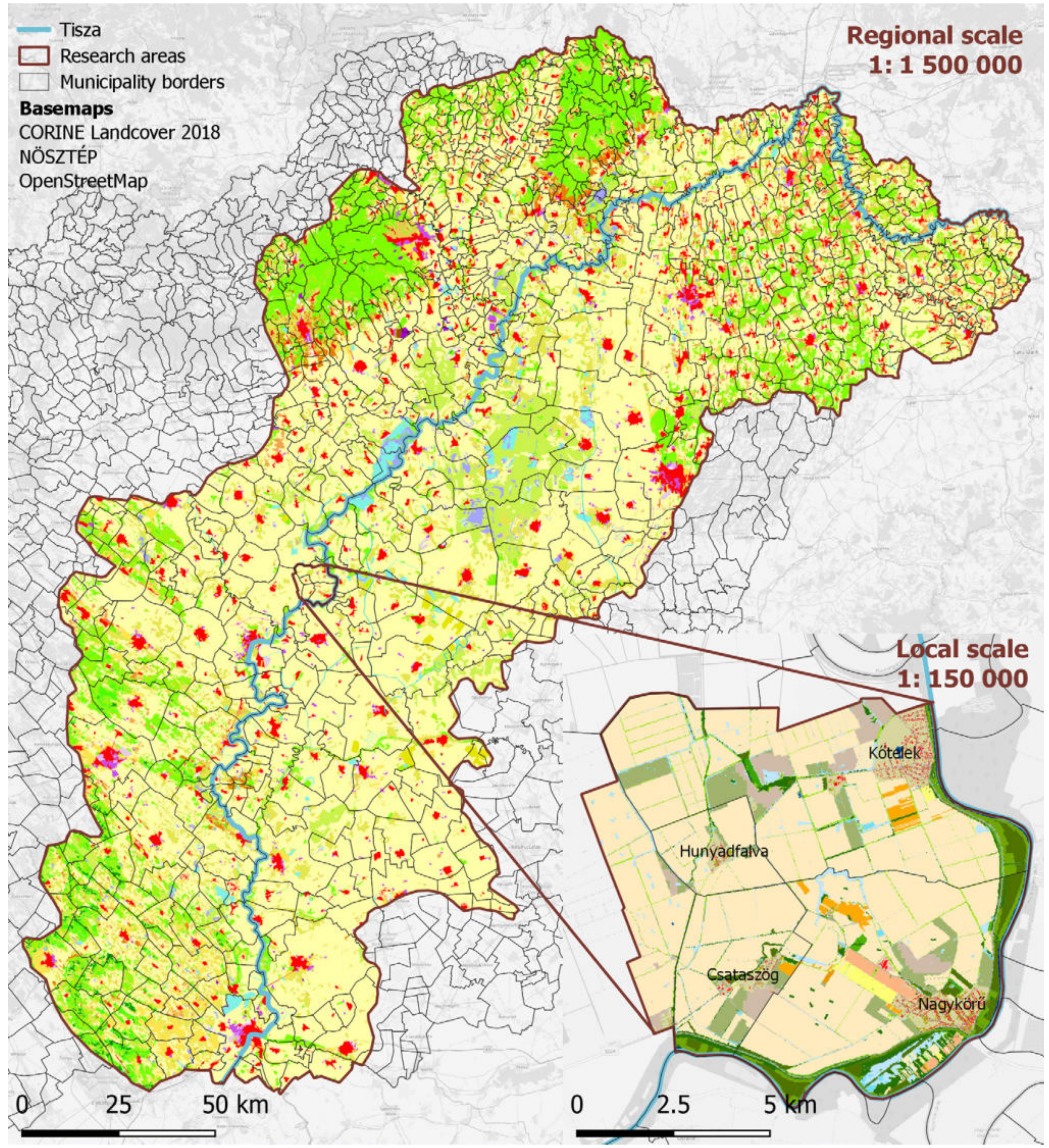
After we produced the input files, the Linkage Pathways tool was used to identify the **links** between the cores, and to generate the **cost-weighted corridors** for the three indicator groups. The corridor layers were truncated by 50,000 values to obtain narrower and specified corridors of the species along the links. These three output layers were then merged and evaluated to determine the most important habitats and connections of the EN.

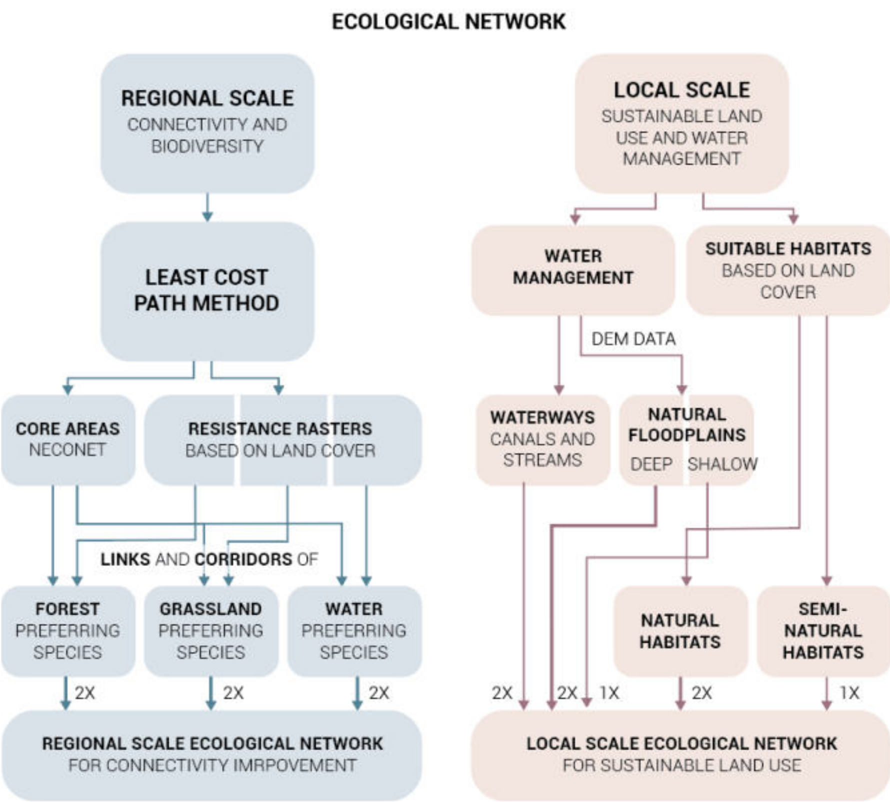
METHOD 2 – LOCAL EN

When modelling the EN on a local scale, our main goal was to include the landscape's natural water cycle and the possibilities that small, sometimes temporary, waterways (stream and canals) provide, alongside already existing habitats.

To determine the natural and semi-natural habitats, we used land cover data from NÖSZTÉP [15], which is a raster-based data source available for the whole of

Fig. 1: Regional- and local-scale research areas





Hungary. The resolution is 20x20 metres per pixel, which provides a more detailed source on this scale than CLC data, in which the MMU (minimal mapping unit) is only 25 hectares. In addition, NÖSZTÉP includes more land use categories, resulting in more actual habitat descriptions. We divided the land cover categories into three types: **natural habitats** (forests, meadows, wetlands and water surfaces), **semi-natural habitats** (orchards, gardens, forest plantations, extensive farmland and parks) and non-habitat areas (built-up areas, industrial areas and intensive farmland).

After identifying the habitats that could potentially be part of the EN, we also examined the river's natural flood system. In the 19th century, it was drastically modified, and the dam currently lies approximately 500-1,000 m distance from the riverbed. The floodplain is currently part of the NECONET in its full extent, as an ecological corridor. We used a DEM model to identify potential floodplains. Under 83 metres elevation, the area was considered to be a **deep floodplain,** and between 84 and 83 metres elevation, the area was considered a **shallow floodplain.** These thresholds were identified by consulting water management professionals and local farmers. According to their observations, above 85 metres (where most of the settlements are built), the land is completely safe from flooding.

