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Development of the Green Infrastructure Network in Agricultural Landscape of Naszály

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Abstract

The thesis of green infrastructure (GI) Green Infrastructure Network in Agricultural Landscape of Naszály presents a comprehensive analysis of the area's ecological network, employing a systematic methodology to evaluate and propose strategies for its development and preservation. The study begins by categorizing the GI elements in the region, forming the basis for a detailed evaluation. This involves constructing a Geographic Information System (GIS) database, which maps and documents the GI elements, providing a spatial and data-driven perspective of the network.

The core of the thesis is the development of an evaluation model that incorporates various indicators and metrics to assess the effectiveness and health of the GI elements. Data collection is conducted through field surveys, satellite imagery interpretation, and network database organization, allowing for a nuanced understanding of the GI network's current state. The evaluation reveals that Naszály, predominantly an agricultural settlement with significant wetland resources, has a relatively low GI network coverage. The study identifies 229 GI elements, covering 21% of Naszály's total area, with grasslands and forests being the most prominent types. The assessment system developed for Naszály provides quantified results for different elements, highlighting the variability in ecological conditions and the overall high level of ecosystem service.

The planning strategies proposed are divided into preservation and development. The preservation strategy focuses on maintaining areas with high ecological value and good ecological characteristics, emphasizing the protection of these areas to maintain their original ecosystem properties. This strategy is crucial for protecting the most valuable parts of the GI network, forming its backbone. In contrast, the development strategy involves improving and adding to the existing GI network. It proposes measures to enhance 20 existing GI elements and add 22 new ones, aiming to consolidate and promote the stable development of the Naszály GI network.

In conclusion, the thesis provides valuable insights into the optimization of GI networks in the Naszály region, emphasizing the importance of both preserving existing valuable ecosystems and developing new elements to enhance the overall GI network. The results of the study provide strategic approaches to manage and improve green infrastructure, contributing to improving the agricultural landscape within Naszály and supporting the development of national green infrastructure.

Keywords: Green infrastructure network, Agricultural landscape, GI evaluation model, Hungarian settlement.

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CHAPTER 1

Introduction and Literature Review

1.1. Research background

Agricultural ecosystems occupy about 40% of the global land area, and human production and life are inseparable from the support of agricultural resources[1]. However, with humanity's pursuit of land use rate and economic efficiency, the intensification of agriculture is exerting unprecedented pressure on agricultural landscapes. Large-scale, long-term, and monoculture farming practices encroach upon and compress natural resources, hindering the connection of isolated patches in the field, with natural and semi-natural habitats and processes gradually being obscured[2]. At the same time, the high-intensity use of pesticides and fertilizers affects human health and well-being, leads to a decline in soil quality, and severely disrupts regional biodiversity and ecological balance. The phenomenon of agricultural intensification accelerates the emission of greenhouse gases, driving climate change while also suffering from its backlash. Droughts and other extreme weather events make agricultural ecosystems more vulnerable.

In contrast, before the era of intensification, humans, nature, and agriculture benefited each other. Agricultural areas were not only a source of food for humans but also regions of flourishing plant and animal diversity. Therefore, rebalancing the relationship between nature and agriculture, focusing on environmental protection in agricultural areas, and the sustainable development of agricultural systems are of utmost importance. This can be achieved by developing the environmental sustainability of agriculture, which can be supported by the implementation of green agriculture and the protection of agricultural landscape diversity.

The Common Agricultural Policy (CAP) maintains environmental rules and encourages green agriculture[3]. In the new European Common Agricultural Policy (CAP 2023-27), three out of the ten Key Objectives involve proposals about environmental protection, landscape conservation, and biodiversity (Figure 1.1.), aiming to mitigate climate change, achieve efficient natural resource management, and halt and reverse biodiversity loss. Additionally, the new CAP plan also promotes the practice of green direct payments. It encourages the maintenance of permanent grasslands, crop diversification, and the setting aside of ecological focus areas to protect the environment and address climate change.

Figure 1.1. Ten key objectives of the common agricultural policy (CAP) (Image source: https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/new-cap-2023-27/key-policy-objectives-new-cap_en)

In Europe, protecting natural resources needs support from agricultural ecosystems. Therefore, identifying key areas for ecological protection in farmlands and stable green resources is essential for promoting green agriculture, which can be supported by the development of green infrastructure.

Green Infrastructure (GI) has been identified as a way to help protect Europe's natural capital by promoting environmental protection outside natural reserves and adapting better to changing conditions. The goal of the European Green Infrastructure Strategy is to integrate GI implementation into existing policies[4]. This makes the task of protecting and developing natural resources almost mandatory in intensively managed agricultural areas (as they aim to receive full labor payments).

Hungary is located in the Carpathian Basin in Central Europe. It experiences a climate influenced by maritime, continental, and Mediterranean subtropical climates, usually moist throughout the year. The diverse terrain, fertile soil, and good irrigation conditions provide excellent conditions for agricultural production and human survival.

Agricultural land in Hungary accounts for over 70% of the land use, with farming becoming increasingly intensive. Natural areas and habitats are being destroyed and disappearing. According to the International Union for Conservation of Nature (IUCN), the loss of habitats is already severe for 70% of species. Based on the European Union's Corine land cover database, over half of the wetlands had been destroyed before the 1990s, and the number of wild birds has also decreased by 20-25% in the past decade. These changes are dramatic and continue to accelerate.

On December 21, the Hungarian government submitted the strategic plan for the Rural Development Program CAP 2023.1-2027.12.31, to which the European Union responded on December 22. Following the EU's Biodiversity Strategy[5][6], the associated joint committee prepared a project identified as KEHOP-4.3.0.-VEKOP-15-2016-00001 under the project framework titled

"Establishing long-term protection and development of natural values important to the community and implementing the 2020 EU Biodiversity Strategy objectives at the national level." This project provides applicable results for specific administrative planning tasks in building the national GI network and offers a professional basis for practical decisions in the land use sector.

In the project, GI is defined clearly. It's a network of natural, semi-natural, and near-natural areas, along with other vegetation and water and riparian ecosystems with ecological functions, capable of providing multiple ecosystem services[7].

The overall goal of the GI project is to develop a method and system based on databases of different resolutions and thematic depths[8]. This involves assessing the ecological condition of habitats and the spatial structure of green surfaces, evaluating the remaining green spaces and their conditions, and identifying areas that can be protected or developed for ecological purposes. This aids in planning GI networks at national, regional, or local levels, with a focus on enhancing ecosystem service levels[9][10].

The project also provides a methodological basis for GI development planning at the national scale. The main steps include baseline assessment, identifying potential restoration target areas, assessing the suitability of target habitats, identifying conflict areas, and determining potential areas for network development.

As described in related publications, the project aims to reveal and raise awareness about issues related to green spaces, ecological networks, "green" wealth, and natural resources[11][12]. It promotes the spread of new methods by introducing the concept of GI.

In summary, undertaking strategic planning, development, and management of GI at the regional scale in Hungary is a response to the national strategic plan and complements the regional level of GI network development planning. It can be coordinated with the management within administrative areas, municipalities, and ensures the maintenance and development of ecosystem services within the region.

1.2. Research contents

GI networks exist in both rural and urban environments[13]. With the current state of Hungary's agricultural ecosystem as a starting point, I aim to enhance the GI network in rural areas at a regional scale, particularly in areas with more natural elements and development potential. These areas often have a closer connection to agricultural landscapes and natural ecosystems, making them key areas for promoting green agricultural development and enriching the ecological diversity of agricultural landscapes[14].

My thesis focuses on the Naszály administrative area as the study region. The research involves investigating, identifying, analyzing, evaluating, protecting, and developing the GI network related to agriculture in the Naszály administrative area (except for the inner area). The main focus is on elements with ecological value such as shelter belts, buffers, boundaries, and patches including forests, permanent grassland, groups of trees and shrubs, wooded strips, field margins, and water protection strips, all definable GI elements.

1.3. Research objectives and significance

(1) Obtain a comprehensive regional introduction of Naszály to supplement the description of Naszály in the urban landscape image manual provided by Naszály government documents.

(2) Construct a database for Naszály's GI network, enabling it to support the national GI system as part of the GI network and provide data support.

(3) Explore a GI assessment methodology that is universally applicable at the regional scale in Hungary, offering references and insights for evaluating other settlements.

(4) Define and evaluate the elements and network of the green infrastructure network related to the agricultural landscape to identify potential target areas (for protection or development).

(5) Propose a GI planning strategy at the Naszály regional level to enhance the ecological value, natural protection, visual importance, and connectivity of the GI network.

1.4. Materials and methodology

The fundamental materials used in this study include satellite remote sensing orthoimagery from Google Earth 2022, UAV (Unmanned Aerial Vehicle) imagery from field surveys, and some related online databases (Figure 1.2.). These resources assist in defining types of land parcels, boundaries, and landscape features in land use.

Figure 1.2. Reference online database (Image by author)

The methodology of this study is primarily divided into three parts, according to different research contents. The initial phase is a regional background investigation, utilizing methods such as literature review, map collection, and field surveys. Key materials for this phase include Forest Map, MePAR, TIR, and Arcanum Maps, which are used for a general overview and organization of information.

The middle phase focuses on the evaluation of the GI network, which is the core part of the study. This phase is based on map imagery and primarily uses QGIS 2.18.27 software for building the GI system. Detailed explanations will be provided in the subsequent Chapter 5.

The final phase involves planning and conceptualizing the GI network. Based on the results obtained from the first two phases, this phase returns to the characteristics of the GI elements themselves to provide feasible protection and development plans or suggestions.

1.5. Thesis structure

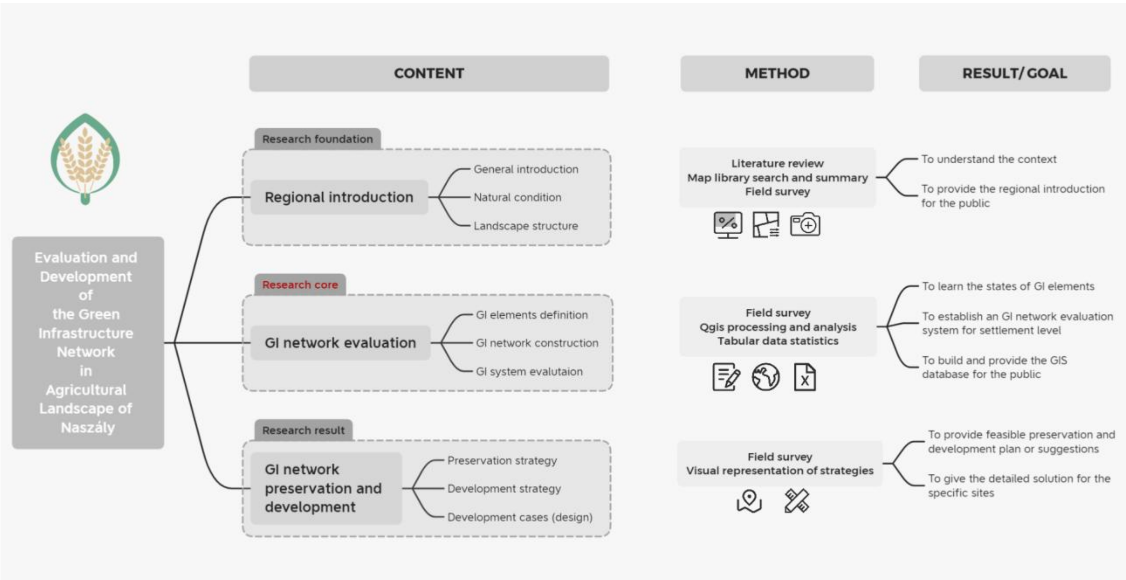


Figure 1.3. Thesis structure (Image by author)

CHAPTER 2

General Introduction of Study Area

This chapter is a general introduction to the study area, including the chosen reasons and other basic information such as administrative divisions, area, surrounding environment, population and society, in order to give readers a general background of Naszály.

2.1. The Reason for Selection

Considering the relevance of this research subject and the feasibility of conducting it, based on the pre-study of the Ecosystem Base Map of Hungary (Figure 2.1.), it is an excellent choice to select a single settlement's administrative area in Hungary. This area is rich in green resources, has high landscape value, has a moderate administrative area, and consists mainly of agricultural land.

From the perspective of research background and land cover type, the land characteristics of the study area, as a typical agricultural area in stable use, support the definition of the term agricultural landscape in this study. On a large scale, whether divided by administrative jurisdiction or national landscape characteristics, farmland in the Naszály region accounts for a substantial portion of the regional area and is a component of the core agricultural hinterland in Northwestern Hungary. Additionally, thanks to the unique geographical and climatic conditions, since the formation of a small-scale settlement in the Naszály region in the 13th century, the residents have formed a production and lifestyle based on agricultural activities such as crop planting, animal raising, and processing of agricultural and sideline products. Today, the area retains to a certain extent the use and structure of agricultural land, where land reclamation is orderly, neat, and uniform[15].

From the perspective of natural resources and landscape characteristics, the study area has diverse landscape characteristics, rich blue and green natural resources reserves, and high ecological potential, which supports the relevant research on GI extensively. From the regional scale, the five designated nature reserves overlap in the Fishpond area at the northeast corner of the study area, forming the core area of the national ecological network, ecological corridors, and buffer zones, and representing the area with the highest ecological value. Although much of Naszály is covered by a cultivated plain landscape, there are mosaics of meadows, woodlands, and forests that serve as patches, corridors, or buffer areas in the ecosystem. Together with the rich water and wetland systems in the region, they provide shelter and transportation channels for birds and other organisms.

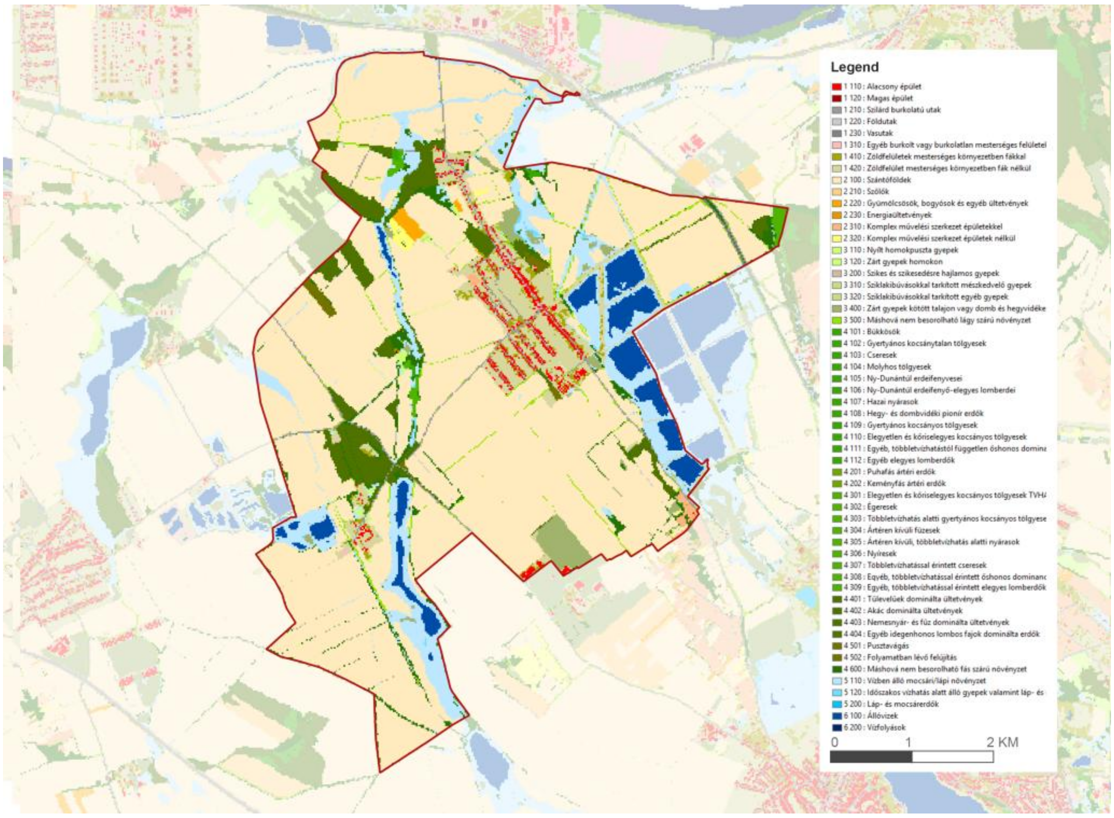


Figure 2.1. Ecosystem Base Map of Naszály
(Image by author, Reproduction: http://alapterkep.termeszetem.hu/)