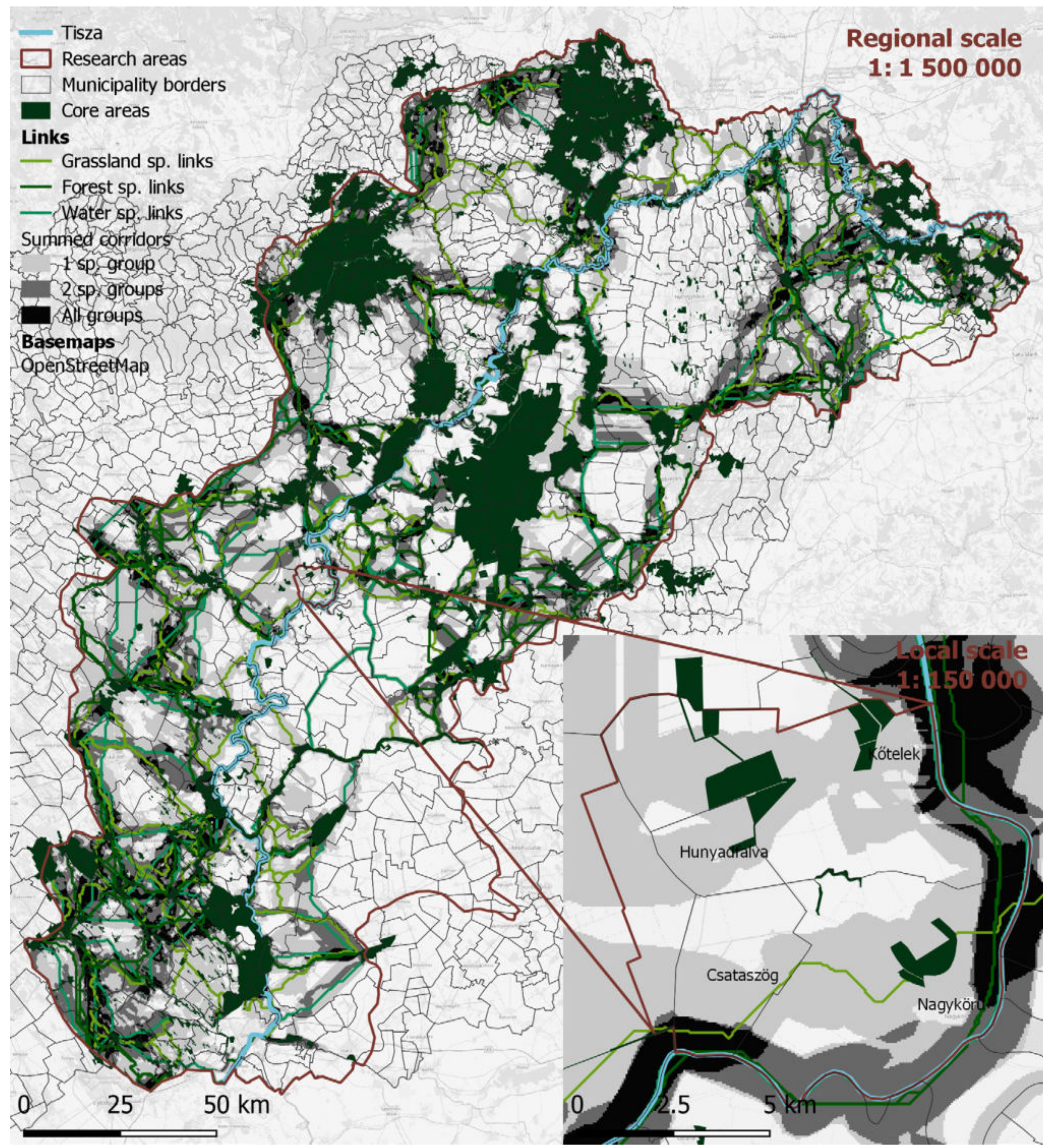
We also considered the smaller elements of the water system: the **streams and canals.** We calculated a 20-metre buffer zone around the shores for them to be effective ecotones and water retention tools. These waterways can be used to manage flooding and maintain water afterwards to help biodiversity conservation and address the lack of water on farmlands. Some of these waterways are only temporary, and especially in the summer drought, they become dry ditches, something we can also confirm after our observations made on site at the beginning of September. We acquired the spatial data of these elements from OVF (General Directorate of Water Management) for our research.

After identifying all the potential aspects of the EN, we summarised the ecological values in both scales. The methodology and the weighting of each category (indicator groups networks, natural and semi-natural areas, deep and shallow floodplains, waterways) are presented in Fig 2. The regional- and local-scaled results were then evaluated and compared to each other to identify the advantages and disadvantages of each method.

RESULTS

Evaluating **regional network** suitability based on the connectivity analyses (Fig. 3), we could establish the river's role as an ecological corridor: for all three species groups, the Tisza was an important link along its whole length. It provides an important connection for the different kind of species, because of the chain-like habitats along its shores. While the Tisza is part of the NECONET along its whole length, our results show that a buffer of at least 1,500-2,500 metres wide is needed,

◂◂**Fig. 2:** Methodology
Fig. 3: Regional-scale results



while today, protection is between 300-1,500 metres on average.

We could also observe key patches that are crucial habitats for preserving wildlife. Not only was the importance of already protected areas (like Hortobágy or other nature reserves) supported, but the importance of smaller, stepping-stone patches was also revealed. The Forest of Baktalórántháza Nature Reserve plays an important role in the ecological network, despite its size. Similarly, the forest in Fülöpjakab and the forest next to Nagykőrös also serve as key ecological stepping stones between larger protected areas.

We could also find the missing regional links when evaluating our results. We found that there is a lack of connectivity between the Nyékládházi and Ónodi lakes, and between some habitats in the Bükk National Park and the Kesznyéten Protected Landscape Area. Between the protected area of Pusztaszer and Bócsa-Bugac, the NECONET includes smaller, stepping stone-like patches, while according to our results, the area is severely lacking in buffer zones.

We found conflicting results within the **local-scale network** (Fig 4). Habitat suitability and floodplain analyses showed contrasting pictures. While according to both calculations, the river and its shore represent an ecologically important area, the floodplains are located in the middle of the area, and are mainly used for intensive farming, while suitable habitats are concentrated in the northern and southern sections of the research area.

The shores of the canals and streams proved to be the most valuable areas because of the linear vegetation and lower elevation. Other outstanding results can be found around the wetland areas, such as those along the border of Csataszög and Kőtelek, or that east of the built-up area of Csataszög.

When **comparing the two results,** we found that the regional-scale analyses completely miss the importance of smaller-scale wetlands and canals, as expected, especially that on the administrative border of the two settlements. Two regional links are outlined along the natural habitats for the grassland-preferring species group, and the intensively-farmed floodplains proved to be unsuitable for EN development on the regional scale. The reason for this difference is that when calculating the least cost paths, we used land cover data as the base of the resistance rasters, only from different sources, and this way we obtained a similar result, which was expected. The valuable areas and connecting links for the forest- and water-preferring groups concentrate along the river.

Both the connectivity-based and the land use and water management-based methods found the river outstandingly important regarding the EN. This proves that the Tisza is an important corridor on a regional scale, and a valuable source habitat when examining the local scale. Additionally, it would be beneficial for both of these roles to extend and create buffer zones along the shoreline.

DISCUSSION

Only the local-scale network showed the significant importance of streams and the vegetation along them, which means that these areas are an important part of the EN on the local scale, for local connections, and can be used both as links between valuable habitats and for water retention. These areas will be used mostly by grassland-preferring species, but when new wetland areas appear, water-preferring species could also be observed.

We found that both the regional- and local-scale results were useful for modelling the EN, but by evaluating them together, we could specify the role of our local area in the regional context. The area of Nagykörű lies along the Middle-Tisza Protected Area, just under the important core habitats of Lake Tisza, and the suggested EN could serve as a link between this natural protected area and the Tápió-Hajta Regional Protected Area. When developing the EN and the habitats on a local scale, we can also consider the needs of species that are native to these protected sites.

We would suggest that the next step of this research should be to focus on feasibility and to designate more areas to sustainable land use and water management, especially along canals, making them part of the EN as restoration areas. This way, the local development of the EN could begin, serving as an example for other projects, while also showing the advantages of water retention. In discussions with local farmers, we found that some of them are open to change; we hope that they will take the next steps in sustainability, and our research could help them locate possible areas. ⦿

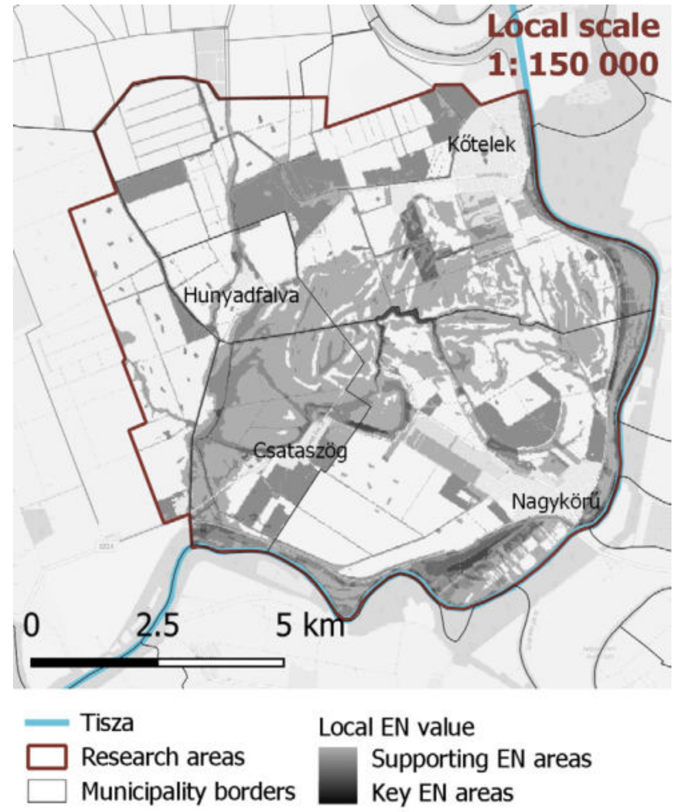


Fig. 4: Local-scale results

1 Jongman, Rob H. G. - Bouwma, Irene M. - Griffioen, Arjan - Jones-Walters, Lawrence - Van Doorn, Anne M. (2011): The Pan European Ecological Network: PEEN, Landscape Ecology. DOI: https://doi.org/10.1007/s10980-010-9567-x

2 Jongman, Rob H.G. – Külvik, Mart – Kristiansen, Ib (2004): European ecological networks and greenways, Landscape and Urban Planning 68, 305–319 https://doi.org/10.1016/S0169-2046(03)00163-4

3 Fangning, Shi – Shiliang, Liu – Yongxiu, Sun – Yi, An – Shuang, Zhao – Yixuan, Liu – Mingqi, Li (2020): Ecological network construction of the heterogeneous agro-pastoral areas in the upper Yellow River basin, Agriculture, Ecosystems and Environment 302 https://doi.org/10.1016/j.agee.2020.107069

4 Konkolyné Gyuró Éva (2003): Környezettervezés, Mezőgazda Lap- és Könyvkiadó Kft., Budapest, ISBN: 9632861078

5 Mander, Ülo - Külvik, Mart - Jongman, Robert (2003): Scaling in territorial ecological networks, Landschap January 2003, ISSN 0169-6300

6 Jongman, R.H.G. – Veen, P. (2007): Ecological networks across Europe, Zeist, the Netherlands, In: de Jong, T.M., Dekker, J.N.M., Posthoorn, R.: Landscape ecology in the Dutch context, nature, town and infrastructure, Zeist, the Netherlands: KNNV, p. 141 - 168. - ISBN 9789050112574