2.2. Location, Administrative division, connection with surroundings

Naszály (47°41’54“ N, 18°15’46” E), is located in the northwest of Hungary, the straight-line distance from the capital Budapest is about 65 km. It is a village with an area of 33.22 km^2 in Komárom-Esztergom County, Hungary. It is located in the flood plain on the south bank of the middle reaches of the Danube, close to the Slovakian border. In the straight-line distance, the northern border zone of the area is only 1.1 km away from the riparian forest belt.

According to the scale from large to small, the division of administrative regions in Hungary includes four levels. On a national scale, Hungary is divided into seven statistical (NUTS 2) regions. The study area is located in the Central Transdanubia region, which is also part of the Outer Danube (NUTS 1) region. On the regional scale, Central Transdanubia is divided into three counties. Komárom-Esztergom County, where the study area is located, is located on the north side and is the smallest part of the three counties. On the county scale, Komárom-Esztergom consists of six districts. The Tata District is located in the north-central part and is the fifth largest in area and the second largest in population. From the district scale, Tata consists of ten villages and towns. Naszály is located on the northwestern edge, as shown in Figure 2.2. It borders the Komárom District to the west and north, and four villages in the same district to the southeast.

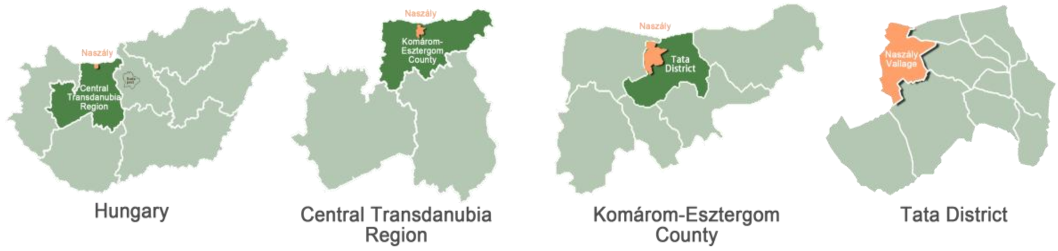


Figure 2.2. Administrative division of Naszály (Image by author, Reproduction: Wikipedia)

In terms of natural environment, besides the adjacent Danube River, Naszály is rich in water resources around Naszály. It is famous for the Ferencmajor fish pond system in the east of the region and the Tata Lake area farther away. The northeast connects the rolling Gerecse Mountains, where large areas of nature and landscape conservation such as the Dunaalmás Quarries Nature Reserve and the Gerecse Landscape Protection Area are located.

Figure 2.3. shows there are 7 urban and rural settlements adjacent to Naszály, which are mainly connected to each other through a rich road network. The large urban settlements include Tata, the capital of the district in the southeast, and Komárom in the northwest, which are directly connected by secondary roads 8138, 8134-8139. As a rural stronghold, Naszály is directly connected with Almásfüzitő to the north and Mocsa to the west by roads 8138, 8134-8141. The surrounding countryside also includes Kocs in the southwest, Neszmély in the northeast and Szomód in the east.

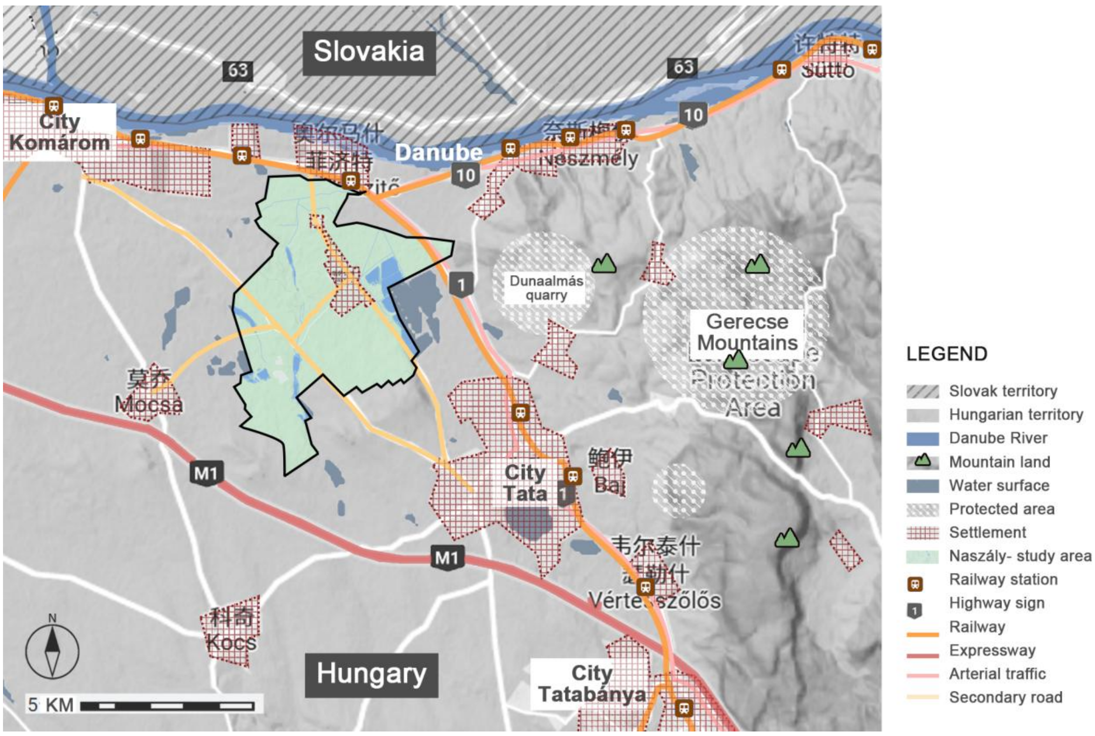


Figure 2.3. Naszály with its surroundings (Image by author, Reproduction: Google maps)

It is worth noting that although there are efficient and convenient railway transportation networks in the north and east of the Naszály area, which serve as links between towns along the Danube and the capital Budapest and the northern land respectively, there is no railway line that passes directly through the central area of Naszály. That is to say, Naszály cannot become one of the stations of the national railway network, which greatly reduces the feasibility of residents to travel by public transport, and to a certain extent hinders its communication and interchange with external regions.

2.3. Population, Society

The results of statistical data from the Hungarian National Atlas show that Naszály has a population of 2317 and a population density of 75.66/km^2. In 2018, in terms of gender structure, the proportion of women in Naszály was higher than that of men. The number of women per 1,000 men was 1,029.67 (Femininity index), slightly higher than the National statistical mean. In terms of age structure, cities and towns are aging, as shown in Figure 2.4. The ratio of the elderly (65+ years) to children (0-14 years) is 108.33 (Ageing index), which is far lower than the national average, so the aging phenomenon is relatively mild[16].

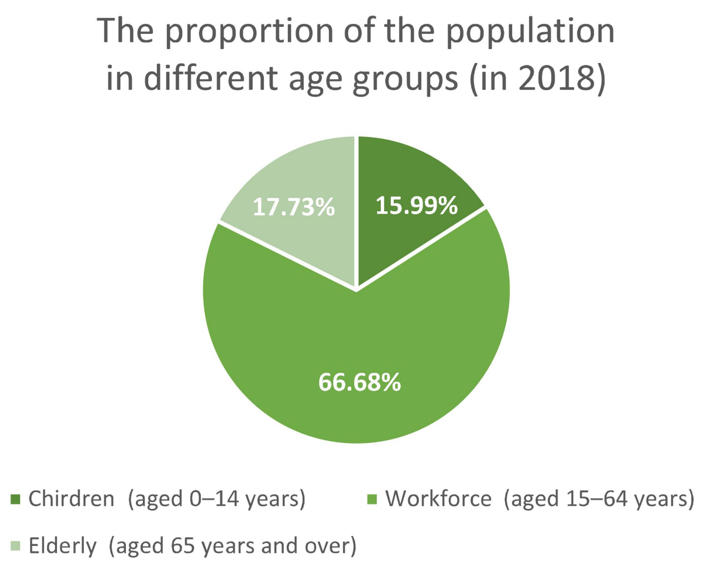


Figure 2.4. The proportion of the Naszály population in different age groups
(Image by author, data from https://emna.hu/en@47.6979481,18.2587767,13.00z)

Religiously, 77.94% of the population has denominational affiliation, mainly Roman Catholics and Reformed (Calvinists).

In terms of economic structure, more than half of employees are engaged in jobs related to the tertiary industry, as shown in Figure 2.5. Although land use in the Naszály region is dominated by agricultural land, the number of people engaged in agricultural production accounts for only 5.49% of the total number of employees. In terms of income level, the growth rate of per capita income based on personal income tax from 2009 to 2018 was 184.4%, which was basically the same as the national average. The specific income per capita is 1,410,100 HUF, which is much higher than the average[16].

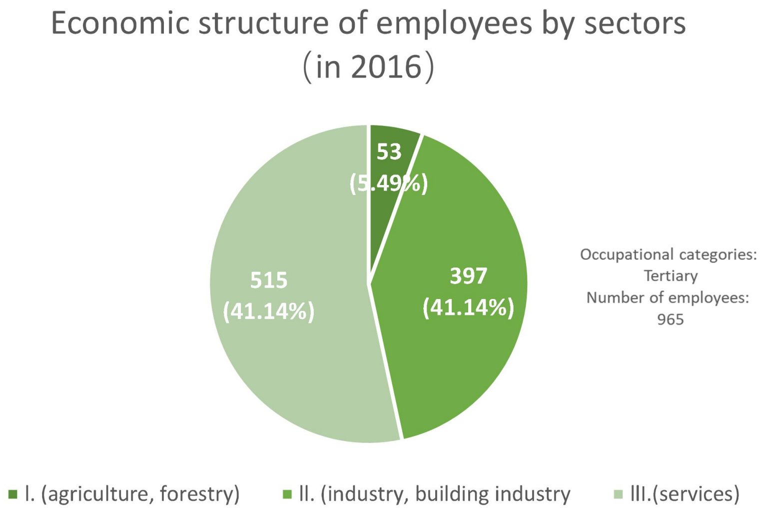


Figure 2.5. Economic structure of employees
(Image by author, data from https://emna.hu/en@47.6979481,18.2587767,13.00z)

The specific income per capita is 1,410,100 HUF, which is much higher than the average[16].

The life of the inhabitants of Naszály has a high index of vitality and well-being. The residence of the settlement's main outbound commuters. The public facilities in the stronghold are relatively complete, including municipal institutions such as kindergartens, primary schools, medical services, and cultural houses. High level of education and participation in cultural and sports activities. Residents' leisure life is undertaken by civil communities. Residents enhance their value identity by organizing folk activities such as pottery, dance and music, as well as cultural and sports activities such as literature, volleyball and cheerleading[17].

CHAPTER 3

Natural Condition

This chapter delves into Naszály's natural condition from five aspects: topography, climate, soil, hydrology, and biological species. Understanding the environmental conditions of a region is essential for studying GI network systems, as it can provide theoretical support for the determination, evaluation, protection, and development of GI elements, such as the assessment and utilization of native plants.

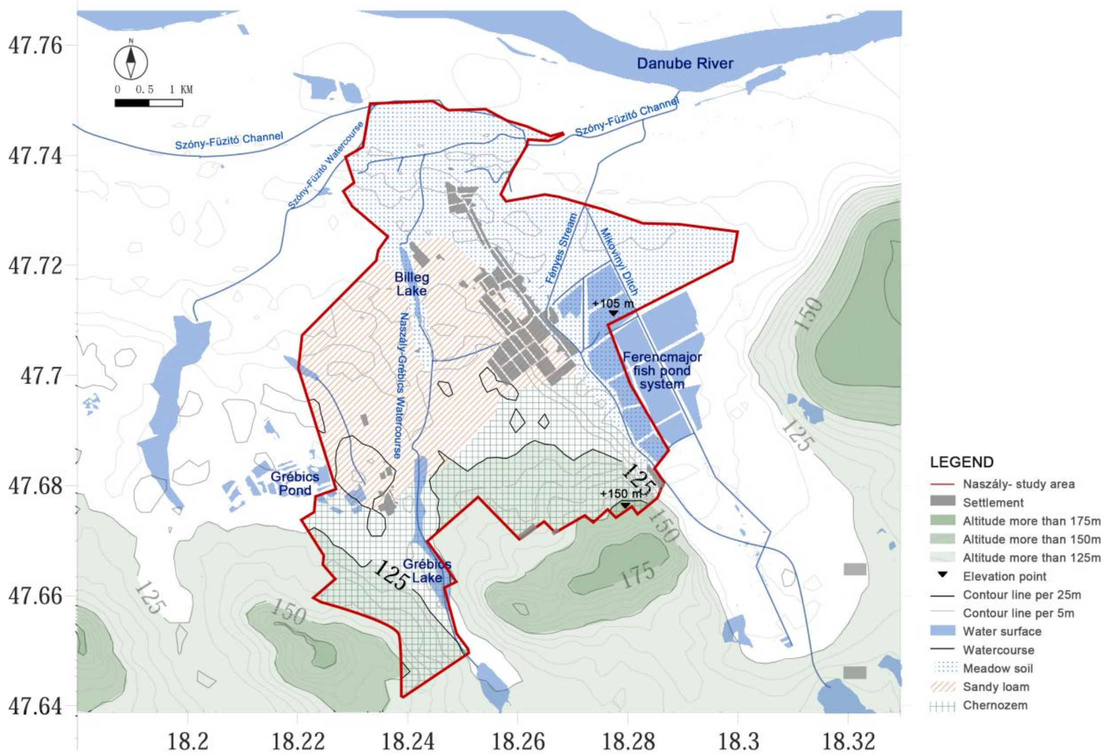


Figure 3.1. Natural condition of Naszály (Image by author)

3.1. Topography

Naszály is a part of a low-lying, poorly segmented terraced alluvial cone plain along the Danube. The area is largely flat, but dotted with some small earth mounds, see Figure 3.2. for details. Most areas are at an altitude of 120-130 m. The west side of Naszály connects the entire alluvial plain of the platform, and extend eastward through the low-lying Ferencmajor fish pond, reaching the foot of the Gerecse Mountains. The northern side is close to the Danube floodplain, which is low and gentle, and the southern part is slowly rolling hills and plains. In the interior of Naszály settlement, the terrain is almost bounded by Road No.8138 in the residential area, showing a low in the northeast and high in the southwest. The lowest elevation point is about 105 m in the fish pond area. The highest elevation point is about 150 m, located in an hilly terrain near the southeastern boundary of the TATA region.

Figure 3.2. Gentle and vast Naszály region (Photo from Google Map)

3.2. Climate

Naszály is located in the temperate continental climate zone, characterized by a semi-arid and semi-humid environment, tending towards humidity. Such a climate is highly conducive to the cultivation of arable and horticultural crops. Annually, the region benefits from sunlight for approximately 1920 to 1940 hours. In the summer, sunlight duration stands at 780 hours, whereas the winter period receives about 180 hours. The mean annual temperature ranges between 9.8-10.2°C, with the semi-annual summer average being 16.5-16.8°C.