7 Bennet & Mulongoy 2006 – Bennett, Graham – Mulongoy, Kalemani Jo (2006): Review of Experience with Ecological Networks, Corridors and Buffer Zones. Secretariat of the Convention on Biological Diversity, Montreal, Technical Series No. 23, ISBN: 92-9225-042-6

8 Opdam, Paul – Steingrover, Eveliene – van Rooij, Sabine (2005): Ecological networks: A spatial concept for multi-actor planning of sustainable landscapes, Landscape and Urban Planning 75 (2006) 322–332, https://doi.org/10.1016/j.landurbplan.2005.02.015

9 Godfrey, Mark (2015): Reducing Ecological Impacts of Shale Development, The Nature Conservancy [20. 01. 2023.]

10 Blasi, C. – Zavattero, L. – Marignani, M. – Smiraglia, D. – Copiz, R. – Rosati, L. – Vico, E. D. (2008): The concept of land ecological network and its design using a land unit approach, Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology,142:3,540 – 549, DOI: https://doi.org/10.1080/11263500802410892

11 Nie, Wenbin – Shi, Yan – Siaw, Martin John – Yang, Fan, Wu, Renwu – Wu, Xu – Zheng, Xueyan – Bao, Zhiyi (2021): Constructing and optimizing ecological network at county and town Scale: The case of Anji County, China, Ecological Indicators 132 (2021) 108294, https://doi.org/10.1016/j.ecolind.2021.108294

12 Sedy, K. – Plutzar, C. – Borgwardt F. – Danzinger, F. – Jurečka, M. – Grillmayer, R. (2022): *A Methodology for Standardised Monitoring of Ecological Connectivity – Guidelines for the Analysis of Structural and Functional Connectivity,* Danube Transnational Programme DTP3-314-2.3 SaveGREEN project, Environment Agency Austria, Vienna, Austria, ISBN 978-3-99004-659-3, https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/56/dc86e1c6e3dac3299b3b411262b93dcdo210f85f.pdf [20. 04. 2023]

13 Érdiné Szekeres Rozália (2002): Utat az élővilágnak! Az ökológiai hálózat védelme Magyarországon, *Vadon,* (9. évfolyam. 3. szám 22-23. o.)

14 2018. évi CXXXIX. törvény Magyarország és egyes kiemelt térségeinek területrendezési tervéről - Hatályos Jogszabályok Gyűjteménye. https://net.jogtar.hu/jogszabaly?docid=a1800139.tv [20. 01. 2023.]

15 Earth explorer – https://earthexplorer.usgs.gov. [20. 01. 2023.]

16 NÖSZTÉP – http://alapterkep.termeszetem.hu/ [20. 01. 2023.]

A KECSKEMÉTI FŐTÉR FEJLŐDÉSTÖRTÉNETE ÉS ZÖLDINFRASTRUKTÚRA SZEREPÉNEK VÁLTOZÁSA

THE DEVELOPMENT HISTORY OF THE MAIN SQUARE IN KECSKEMÉT AND THE CHANGING ROLE OF GREEN INFRASTRUCTURE

ERDÉLYI REGINA | SALLAY ÁGNES

ABSZTRAKT

Kecskemét urbanizációs folyamatában a főtér mindig is kiemelt szerepet játszott, a téren történő minden városépítészeti beavatkozás hosszútávon is érezteti hatását. A város közösségi élete javarészt itt zajlik, amelyhez a történelem során kialakult épület- és téregyüttes mutatós és méltó keretet ad. Szabadtér-rendszerének és térfalainak alakulása mindig társadalmi és gazdasági szinergiák hatására történt, és igazolható, hogy Kecskemét történelmi központjában a társadalom fejlődésével együtt járó változások az építészeti és tájépítészeti térformálásban is megjelentek. Jellemző, hogy térszerkezeti és térhasználati módosulások maguk után vonták a települési zöldinfrastruktúra egyes elemcsoportjainak fokozatos megjelenését a főtéri téregyüttesben. ⦿

4D 67, 72–87. (2023)

DOI: HTTPS://DOI.ORG/10.36249/4D.67.4129

Figure 1: Terracing in the city centre of Kecskemét
OWN EDITED FIGURE

ABSTRACT

The Main Square has always played a prominent role in the urbanisation process of Kecskemét, and any urban intervention in the square would have a long-term impact. The city's community life mainly takes place here, and the complex of buildings and squares that have developed over the course of history provide an impressive and worthy setting. The development of its open space system and its square walls have always been influenced by social and economic synergies, and all significant changes in the historical centre of Kecskemét can be traced and mapped in the appropriate architectural and landscape architectural spatial formations. Typically, changes in the structure and use of space have led to the gradual emergence of certain groups of elements of municipal green infrastructure in the main square complex.

Keywords: Kecskemét, main square, urban open space

INTRODUCTION

The historical city centre of Kecskemét is one of Hungary's most beautiful architectural and urban planning ensembles, a conglomeration of amorphous spaces, partly spontaneous and partly deliberately designed, interlocking with each other. The main square is also an exciting part of the city because of its walls, thanks to the varied architectural style of the buildings these walls are comprised of. Kecskemét's architectural ensemble in its main square is unique in Hungary, as the urbanisation of the town post-German Reunification was completed much later, around the turn of the millennium, and the townscape was shaped by the Art Nouveau architectural trends at the turn of the century, rather than Historicism [1]. The development of the characteristic image of the town square and the prosperity of Kecskemét around the dawn of the 20th century was due to the city's two progressive, far-sighted and modern mayors, Peter Lestár (1819-1896) [2] and later Elek Kada (1852-1913) [3], who created the financial and economic basis and regulatory framework for town planning. The boundaries of the complex town square system cannot be precisely defined: the core is formed by Szabadság Square and Kossuth Square, which themselves consist of several smaller segments, squares and promenades, while the central square is connected to the central part by additional squares and promenades. The historic city centre is defined by seven squares *("the ensemble of seven squares")*, which were formed in the same period in history, and by Deák Ferenc Square, which was created in the 1950s [Figure 1].

The most precise boundaries of the square complex are the churches built in the Middle Ages and in the 16th and 17th centuries, and the representative institutional buildings and tenement houses built in the late 1800s and early 1900s. The area delimited by the square walls covers almost five hectares. Kecskemét's current green space system fits in with the city's traditionally ring-shaped, single-centre urban structure [Figure 2]. The green areas are thus arranged in a ring and radius formation: the central inner area is characterised by mosaic, island-like green areas (Széchenyi Square, Katona József Square, Railway Station Garden, Gyenes Square), which are the result of the growth of the ring system on the original radius urban structure, while the individual functional spatial elements are connected by roadside green areas and their facades (Rákóczi street) and the green areas of the main square system.

MATERIAL AND METHOD

The research involved a literature review and plan and map analysis. In the course of the review of the city's history, monographs, journal articles and plans about Kecskemét were analysed, and the changes affecting green spaces and the plant species used in the given period were revealed on the basis of contemporary pictorial sources in the absence of written sources. Literature data were mapped onto a map of the city in order to make the spatial changes easily understandable. For the map analysis, we used both military surveys and a plan of the current town square. The results of the research have been classified into eras, identifying the most important boundaries that have determined the development of the current appearance of the town square and its current green infrastructure.

RESULTS

In the historical city centre, the structure of the main square has basically undergone three major changes due to socio-economic processes, which have also entailed the relocation of the "ideal" centre of the square [Figure 3]. The first was the extension of the main square itself between 1893 and 1896, while the other two changes took place after World War II.

As a result of the research, we identified three periods in the development of Kecskemét's main square:

- from the creation of the main square to 1914;
- the period between the two world wars; and
- from the Second World War to the present day.

THE CREATION AND DEVELOPMENT OF THE MAIN SQUARE AS WE KNOW IT TODAY UP TO 1914

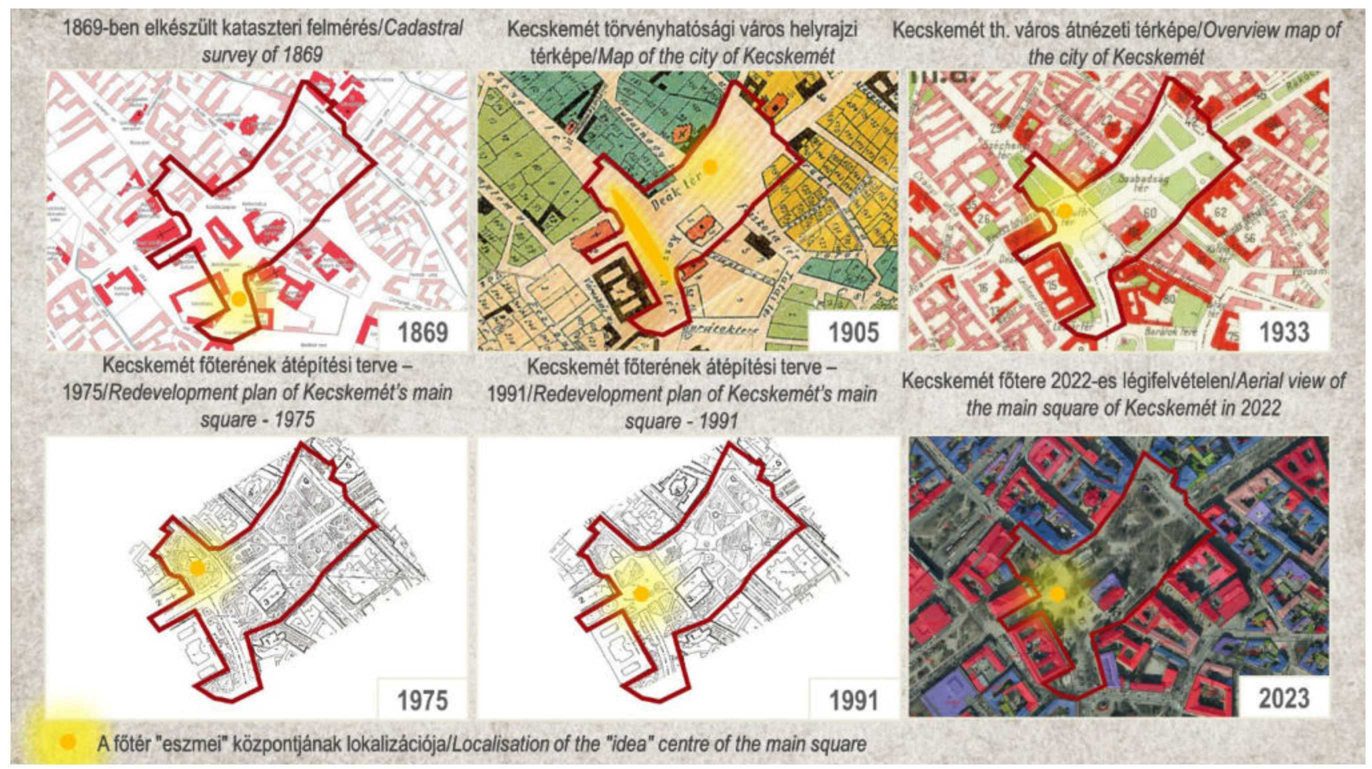
Szabadság Square, Kossuth Square and Széchenyi Square were already built-up areas in 1880, but they took their present form after the market square at the junction of the commercial roads was laid out and rebuilt [4]. In the past, the centre of the town had merely been a spontaneous junction of roads from the settlements around the then market town.