Precipitation levels annually approximate 550-580 mm, with the semi-annual summer periods often experiencing 320-330 mm. Snowfall is frequent during winter months, resulting in ground snow coverage for about 32-35 days.

Predominantly, wind direction originates from the northwest; however, southeasterly winds are also frequently observed. The annual average wind speed is slightly above 3 m/s [18].

3.3. Geology and soil

In the lower-elevation areas of Naszály, bedrock is predominantly characterized by glacial and alluvial sediments. These are overlaid by river sand and multiple layers of aeolian (wind-transported) sand. Near water systems, the foundational rock is composed of freshwater limestone. In the elevated terraced zones, the bedrock primarily consists of loess deposits and gravels.

Naszály is dominated by three predominant soil types: meadow soil in the northern part, sandy loam soil in the western and central areas, and chernozem (black calcareous soil) in the southern region.

3.4. Hydrology

Naszály is situated within the mid-basin of the Danube River. Surface runoff predominantly stems from tributaries of the Danube such as the Szőny Water System (14 km), Kocs-Mocsai Patak (9 km), Grébics Water System (7.5 km), Fényes Stream (14 km), Mikovinyi Ditch (11 km), and Által River (14 km), among other minor watercourses. Naszály boasts abundant water resources, which are uniformly distributed outside the settlement, including four minor streams and four stretch water bodies.

The Ferencmajor fish pond system stands as the largest and richest water body in the northern Danube, bordered by the Fényes Stream and Mikovinyi Ditch. The northern part of Naszály is draped by the fine branches of the Szóny-Füzitó Channel. The Naszály-Grébics Watercourse in the central-western part links the ribbon-shaped Billeg Lake and Grébics Lake. The western region incorporates a section of Grébics Pond. Some UAV images of the water features in Naszály are shown in Figure 3.3.

Given the elevated groundwater levels, the agricultural cultivation areas in Naszály are largely positioned on the higher terraces and hilly zones.

Figure 3.3. Water features in Naszály (Photo from author)

3.5. Vegetation and other Biological resources

In the specified region, the quintessential vegetation type is softwood forest, predominantly distributed along the low flood zones of the Danube River and the banks of its channels and streams. Hardwood forests are relatively rare. The riparian zones primarily feature woody species such as green maple (Acer negundo), idol tree (Ailanthus altissima), gorse (Amorpha fruticosa), American dogwood (Phytolacca americana), late cherry (Prunus serotina), black locust (Robinia pseudoacacia), and others.

The typical climatic vegetation to the terraces is sandy oak, which presumably echoes the historical forest-steppe nature of this vicinity. Currently, this fertile expanse is overlaid by artificial landscapes, especially agrarian. Around 80% of the wooded areas are comprised of plantations, predominantly featuring black locust (Robinia pseudoacacia) and Canadian poplar (Populus x euramericana). Original homogeneous forests and dense shrubberies are only sporadically present.

Within residential areas and neighbourhood regions, Turkish hazel (Corylus colurna) and Tilia (Tilia L.) stand as the most prevalent tree genera, recommended owing to their distinctive scenic value indigenous to the locale.

Shallow lakes and stream banks teem with marsh species, including the sooty sedge (Schoenus nigricans), fragrant onion (Allium suaveolens), and large sedge (Senecio umbrosus). Aquatic vegetation and water-bound insects are abundant, and fish are routinely nourished. The shallowness of the waters provides wild birds an advantage, leading more species to designate this wet area as their habitat.

Attributed to its rich nutrient profile, diverse habitats, and migration paths, a verified count of 206 species has been identified in this region[19].

CHAPTER 4

Landscape Structure

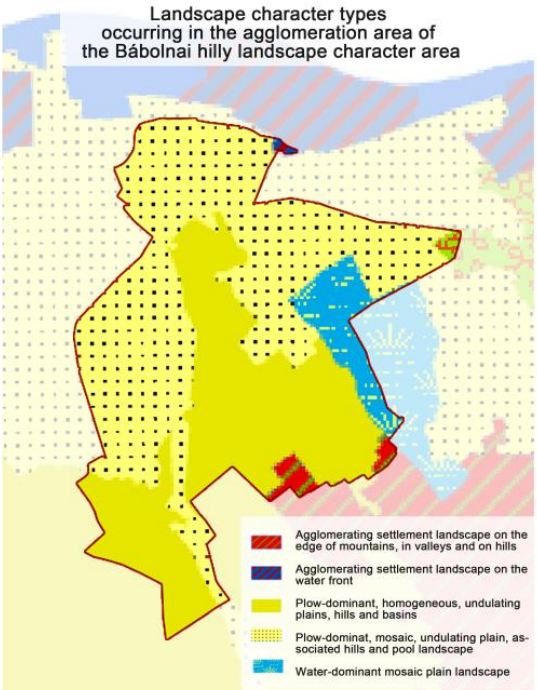
Chapter 4 introduces the landscape structure of Naszály in detail from four aspects. Landscape character is the business card of the site, which helps us quickly understand the overall characteristics of the study area. Landscape history introduces the history of settlement development and landscape features over the past 150 years, providing contribution in determining the stability of GI elements. Land use is the most accurate overview of the current land status of the site, and it is the base map for determining GI elements. Nature conservation and regulation introduces the conservation and regulatory areas of Naszály and provides clear guidelines for the conservation assessment of GI elements as well.

4.1. Landscape character

Landscape character is understood as the distinct, recognizable, and consistent pattern of elements in a landscape that makes one landscape different from another[20]. It can be used to identify the differences and identities between different landscapes, or to understand the differences between landscape units. relationship between.

In Hungary, the National Landscape Characteristics Area Project categorizes descriptive indicators of landscape characteristics into three major groups: indicators of natural factors and characteristic natural landscape elements, indicators of land cover stability and transformation, and anthropogenic and perceptual indicators[21]. It could be seen that in 209. BÁBOLNAI-DOMBVÍK LANDSCAPE CHARACTER AREA, this region is mainly a plow-dominant landscape, with homogeneous and mosaic characteristics concentrated in the south and north. It can only basically determine the landscape characteristics of this area in a broad sense.

In the City Image Manual, provided to Naszály's municipality by Főépítész Bán Gergely, their team divided Naszály into six typical town characteristics in a settlement scale[22]. Town centers are village character areas that mainly serve human living and living activities. The main features of the town's exterior are the landscape character, which consists of the semi-natural environment around ponds and waterways, and the agricultural character, which is mainly farmland, as shown in Figure 4.1.



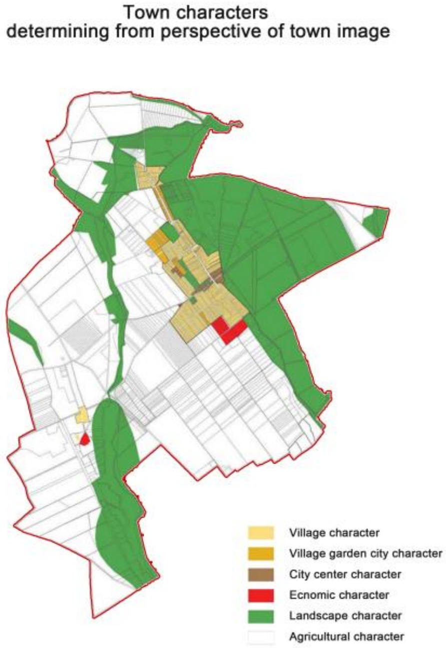


Figure 4.1. National landscape character (left), Town character(right)
(Image edition by author, Reproduction: http://alapterkep.termeszetem.hu/,
https://www.naszaly.hu/epitesi-szabalyzat/)

Based on the above two landscape feature classification models, the landscape features of the study area were divided into two major categories: Artificial landscape and Semi-natural landscape, with a total of 9 sub-features, and showed the most representative images for each feature type.