By the 19th century, a civilized nucleus had developed in the centre of the giant village, and the town centre was filled with new buildings: new churches, a monastery, a town hall, shops, a butcher's and mills were built. Being a clustered settlement, the new buildings were erected without any ordering principle and, as the 1869 map shows, the town centre was a spontaneous cluster of small and large squares. The new services and growth of the municipal apparatus required new buildings, which could only be achieved by reorganising the structure of the town centre.

In addition to the social processes, the boom in cultivation in sandy soil –the result of the phylloxera that devastated traditional vineyards – in turn led to a boom in the local economy in the 1890s, with famous markets and significant exports [Figure 4] [6]. In order to accommodate the ever-growing market, in 1889 the town assembly ordered a financial and planning framework to be drawn up to expand the market area, and the plans were entrusted to Ferenc Kerekes, chief engineer [5].

Figure 2: The main spatial elements of Kecskemét's green space system
OWN EDITED FIGURE, BASE MAP SOURCE: INTEGRATED URBAN DEVELOPMENT STRATEGY OF THE CITY OF KECSKEMÉT (2014), KECSKEMÉT CITY DEVELOPMENT LTD, KECSKEMÉT

Figure 3: Localisation of the "ideological" centre of the main square by period
OWN EDITED FIGURE, SOURCE OF BASE MAPS: CADASTRAL SURVEY OF 1869 (HUNGARIAN NATIONAL ARCHIVES, BÁCS-KISKUN COUNTY ARCHIVES, XV.1.A.1 .86,442-461, 1-19, 1:2500), GUSZTÁV RIHOCSEK, MAP OF THE CITY OF KECSKEMÉT (HUNGARIAN NATIONAL ARCHIVES, XV. 1. A. 1 502, 1:10000), OVERVIEW MAP OF THE CITY OF KECSKEMÉT (HUNGARIAN NATIONAL ARCHIVES, XV. 1. A. 1 129, 765, 1:10000), REDEVELOPMENT PLANS OF KECSKEMÉT'S MAIN SQUARE, 1975, 1991 (ARCHITECT'S WORKSHOP DESIGN, INVESTMENT AND SERVICE LTD. (1994), KECSKEMÉT), AERIAL VIEW OF THE MAIN SQUARE OF KECSKEMÉT IN 2022 (MUNICIPALITY OF THE CITY KECSKEMÉT WEBSITE)



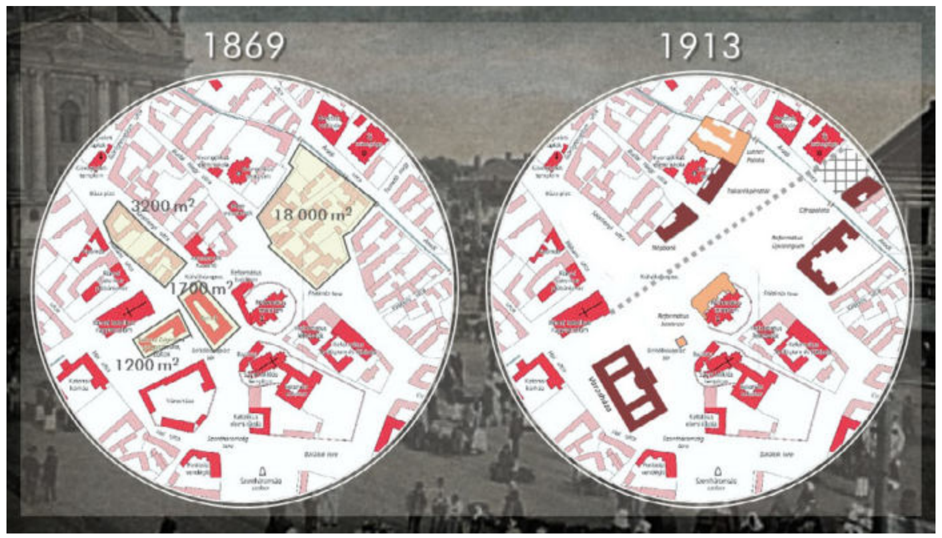


Figure 4: The fruit market of Kecskemét at the beginning of the 20th century
SELF-EDITED FIGURE, SOURCE OF POSTCARDS: POSTCARDS FROM THE ZEMPLÉN MUSEUM'S PICTURE ALBUM VIA THE HUNGARICANA PUBLIC COLLECTIONS PORTAL, NATIONAL SZÉCHENYI LIBRARY, SOURCE OF BASE MAP: GUSZTÁV RIHOCSEK, MAP OF THE CITY OF KECSKEMÉT, 1905 (HUNGARIAN NATIONAL ARCHIVES, BÁCS-KISKUN COUNTY ARCHIVES, XV. 1. A. 1 502, 1:10000

Figure 5: Changes in the layout of the main square between 1869 and 1913
SELF-EDITED FIGURE, SOURCE OF BASE MAP: MAP BASED ON THE CADASTRAL SURVEY OF 1869 (HUNGARIAN NATIONAL ARCHIVES, BÁCS-KISKUN COUNTY ARCHIVES, XV.1.A.1.86,442-461, 1-19, 1:2500)

Figure 6: View of Szabadság Square
SOURCE OF POSTCARDS: ZEMPLÉN MUSEUM'S PICTURE LIBRARY VIA HUNGARICANA PUBLIC COLLECTIONS PORTAL, NATIONAL SZÉCHENYI LIBRARY

The plans were implemented in phases, with several modifications, taking into account the existing church, service and administrative buildings that make up the existing square wall. The north-eastern boundary of the planned square was already defined by the Synagogue and the former Beretva Hotel, and to the south-west by the Great Roman Catholic Church and the new Town Hall. By the mid-19th century, the old town hall was no longer able to cope with the increased official needs, and a tender was launched to design and budget for a new town hall. The winning design was submitted by Ödön Lechner and Gyula Pártos, and the Town Hall was built between 1893 and 1897 [1, 7].

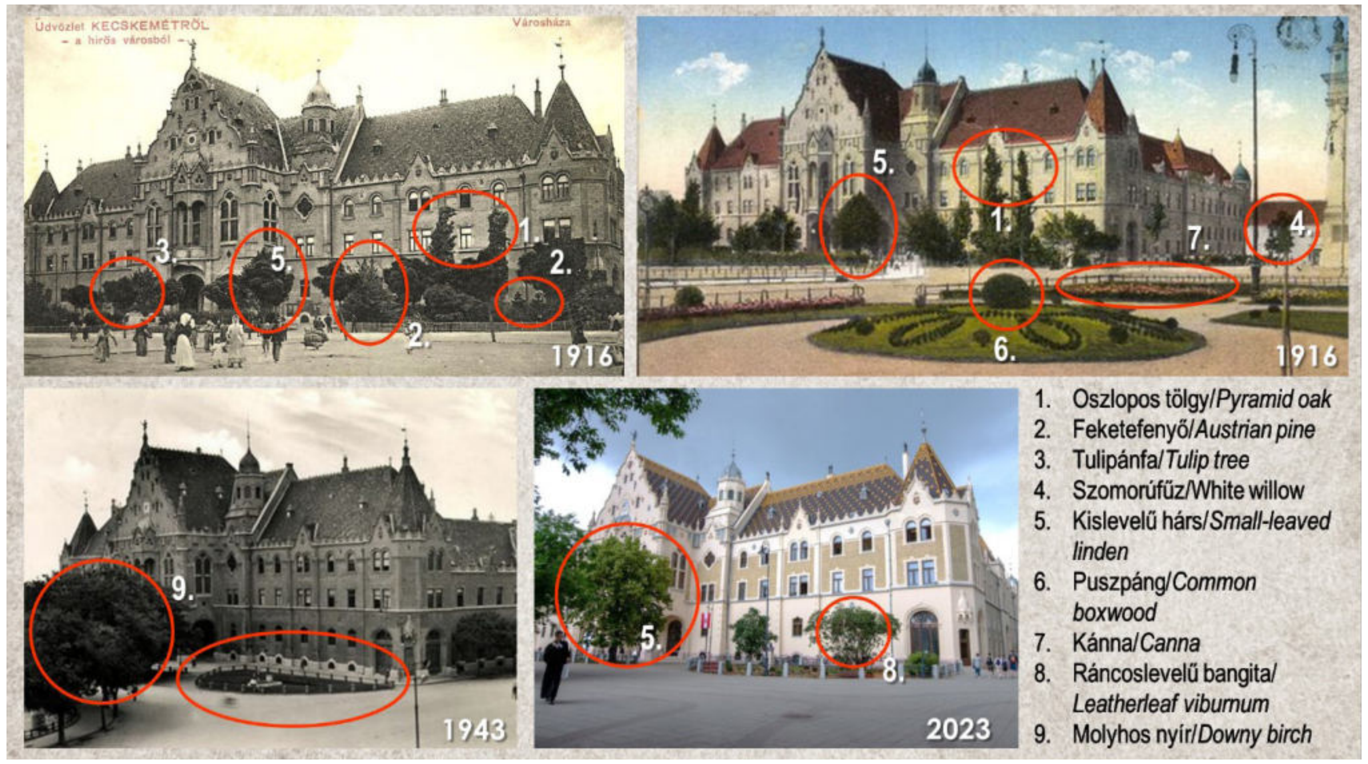
Due to the expansion, the block of flats in front of the Synagogue and the former Beretvás Hotel, the Roman Catholic Church shop, Buttinger's pharmacy and Kozma Square, also consisting of flats, had to be appropriated and then demolished [Figure 5]. In 1876, the headquarters of the Savings Bank Association was built, the main façade of which also defined the north-western boundary of the square to be built. Dimó House and the Casino Block had to be demolished on the north-western boundary of the square in order to create a unified design, and the Commercial Credit Institute and People's Bank were built in their place in 1912 [5, 23]. A straight avenue was needed to connect the fairground with the railway traffic, and this was built at the turn of the century with the construction of the 42 m-wide, 500 m-long Rákóczi street. Between 1910 and 1913, three other large and important buildings were constructed, creating the missing walls of Szabadság Square. Luther Palace was built by the local Evangelical congregation in 1910-11. Opposite this, the Calvinist Church had a huge, imposing building called the New College built in 1911-13 [9-10].

The city's economic prosperity and the high level of construction activity were halted by a major natural disaster, which also prevented the city from continuing its dynamic development: on 8 July 1911, the city weas shaken by an earthquake, estimated at 5.6 on today's Richter scale, causing severe damage to private and public buildings. Due to the budget deficit resulting from the expenses necessary for the reconstruction, the started and planned large-scale investments had to be postponed [11]. In addition to the financial loss, the city was further burdened by the death of Mayor Elek Kada in 1913, and after him, that of Ödön Lechner in 1914 [12]. Kecskemét's golden age finally came to a complete end with the outbreak of World War I.

As a result of the renovations, the square area was extended by more than 24,000 m² and by the turn of the century, a large square consisting of three smaller ones had been created [Figure 5]. In the demolished town centre square, the thoroughfares were paved with cobblestones (12,000 m²) and the market square with bricks (17,400 m²) [5]. Tree planting in the main square began as early as 1897: over the decades, they were mainly used to line the roads and to separate and shade the various kinds of markets. Trees were planted throughout the town by the gardener Károly Bajnóczi, who was appointed the town's chief gardener in 1903 [5]. Typically, trees with round crowns (probably of the genus *Sophora, Acer, Catalpa, Prunus*) were planted, as depicted on postcards of the period. A comparison of postcards after the turn of the century shows that the expansion of the market area (Szabadság Square) and the change in the transport network led to more and more trees being planted [Figure 6].

Until the late 1940s, most of the main square consisted of single-storey structures, with a tree canopy of round-topped trees. Multi-storey planting (shrubs and flower

Figure 7: View of the Town Hall
SOURCE: HUNGARICANA - ZEMPLÉN MUSEUM'S PICTURE LIBRARY VIA THE PUBLIC COLLECTIONS PORTAL, NATIONAL SZÉCHENYI LIBRARY, WWW.SZECESSZIOSMAGAZIN.COM, WWW.BAON.HU
▸▸**Figure 8:** Vegetation of Szabadság Square
SOURCE: EGYKOR.HU, FORTEPAN / GYÖRGY ÁDÁM DR, FORTEPAN / LUDWIG KELLNER
▸▸**Figure 9:** Vegetation of Kossuth Square and the park in front of the Aranyhomok Hotel
SOURCE: FORUM.INDEX.HU, EGYKOR.HU



beds) was only found in the historicised small garden in front of the People's Bank and in the four ornamental gardens in front of the Town Hall. The ornamental gardens in front of the Town Hall were densely planted with the fashionable plants typical of the historicism *(Quercus robur 'Pyramidalis', Pinus nigra, Liriodendron tulipifera)* [Figure 7]. The change of habitat of the *Tilia cordata* planted for the millennium is clearly visible from the pictorial sources, and the tree is still present today.

THE PERIOD BETWEEN THE TWO WARS

Between the two world wars, the use of space in the main square was still dominated by the fruit market, but the core of the function shifted from Kossuth Square and the spaces developed different functional characteristics. Széchenyi Square was the producers' market, Szabadság Square and Rákóczi street the consumer (mixed) market [6], and various shops were located on the ground floor of the multi-storey buildings fronting the square. Széchenyi Square was used more by the wealthy and the elite, while Liberty Square was used by the less wealthy. In 1949, the market, which played an important role in the life of the city, was finally moved away from the main square to an area cleared out of the eastern side of the Piarist monastery garden [13]. In 1929, a two-storey Calvinist tenement building was built as a south-eastern square wall next to the Calvinist Church on the corner of Kálvin Square, which was considered the outflow of the square complex [13]. Although the main square was already landscaped in 1897, no landscaping took place until 1949, except for the historicising rail in front of the People's Bank, because the high market turnover and the lack of water supply did not allow it [5]. The landscaping of Szabadság Square was

started immediately after the water supply was provided, and the market was relocated to this area. In front of the People's Bank, a circular group of flowers and low shrubs planted and trimmed in a solitary or geometric pattern formed the green area, along with grassy beds. Photographs taken from the tower of the Great Roman Catholic Church and from Szabadság Square [Figure 8] show that the style of the historicised garden area was simplified after the devastation of World War I, to make it easier and cheaper to maintain. The photograph of the church tower shows the strengthening of the trees lining the Szabadság Square market and the boulevard through the main square, and the felling of the tree line along the diagonal axis of traffic in front of the New College. In the ornamental gardens in front of the Town Hall, the vegetation was completely eradicated [Figure 7]. The *Betula pubescens* in front of the Town Hall was replaced by *Celtis occidentalis*.

CHANGES IN THE HISTORIC CITY CENTRE AFTER 1945

Immediately after the Second World War, in 1946, a monument to Soviet heroes was built on Szabadság Square, in line with the ideology of the time. The obelisk, covered with black granite slabs, was placed on a pedestal rising from the ground level, with a ceramic-clad parade ground in front of it [13]. The monument was installed at the centre of a spatial composition structured on axial symmetry, a rigid composition that replaced the historicised spatial part of the earlier geometric forms.

In 1950, Kecskemét was promoted from a city of jurisdiction to a county seat under the administrative territorial reforms. Due to the space requirements of the new public institutions, the historic main square was enlarged in a westerly direction, and Deák Ferenc Square was created with its new commercial, administrative and cultural institutions [5].

With the provision of the water supply, the landscaping of Szabadság Square was immediately started and the market was relocated from this area. Contemporary postcards show that while the trees in the western part of the square were planted in regular rows, Szabadság Square was landscaped with irregularly arranged groups of trees [Figure 8]. This part of the square is planted with *Betula p., Picea pungens, Populus nigra 'Italica', Celtis:* two of the poplars are still present in this part of the square, as are the hackberry hedges that line the *'Mende axis'*. In the centre of the square, a piece of circular water architecture *("Frog Pond")* was created, with large flowerbeds lining the square and the surrounding promenade. Presumably to minimise maintenance costs, these flower beds were removed in the following decades. It was common to enclose these larger green areas for safety reasons (the parks were bordered by public roads) and to protect them from vandalism (mainly trampling).

The market function was maintained in Kossuth Square and the area in front of today's Aranyhomok Hotel, which is connected to Szabadság Square. In 1959, Kossuth Square was landscaped by a social project with an architectural design, with the statue of Kossuth in the centre, asphalt paved walkways, green areas lined with rose beds and planted with silver pines, whip-lash lamps and candelabra fluorescent tubes [14]. The square in front of the Aranyhomok Hotel was the site of the fruit market until 1957, and then the central bus station until 1962, which was demolished before the hotel was opened. The landscaping of the square was completed after the hotel was built in 1962-63, based on the plans of architect György Wossala and mechanical engineer Károly Szücs, with the planting of pre-grown ground pines and birch trees, a fountain and a water basin [5]. The fashionable evergreen species of the 1970s *(Juniperus virginiana 'Grey Owl', Cedrus atlantica 'Glauca', Picea pungens)* were introduced here, with ornamental beds being planted first with roses and then with the iconic *Celosia argentea var. plumosa* [Figure 9]. The last major change in the structure of the current spatial system was the construction of the Aranyhomok Hotel. The funnel-shaped Széchenyi Square of that time was replaced by a piazza, which today is Széchenyi Square [15]. Further changes occurred within the square walls. In 1958, the Beretvás Hotel, built in 1856, was demolished due to its obsolete structure, and the OTP Head Office Building was built in its place in 1968-70 [5]. The Art Nouveau buildings harmonise well with the old ones (Baroque churches), but the insertion of modern buildings into the main square walls still has a disharmonious effect. The character of the grid-like mass of the Aranyhomok Hotel is somewhat offset by the green space created.