The landscape characteristics of the Naszály are mainly agricultural and arable landscape, see Figure 4.2. for more details. It is characterized by continuity and homogeneity, covering almost 2/3 of the land. Downtown areas are dominated by villages and residential garden landscape characters. Most of them are one- or two-story, self-built houses that include front and rear gardens and private land behind them,which usually used to grow crops or raise animals. What’s more, areas with semi-natural landscape character in Naszály are mainly water bodies (watercourses and ponds) with lush wetland herbaceous plants, as well as artificial forests and grasslands.

This method is based on the degree of impact and results of human activities on landscape features, and becomes the key to identifying the characteristic form of this land in general.

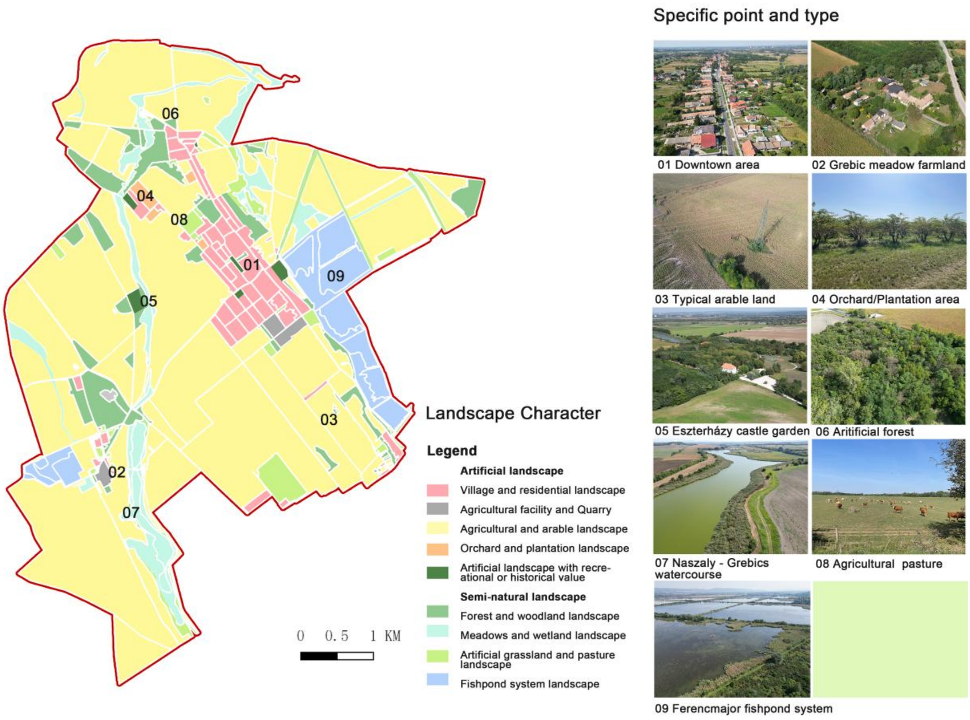


Figure 4.2. Landscape character in Naszály (Image by author)

4.2. Landscape history

Village settlements date back to the Iron Age, and the remains of mass burials preserve this ancient memory. In documented history, the area appeared as a settlement in 1234. Mentioned under the name Naszal in 1628. Despite the ravages of the Turkish war, the village's development never stopped. In the 17th and 18th centuries, under the management of the Csáky and Péchy families, the settlement was transformed into a reform village. From 1727 to 1945, the Esterházy family was the largest landowner in the village. After Naszály returned to the jurisdiction of Tata Manor, the vast territorial borders led to a rapid increase in population and great changes in local settlement life. The model farms in sterházy provided many employment opportunities, and the agricultural planting, animal husbandry and wine industries also began to develop rapidly. Naszály gradually became a small and medium-sized settlement mainly based on agriculture.

The natural history of Arable areas is not supported by detailed documentary descriptions, but the general evolution of landscape characteristics can be observed from their historical base maps.

The First Military Survey of Kingdom of Hungary (1782-1785) mainly shows the topographic features and land use types of the Naszály area, as shown in Figure 4.3. The residential area is small in size (approximately 50 households) and is clustered in the central and eastern part of Naszály. The northern and eastern parts of the residential area are low-lying meadow plains. The central and southern parts are gently rolling hills, extending to the south. The west is flat farmland used for farming, and most of the areas outside the north are also used for planting. In this stage, Arable land accounts for the highest proportion among all types of land.

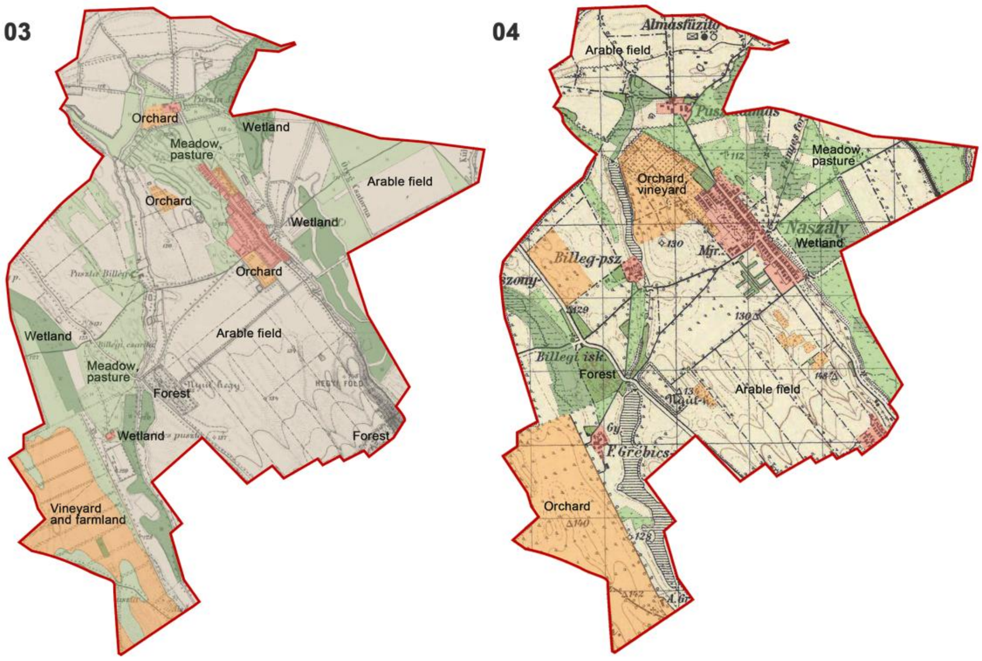
In the Second military survey of the Habsburg Empire (1819-1869), the land occupied by meadows and pastures expanded very rapidly to the southwest, accounting for almost half of Naszály's land cover with Arable land, as shown in Figure 4.3. In the northeast corner, a wetland system intertwined with small rivers gradually emerged, affecting the structure of this land. A grape planting area of a certain scale has also been formed in the southwest corner. At the junction of the rivers in south-central Naszály, an artificially planted forest is forming.

Figure 4.3. Historical land use map in Naszály - 01 and 02

(Image by author, Source: https://maps.arcanum.com/en/map/corona-hungary/)

In the Third Military Survey (1869-1887), as the marsh world drained based on the plans of Sámuel Mikoviny, the boundaries of the Naszály wetland became blurred, the structure changed, and the number of waterways increased in the area (Figure 4.4.). On the other hand, as urban expansion intensified, the road system became clearer and more organized. The emergence of Alee-tree gives the road more historical importance and unique landscape features. The scope of cultivated land is expanding in all directions, and while the area is becoming larger, the shape is also becoming more regular.

The Military Survey of Hungary (1941) clearly shows the development of the Naszály-Grébics Watercourse and changes in the water channel on the east side, with parts of the wetland becoming more connected (Figure 4.4.). The most obvious thing is that the prototype of the Ferencmajor fishing pond has taken shape. At the same time, the area covered by grasses shrunk to some extent and the area of plantations increased significantly. In particular, the emergence of prominent vineyards near the village also confirms the glorious history of its wine industry.