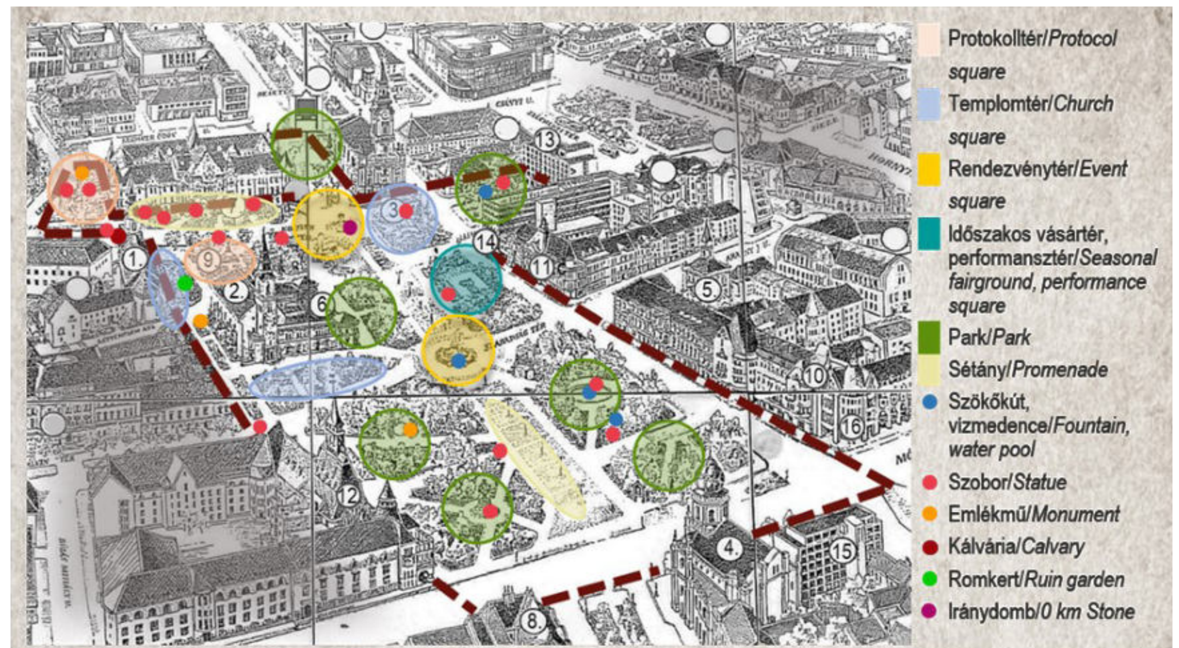
By the end of the 1970s, the main square had become an important traffic junction, with heavy road traffic, the Békéscsaba and Dunaföldvár roads running into it, as well as the traffic of 26 streets. The high presence of motorised traffic, air pollution and noise pollution made it impossible to relax in the park in Szabadság Square, to enjoy the safe flow of pedestrian traffic or to enjoy the Art Nouveau square wall complex, and the whole square was affected. To relieve the congestion, in 1976 the city council decided to start building an internal rail system based on the General Plan proposal and to convert the historic square into a pedestrian zone [15]. At this time, the town centre was rehabilitated with a focus on historic preservation – based on the designs of architect Gábor Farkas, landscape and garden architect Antal Mayer and sculptor Gusztáv Pálfy – and the square was restored to its current state. Kéttemplom köz, a pedestrian street with the renowned Kodály Institute, is an integral part of the central car-free space. At the mouth of Kéttemplom street, a ruin garden was created on the northern side of the Franciscan monastery complex by demolishing the bazaar row [13].

By the end of the 1990s, owing to functional changes (e.g. the demolition of the Soviet monument) and wear and tear, the main square and its immediate surroundings needed cleaning up. The square complex has been completely rebuilt in parts, both in terms of paving, utilities, street furniture, street lighting and green areas. Kossuth Square was rolled back, the polygonal green areas lined with rose beds were removed and replaced by much smaller, circular, curved small stone paved areas with prominent tree shade. This design detail, popular in the 1970s, has the advantage today of being able to create multi-storey, representative planting without compromising the current public use of the square (fairs, festivals). As the final phase of the overall square reconstruction, Szabadság Square and its surroundings (Kalvin Square, Kéttemplom street) were renovated in 2015 as part of the Functional Urban Regeneration Programme [17]. Between 22-27 June 1982, an international ICOMOS colloquium on *"The monuments of the last hundred years"* was held

Table 1: Green infrastructure developments for the three defined eras
OWN DATA TABLE

From the creation of the main square to 1914	Between the two world wars	From the Second World War to the 1990s
The main square is mainly planted with trees with globular crowns *(Acer p. 'Globosum', Catalpa sp., Prunus f. 'Globosa')* and *Sophora japonica*	No major development of green infrastructure, but an increase in the number of trees lining roads and various types of market	In 1949, the landscaping of Szabadság Square was started with irregularly arranged groups of trees
Historicising ornamental garden in front of the People's Bank with flower beds and low shrubs		In 1959, Kossuth Square was landscaped, and in 1962, the area in front of the Golden Sands Hotel was landscaped with three levels of vegetation
Planting of the ornamental gardens in front of the City Hall with trees and medium-height shrubs		In 1976, new green areas were created during the conversion into a pedestrian zone
		In the 1990s, large-scale priority tree planting was introduced

Figure 10: Functional division of the main square, elements of the square wall
OWN EDITED FIGURE



Sz./N.	Év/Year	Név/Name	Tervező/Planner
1.	XIII.-XIV. sz.	Szent Miklós templom/*The Friar's Church*	Ismeretlen/*unknown*
2.	1680-84	Református templom/*Calvinist Church*	Ismeretlen/*unknown*
3.	1774-1806	Nagytemplom/*The Great Roman Catholic Church*	Oswald Gáspár
4.	1864-71	Izraelita Templom/*Synagogue*	Zitterbart János
5.	1875-76	Takarék Pénztár Egyesület Székháza/*Head Office of the Savings Bank Association*	Pártos Gyula
6.	1877-78	Református Egyház „bazársora"/*Commercial Building of the Calvinist Church*	Pártos Gyula
7.	1873-1897	Városháza/*Town Hall*	Lechner Ödön, Pártos Gyula
8.	1902-03	Cifrapalota/*Ornamented Palace*	Márkus Géza
9.	1906	Kossuth-szobor/*Statue of Lajos Kossuth*	Telcs Ede
10.	1910-11	Luther Palota/*Luther Palace*	Mende Valér
11.	1909-12	Kereskedelmi Hitelintézet és Népbank/*Commercial Credit Institute and People's Bank*	Korb Flóris, Giergl Kálmán
12.	1911-1913	Református Újkollégium/*Calvinist New Collage*	Mende Valér
13.	1959-62	Aranyhomok Szálloda/*Golden Sands Hotel*	Janáky István, Albert Jenő
14.	11965-68	Lordok Háza/*House of Lords*	Neuhauser László
15.	1968-70	OTP Székház/*OTP Head Office*	Neuhauser László
16.	1986-87	Lakóház/*Apartment building*	Farkas Gábor

Figure 11: Percentage of surface qualities in the main square
OWN EDITED FIGURE
Figure 12: NDVI vegetation index for the main square and its surroundings
OWN EDITED FIGURE
Figure 13: Current vegetation of the main square in Kecskemét
OWN EDITED FIGURE BASED ON OWN FIELD SURVEY

in Budapest and Kecskemét [18]. The main square of Kecskemét and its surroundings were declared an *"area of monumental significance"* by the then Ministry of Environment and Regional Development and the Ministry of Culture and Public Education.

THE MAIN SQUARE IN KECSKEMÉT TODAY

The main square currently performs sacral, representational, recreational, relaxation and aesthetic functions. The division of space according to its purpose is illustrated in Figure 10. The main square is decorated with four water basins, the ruin garden, 17 statues, three monuments, the statues of the Calvary and Iránydomb (Beacon hill) [Figure 10].

Representing the formal solutions of the 1970s, the square is defined by a straight structural axis with a north-east-west orientation – a wider corridor created on the site of the former main road – three transverse axes, as well as circular terraces and diagonal pedestrian walkways [Figure 11]. The square is divided into two parts with two different characters. In the western part, there are larger continuous paved pedestrian surfaces, while the eastern part is more park-like; the landscaped areas (e.g. Szabadság Square, the green space in front of the Aranyhomok Hotel) and their spatial functions have been retained. After the demolition of the Soviet monument, the paved area between the Calvinist Church and the old People's Bank was transformed into a performance space *("Square in Square")*, designed by Gábor Farkas [16]. A fountain was built at the intersection of the axis connecting Kálvin Square and Arany János street and the main axis, and a landmark dome was built at the intersection of the promenade in front of the Town Hall on Kossuth Square and the main axis. The third transversal axis connects the Luther Palace and the Calvinist New College, named after the designer of the two buildings, Valér Mende *("Mende axis")*.

The main square is chiefly defined by its abundant and taxonomically rich vegetation. 22% of the almost 50,000 m² of the square is covered by wooded grassland, 9% by ornamental gardens and 2% by wooded shrubs [Figure 11]. The square contains nearly 250 trees and shrubs, with a total value of HUF 1.4 billion [19]. Facades are more visible in the built-up area. Tree groups can be found in the raised beds bordered by small pebbles, typical of the 1970s. Despite the major structural alterations, it is noticeable that the tree lines and tree groups still have a separating function, further dividing the spaces created by the built-up square walls. The green area in front of the Aranyhomok Hotel has a three-level plant stand, as does the green strip along the former bazaar row separating the traffic axes with the remaining trees of the tree line along the old boulevard. All these are clearly visible on the NDVI vegetation intensity map; the average vegetation index of the main square complex is 0.22 [Figure 12].

The typical species in the N-S axes and in the hedges west of Arany János street is *Celtis occidentalis,* while *Sophora japonica* is the species common to Rákóczi street up to the axis of Arany János street. The oldest specimen, the Millenium memorial tree, is 127 years old. The *"Hazelnut grove"* between the Town Hall and the Great Roman Catholic Church consists of a double *Corylus colurna* tree planted in 1978. More than three specimens of the genera *Betula, Ginkgo, Liriodendron, Morus, Picea, Fraxinus, Prunus, Acer, Quercus* and *Tilia* have been planted as specimens in the bare ground. The main square is also home to a number of introduced taxa *(Morus alba 'Pendula', Styphnolobium japonicum 'Pendula', Populus nigra 'Italica', Prunus serrulata 'Amanogawa')* [20]. *Liquidambar styraciflua, Paulownia tomentosa, Sequoiadendron giganteum, Ulmus minor* and *Platanus acerifolia* are also present in low numbers, with a total of five trees of local historical value.

The number of woody plants with shrub habitus is low, with 27 shrubs or groups of shrubs of the same species, with an average age of 40 years. *Berberis thunbergii* and *Ligustrum ovalifolium* appear as mass shrubs, and *Paeonia lactiflora* and *Viburnum rhytidophyllum* in front of the Town Hall are of considerable botanical value. The flower beds cover 440 m² and the dominant taxa in the annual and perennial beds are *Salvia, Celosia, Tagetes, Begonia, Rudbeckia, Gaura* and *Ipomoea.* The conversion of part of the annual flowerbeds (about one third) into rose beds

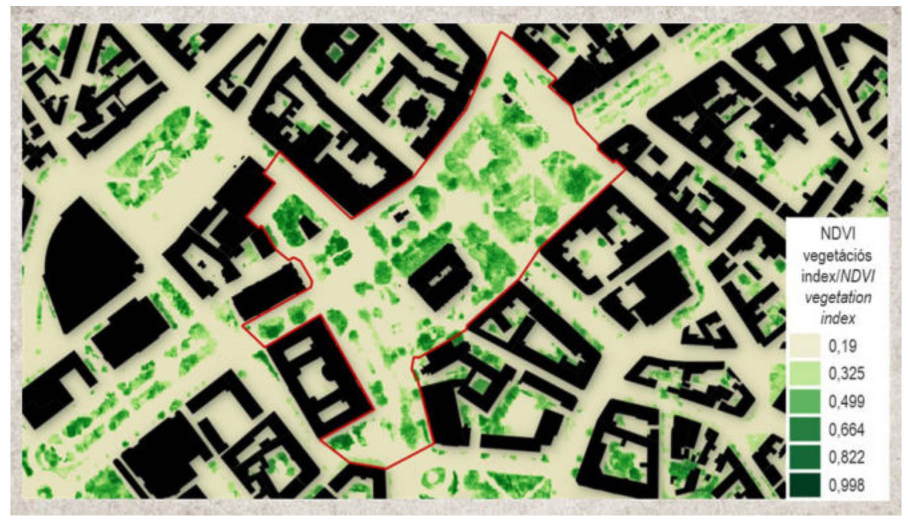


Table 2: Plant species used from the creation of the main square to the present day
OWN DATA TABLE

	The town square from its creation until 1914	In between the two world wars	From World War II to the 1990s	Nowadays
Trees				
Alley	Sophora jap. Acer p.'Globosum' Catalpa sp. Prunus f. 'Globosa'	Sophora jap. Celtis occident. Betula pubesc.	Sophora jap. Celtis occident. Tilia cordata Corylus colurna	Sophora jap. Celtis occident. Sophora jap. Corylus colurna Gleditsia triacan. Tilia tomentosa Carpinus betulus 'Pyramidalis'
Solitary trees/ irregular groups of trees	Tilia cordata (Millenium emlékfa) Quercus robur 'Pyramidalis' Pinus nigra Salix alba	Tilia cordata (Millenium ef.) Salix alba	Tilia cordata (Millenium ef.) Betula p. Picea pungens Populus nigra 'Italica' Metasequoia gl. Quercus robur Aesculus hippo. Salix alba Acer saccharin. Picea omorika 'Pendula' Fraxinus excel. Larix decidua Cedrus atlantica 'Glauca' Tilia tomentosa	Gingko biloba Prunus cerasifera 'Atropurpurea' Morus alba 'Pendula' Liriodendron tul. Liquidambar sty. Acer platanoides Tilia cordata Ulmus x holland. Quercus robour 'Fastigiata' Morus alba 'Macrophylla' Prunus sp. Acer campestre Juglans nigra Tilia cordata (Millenium ef.) Betula p. Picea pungens Populus nigra 'Italica' Metasequoia gl. Quercus robur Aesculus hippo. Salix alba Acer saccharin. Picea omorika 'Pendula' Fraxinus excel. Larix decidua Cedrus atlantica 'Glauca' Tilia tomentosa Aesculus carnea 'Briotii'

and the preparation of the technical/legal framework for the planting of roses in public spaces is under way. Direct park maintenance (management and maintenance of flower areas, grassing, shrubs, hedges, fountains) is carried out by the green area management department of Kecskemét City Management Nonprofit Ltd. Automatic watering systems are currently in operation in the ornamental gardens in front of the Town Hall, in the green areas next to the Calvinist Church, in front of the Aranyhomok Hotel and the Great Roman Catholic Church and in the *Mogyorós liget* ("Hazelnut Grove").

CONCLUSIONS

In the case of the eastern park-like area of the main square, the large mass of woody vegetation has now developed a well-closed canopy with the development of irregularly arranged groups of trees. The shading capacity of the vegetation in the main square can significantly reduce the warming of the enclosed areas and mitigate the urban heat island effect. In Kecskemét, per capita green space is 3 m²/person, which can be considered almost insufficient [19]. It can be said that there is a significant lack of public green space (at least 3-5 ha) in relation

	The town square from its creation until 1914	In between the two world wars	From World War II to the 1990s	Nowadays
Shrubs				
Mass-forming shrubs	–	Spiraea sp. (white) Syringa sp.	Berberis th. Ligustrum ov. Paeonia suffrut. Viburnum rhyt. Taxus baccata Platycladus orie.	Berberis th. Ligustrum ov. Paeonia suffrut. Viburnum rhyt. Taxus baccata Platycladus orie. Lonicera nitida 'Maigrün' Euonymus jap.
Solitaries	Buxus semperv.	–	Taxus baccata Viburnum rhyt. Juniperus virginiana 'Grey Owl' Xanthoceras sorbifolium	Viburnum rhyt. Taxus b. 'Anna' Taxus baccata 'Stricta Viridis' Cotinus c.'Royal purple' Ilex aquifolium Juniperus virginiana 'Grey Owl'
Roses	–	Bed roses	Bed roses	Rosa 'Cubana' Rosa 'Nostalgie' Rosa 'Aprikola' R. 'Chippendale' R. 'Orangerie' R. 'La Sevillana' Rosa 'Memoire' Rosa 'Kosmos' R. 'Lions-Rose' Rosa 'Amica' R. 'Augusta Luisa'
Perennials	Canna (pink.)	–	–	Pennisetum alop. Miscanthus s. 'Yaku Jima' Yucca filament. Iris sp. Stipa tenuifolia Festuca glauca Hemerocallis sp. Stachys byzant.
Annuals	–	–	Salvia splend. Begonia cucull. Celosia argentea var. plumosa Tagetes sp.	Salvia g. 'Amistad' Celosia sp. Tagetes sp. Begonia sp. Rudbeckia sp. Gaura sp. Ipomoena sp. Impatiens sp.

to the population, and therefore the main square and its rich vegetation, designed for sacral, representational, recreational and aesthetic purposes, are an important element of the green infrastructure network in the city centre.

Looking at the average age of the stand, the vegetation is young, the main square has developed taxon-rich green areas, and a diverse stand has been established since the late 1990s [Table 2]. Some of the Japanese chestnut and oyster trees in the hedgerows are already senescent, and the condition of healthy individuals is deteriorating year by year due to increasing UV radiation and urban climatic factors (heat island effect, atmospheric drought). The oldest tree in the main square is the *"Millennium Linden Tree"*, planted in May 1896 in front of the Town Hall. The crown base and the skeleton are decayed, the crown is one-sided and lateral, but with professional care, it can be maintained for several more years. Five of the pioneers have reached old age: *Acer saccharinum, Betula pendula, Populus nigra 'Italica'*. Most of the pine trees planted in the 1960s have been felled, but a few remain on Kossuth Square, on the green area in front of the Aranyhomok Hotel and next to the Calvinist Church. Although they are not native species, they should be preserved because of their important role in the landscape.

Today, there are no major social or economic factors that have a dominant impact on the morphology of the town square. In the course of time, the functional and visual system of the square complex, the order and way of using the public space, the gradual replacement of the vegetation in line with the use of the space, as well as the planned major investments affecting the institutions around the square – development of the Kodály Zoltán Music Pedagogical Institute in Kecskemét, the complex renovation and landscaping of the Katona József National Theatre in Kecskemét – will be modified by the integration of new open spaces or new spaces into the main square. The current local developments and design projects needed to influence the image of the main square are concentrated on Kossuth Square, including the fully renovated area in front of the Town Hall.

KNOWN BUT NOT YET IMPLEMENTED DEVELOPMENTS

The *Celtis occidentalis* alley in front of the Town Hall is ageing. More than 20 years ago, the horticultural expert opinion prepared as part of the planning documentation for the town square and its immediate surroundings stated that the tree line was in a critical condition, posing a risk of accidents [21]. Kecskemét City Management Nonprofit Ltd. has started to record the actual condition of the tree line by means of a FAKOPP survey. The trees have undergone multiple truncations, and some of them appear to be severely decayed even by a simple visual inspection. It is proposed to replace the tree line because of both technical and urbanistic considerations, and a renewal plan has already been drawn up. Along with the new tree line, a row of rain gardens of 8 x 2 m per unit is planned in the form of a green strip.

The renovation of the Town Hall will also involve the reconstruction of its public front, side and back gardens. As an integral part of the building, the ornamental gardens are representative green spaces that further enhance the castle-like character of the building, and have been an integral part of the building since its construction. The technical content of the restoration and improvement of the green areas is defined in the plan by green area unit, with the following elements: installation of an automatic watering system, installation of perennial ground-covering perennial grasses as turf, installation of annual, autumn-winter and specimen plants, restoration of the fence, repair and painting of utility elements, and construction of a rainwater silt trap for the rainwater collected from the Town Hall roof.