Third Military Survey(1869-1887)

Military Survey of Hungary(1941)

Figure 4.4. Historical land use map in Naszály - 03 and 04

(Image by author, Source: https://maps.arcanum.com/en/map/corona-hungary/)

Figure 4.5. shows that there are two very obvious changes in Georeferenced Spy Satellite Photos Mosaic (1960's). The area of residential areas has expanded dramatically. At the same time, the area of fruit plantations such as orchards and vineyards has shrunk significantly, and the agricultural structure is dominated by the cultivation of crops. The area of meadows and pastures expanded slightly and gradually became connected with the surrounding area. Some dense shrublands have also developed over time and gradually transformed into small patches of forest.

Figure 4.5.(right) shows a satellite image of Naszály in winter. Vegetation cover in many areas is significantly different from the summer period, making land use identification difficult. What can be recognized is that the areas of forests and grasslands have not changed much, and the areas of towns are almost fixed. A relatively regular wetland appeared on the west side, which was the prototype of today's Grébics Pond.

Figure 4.5. Historical land use map in Naszály - 05 and 06
(Image by author, Source: https://maps.arcanum.com/en/map/corona-hungary/, www.google.hu/intl/hu/earth/)

In the Google Earth Historical Image (2001), part of the wetland meadow area was encroached by farmland, and many small woody patches formed a continuous and dense forest, as shown in Figure 4.6. The Ferencmajor fishing pond has been cleaned and restored, forming the neat and tidy shape of the water body it has today. The boundaries of residential areas became clearer and the area was slightly reduced. The most obvious change is reflected in the orchards, which are almost completely intact except for a small area of plantation.

To this day, Google Earth Historical Image (2022) displays current land information (Figure 4.6.). The area of wetlands has decreased significantly, and they have gradually grown into forests or been encroached upon by farmland. The proportion of plantations has also recovered.

In general, the settlement structure of Naszály has not changed significantly over the past two hundred years. The area covered by forests and grasslands is always low. Forest and grassland coverage has always been low, and some forest patches with historical value have disappeared. The area of fruit plantations and vineyards has shrunk significantly, and now it has become an agricultural planting structure dominated by corn and sunflower cultivation. The wetland system in the eastern region has a history of hundreds of years. After drainage plans in the 19th century and gradual restoration in the 20th century, today's 9 typical lowland round filled fish ponds were formed.

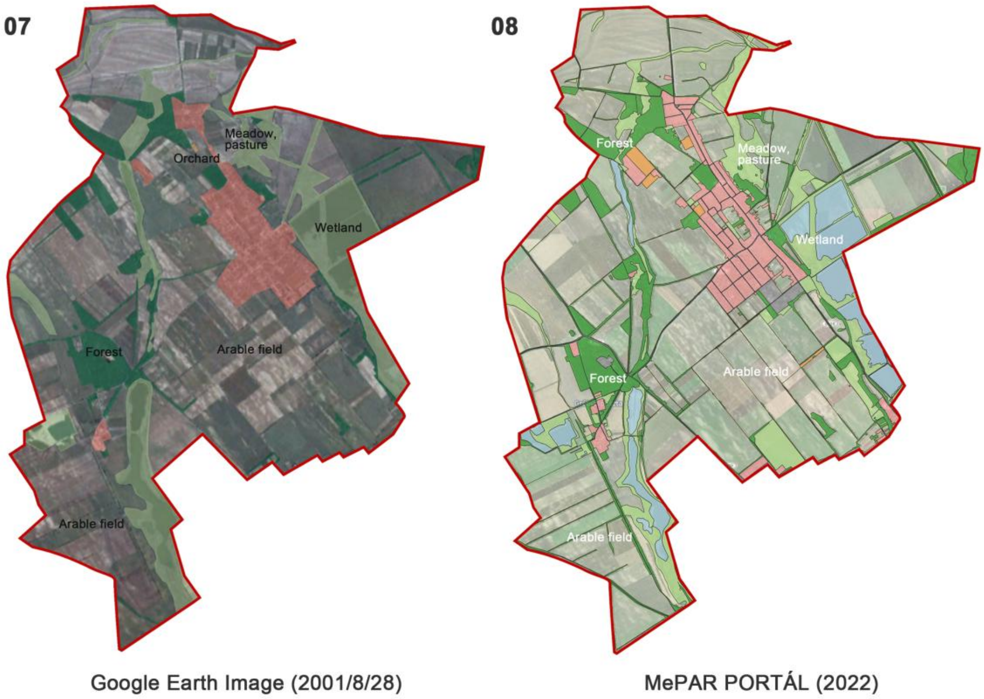


Figure 4.6. Historical land use map in Naszály - 05 and 06
(Image by author, Source: www.google.hu/intl/hu/earth/,
https://mepar.mvh.allamkincstar.gov.hu/#/)

4.3. Land use

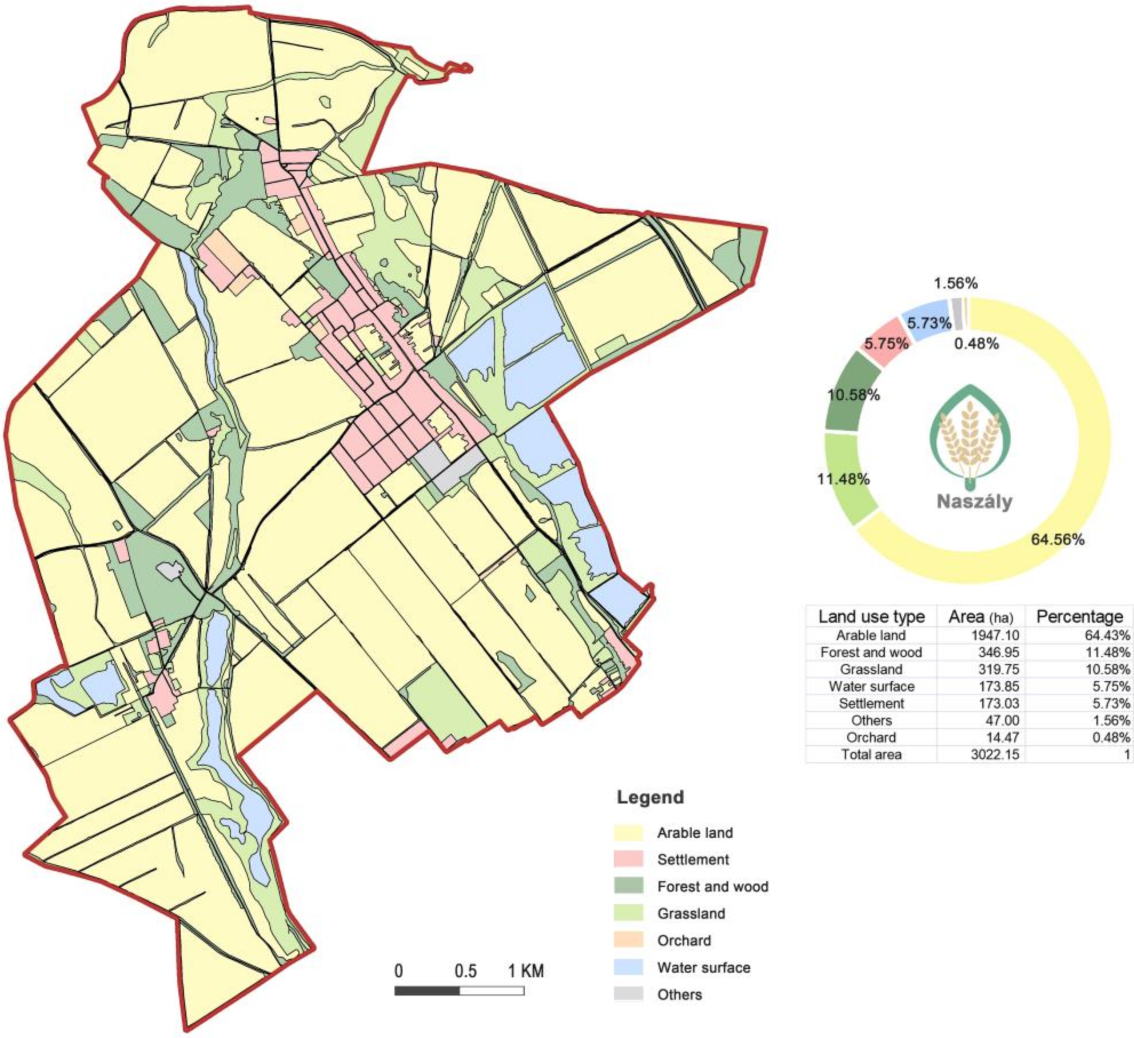
In this section, I divided Naszály's land use types into 7 categories with reference to the division of plot boundaries in MePAR, as shown in Figure 4.7.