In the Kecskemét urban development plan, the extension of the pedestrianised area of the main square in all directions by increasing the green areas and creating an uniform image – keeping in mind climate-friendly planning principles – is a district objective, which requires the transformation of the city centre traffic and parking system (construction of parking garages, underground garages) [22]. Currently, the role of the footpath in traffic and urban planning is being rethought in order to further expand the zone for pedestrians and other soft transport modes. The aim is to create a city centre with a public space system consisting of public spaces, green spaces and traffic-relieved transport areas, largely paved or covered with trees, within a radius of up to 750 m from the historic city core [Figure 1]. ⦿

1 ifj. Gyergyádesz László (2019): *Kecskemét szecessziós építészete – I. Modern és magyaros.* Kecskeméti Lapok Kft., Kecskeméti Katona József Múzeum, Kecskemét

2 https://www.arcanum.com/hu/online-kiadvanyok/Lexikonok-magyar-eletrajzi-lexikon-7428D/l-76823/lestar-peter-769CA/ [2023. 03.18.]

3 https://www.arcanum.com/hu/online-kiadvanyok/Lexikonok-magyar-eletrajzi-lexikon-7428D/k-760F2/kada-elek-76110/ [2023. 03.18.]

4 Füzi László – Walter Péter (2005): *Kecskemét Fő tere. Vallomás a városról,* Kecskeméti Lapok Kft., Kecskemét

5 Juhász István (1998): *Kecskemét város építéstörténete.* Kecskeméti Füzetek 8., Kecskemét Monográfia Szerkesztősége-Tiberias Bt., Kecskemét

6 Szilágyi Zsolt (2017): *Föld és Hatalom. Mezővárosi elit Kecskeméten 1920–1939,* L'Harmattan Kiadó, Budapest

7 Sümegi György (1987): *A kecskeméti városháza.* Kecskemét Város Tanácsa, Kecskemét

8 Heltai Nándor (1998): *Kecskemét.* Kecskeméti Lapok Kft., Kecskemét

9 https://kecskemet.hu/luther-palota [2023. 03.21.]

10 https://kecskemet.hu/kecskemeti-reformatus-ujkollegium [2023. 03.21.]

11 https://kecskemet650.hu/kronika/foldrenges-kecskemeten [2023. 03.16.]

12 https://archivum.mtva.hu/stories/Lechner-odon--a-magyar-epiteszeti-szecesszio-megteremtoje [2023. 03.19.]

13 Sárosi Edit – Szilágyi Magdolna – Szilágyi Zsolt (2018): *Kecskemét – Magyar Várostörténeti Atlasz 7.* Kecskeméti Katona József Múzeum, MTA BTK Történettudományi Intézete, Budapest–Kecskemét

14 Entz Géza – Genthon István – Szappanos Jenő (1961): *Kecskemét.* Városképek–Műemlékek, Műszaki Könyvkiadó, Budapest

15 Gutai Mátyás (2005): *Kortárs építészek Kecskemétről.* Kecskeméti Füzetek 15., Kecskemét Monográfia Szerkesztősége-Tiberias Bt., Kecskemét

16 Erhardt Gábor (2016): *Interjú Farkas Gábor főépítésszel. Országépítő* (27/1.), 33-43.

17 https://magyarepitok.hu/teljesen-megujult-kecskemet-belvarosa [2023. 03.19.]

18 Dr. Fejérdy Tamás (2011): *Karták könyve. Műemlékvédelmi, örökségvédelmi dokumentumok gyűjteménye.* ICOMOS Magyar Nemzeti Bizottság 2011, Építésügyi Tájékoztatási Központ Kft., Budapest

19 Hoyk Edit – Kanalas Imre – Farkas Jenő Zsolt – Szemenyei Gyula (2019): Környezeti kihívások a városfejlesztésben Kecskemét példáján, Farkas Jenő Zsolt; Kovács András Donát; Perger Éva; Lennert József; Hoyk Edit; Gémes Tünde (szerk.) Alföldi kaleidoszkóp: A magyar vidék a XXI. században: Tanulmányok a 70 éves Csatári Bálint köszöntésére. Kecskemét: MTA KRTK Regionális Kutatások Intézete, 2019. pp. 133-146.

20 Kiss Tímea – Ecseri Károly – Hoyk Edit (2020): *Kecskemét főterének kimagasló értékei: a fák = The Outstanding Values of Kecskemét's Main Square are the Trees.* GRADUS, 7 (2). pp. 26-31. DOI: https://doi.org/10.47833/2020.2.AGR.005

21 Építészműhely Tervező, Beruházó és Szolgáltató Kft. (1994): *Előkészítés-vizsgálat és programjavaslat a Kecskemét, Főtér és környezete tervfelülvizsgálathoz, valamint új rendezési tevéhez.* Kecskemét

22 Kecskeméti Városfejlesztő Kft. (2022): *Kecskemét Megyei Jogú Város Településfejlesztési Terve 2022-2030 – Véleményezési változat,* Kecskemét

23 Körner Zsuzsa – Nagy Márta: A *városrendezési szabályozások története Magyarországon;* Műegyetemi Kiadó, Bp. 2004.

SZERZŐK ÉS TÁMOGATÓK / *AUTHORS & SPONSORS*

Magyar Agrár- és Élettudományi Egyetem / *Hungarian University of Agriculture and Life Sciences*

Akvakultúra és Környezetbiztonsági Intézet, Természetesvízi Halökológiai Tanszék / *Institute of Aquaculture and Environmental Safety, Department of Freshwater Fish Ecology*

BÁNYAI ZSOMBOR
PhD hallgató / *PhD student* e-mail: zsombor.banyai@gmail.com

WEIPERTH ANDRÁS
tudományos főmunkatárs / *senior research fellow*
e-mail: weiperth.andras@uni-mate.hu

Tájépítészeti, Településtervezési és Díszkertészeti Intézet, Budapest / *Institute of Landscape Architecture, Urban Planning and Garden Art, Budapest*

Tájtervezési és Területfejlesztési Tanszék / *Department of Landscape Planning and Regional Development*

DANCSOKNÉ FÓRIS EDINA
egyetemi adjunktus, PhD / *assistant professor, PhD*
e-mail: dancsokne.foris.edina.klara@uni-mate.hu

ERDÉLYI REGINA
PhD hallgató és városrendezési ügyintéző Kecskemét Várostervezési Osztályán / *PhD student and Town planning administrator at Department of Urban Planning of Kecskemét*
e-mail: erdelyiregina11@gmail.com

FILEPNÉ KOVÁCS KRISZTINA
egyetemi docens, PhD / *associate professor, PhD*
e-mail: filepne.kovacs.krisztina@uni-mate.hu

JOMBACH SÁNDOR
egyetemi docens, PhD / *associate professor, PhD*
e-mail: jombach.sandor@uni-mate.hu

KOLLÁNYI LÁSZLÓ
egyetemi docens, CSc / *associate professor, CSc*
e-mail: kollanyi.laszlo@uni-mate.hu

KUTNYÁNSZKY VIRÁG
PhD hallgató / *PhD student*
e-mail: kut.virag@gmail.com

LIU MANSHU
PhD hallgató / *PhD student*
e-mail: lms_1002@163.com

SALLAY ÁGNES
egyetemi tanár, PhD / *professor, PhD*
e-mail: sallay.agnes@uni-mate.hu

SHI ZHEN
PhD hallgató / *PhD student*
e-mail: Shi.Zhen@PhD.uni-mate.hu

SZILVÁCSKU MIKLÓS ZSOLT
egyetemi adjunktus, PhD / *assistant professor, PhD*
e-mail: szilvacsku.miklos.zsolt@uni-mate.hu

ÜSZTÖKE LAURA
PhD hallgató / *PhD student*
e-mail: usztoke.laura@phd.uni-mate.hu

WANG XINYU
PhD hallgató / *PhD student*
e-mail: sdwangxinyuxw@126.com

YANG YANG
PhD hallgató / *PhD student*
e-mail: Yang.Yang@phd.uni-mate.hu

YASEEN N. HASSAN
PhD hallgató / *PhD student and at University of Sulaimani, Sulaimani, Iraq Department of Horticulture, College of Agricultural Engineering Sciences*
e-mail: yaseen.hassan@univsul.edu.iq

Tájvédelmi és Tájrehabilitációs Tanszék / *Department of Landscape Protection and Reclamation*

HUBAYNÉ HORVÁTH NÓRA
egyetemi docens, PhD / *associate professor, PhD*
e-mail: hubayne.horvath.nora@uni-mate.hu

MÓDOSNÉ BUGYI ILDIKÓ
mesteroktató / *lecturer*
e-mail: modosne.bugyi.ildiko@uni-mate.hu

VARGA DALMA
PhD hallgató / *PhD student*
e-mail: dalmavarga2@gmail.com

Kertművészeti és Kertépítészeti Tanszék / *Department of Garden Art and Landscape Design*

FEKETE ALBERT
egyetemi tanár, PhD, Dr. Habil., DLA / *professor, PhD, Dr. Habil., DLA*
e-mail: fekete.albert@uni-mate.hu

Hanoi University of Civil Engineering, Faculty of Architecture and Urban Planning, Department of Landscape Architecture

TRANG DAM THU
egyetemi adjunktus, PhD / *assistant professor, PhD*
e-mail: damthutrang2004@gmail.com

DUNG DANG VIET
egyetemi adjunktus, PhD / *assistant professor, PhD*
e-mail: Dungdv@huce.edu.vn

Eötvös Loránd Tudományegyetem, Természettudományi Kar, Földtudományi Doktori Iskola / ***Eötvös Loránd University, Faculty of Science,*** *Doctoral School of Earth Sciences*

ZHANG XIAOYAN
PhD hallgató / *PhD student*
e-mail: zxy@student.elte.hu

NEMZETI KULTURÁLIS ALAP

ORMOS IMRE ALAPÍTVÁNY