It is obvious that arable land is the type with the widest coverage here. Approximately two thirds of the land is covered by arable land, totaling 1947.10ha, containing 93 parcels with defined boundaries. Most plots have obvious farming and sowing directions, which are relatively easy to identify. Among them, the largest continuously cultivated land area is 983,411.86 m^2. The most common types of crops in the cultivated land are corn and sunflower. There are also some areas where rapeseed, wheat and other cereals are planted. In addition, some non-plantation sensitive strips on field ridges and field edges are of ecological importance and are recorded by MePAR.

What's more, the area of forests and woody plants is 346.95ha, accounting for 11.48% of the total land use area. The large area of forest is a plantation dominated by Black locust (Robinia pseudoacacia) and Canadian poplar (Populus x euramericana). A small part is a natural mixed forest containing Austrian pine (Pinus nigra) and Scots pine (Pinus sylvestris). There are also native plant forests including Alnus glutinosa (Common alder) and European ash (Fraxinus excelsior). Several woody strips, tree lanes and woody groups are also defined within the forest. In particular, the woody lines at the edges of fields are highlighted by MePAR for their ecological importance.

Grassland’s area ratio is 10.58%, which is slightly lower than forest’s ratio. About 3/4 of the grassland is unused and untrimmed wetland meadows near water bodies, dominated by hygrophytes such as the common reed (Phragmites australis). The other 1/4 of the grassland is pasture for cattle and sheep and open lawns. Most of them are classified as permanent lawns of MePAR as 'Education for All Elements'.

Settlement area is 173.03 ha, mainly distributed on both sides of Road No. 8138. There are also small parts located outside Grébicspuszta and Naszály. The water body covers an area of 173.85 ha, accounting for 5.75% of the total area. Other land type includes roads, industrial areas, abandoned open spaces (eg. mines), and its area is 1.56%. The smallest proportion is Orchard (0.48%), with an area of 14.47 ha, including fruits such as elderberry (Sambucus nigra) and Grapes (Vitis sp.). These categories have been introduced above and will not be repeated here.



Land use type	Area (ha)	Percentage
Arable land	1947.10	64.43%
Forest and wood	346.95	11.48%
Grassland	319.75	10.58%
Water surface	173.85	5.75%
Settlement	173.03	5.73%
Others	47.00	1.56%
Orchard	14.47	0.48%
Total area	3022.15	1

Figure 4.7. Land use types and statistic data in Naszály (Image by author)

4.4. Nature conservation and regulation

Naszály region is located in the western foothills of the Gerecse Mountains. The Ferencmajor fishpond system at the foot of the mountains provides this area with abundant water and living resources. Due to its unique geographical location and environmental factors, Naszály has a high natural value, especially in the eastern region. These areas are supervised by EU or national ecological protection agencies and are interconnected, forming a complex, diverse and relatively complete nature protection and supervision network system.

This system consists of five sub-levels, including Ex lege protected area, Natura 2000, Ramsar site, Natural park and national ecological network, illustrated in Figure 4.8.

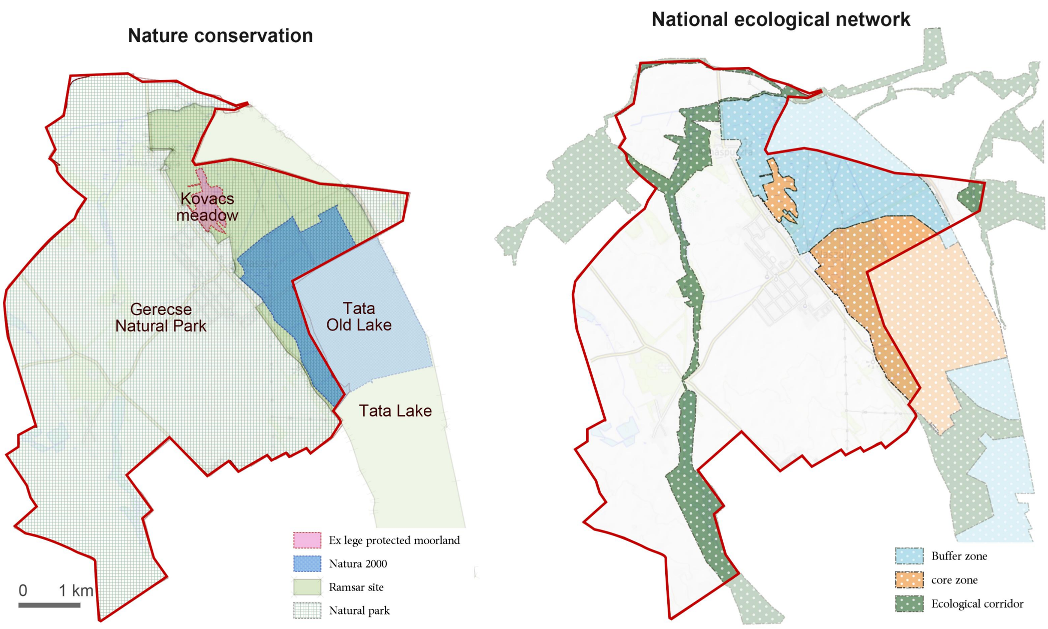


Figure 4.8. Nature conservation (left), National ecological network(right)
(Image by author, Source: http://web.okir.hu/map/?config=TIR&lang=hu)

In Hungary, all springs, bogs, caves, sinkholes, saline lakes, mud mounds and earthworks are protected pursuant to Act LIII. of 1996 on the protection of nature[20]. Within Naszály, the large Kovacs meadow east of the settlement is perennial Covered by shallow water, it is rich in wetlands and swamp life. This area is protected by law as a marsh nature reserve (Ex lege).

Natura 2000 is a connected European ecological network, which ensures the protection of biological diversity through the protection of natural habitat types, wild animal and plant species of community importance and contributes to the maintenance and restoration of their favorable nature conservation status[23]. Naszály, Ferencmajor Fishpond System is a part of Tata Old Lake, protected under the Birds Directive. It consists of 9 typical lowland round-filled fishponds, the lake bed is usually shallow and muddy. There are a rich variety of aquatic plants and aquatic insects, and fish are constantly being fed. This superior condition makes it a home for birds. It contains 39 species of waterbirds protected by the EU, such as Bean Goose (Anser fabalis), Crane (Grus grus), Greylag Goose (Anser anser).

In Hungary, all springs, bogs, caves, sinkholes, saline lakes, mud mounds and earthworks are protected pursuant to Act LIII. of 1996 on the protection of nature. In Naszály, the large Kovacs meadow east of the settlement is covered by shallow water all year round , rich in wetlands and swamp life. This area is protected by law as a swamp nature reserve.

Tata Lake region was in the list of Wetlands of International Importance, following Hungary's 1979 accession to the Ramsar Convention on wetlands of international importance. It is a mosaic and diverse of habitats is formed, including meadows, pastures, fens, remainings of fenand areas, reedbeds, ploughlands, fishponds, streams, which belongs to delta of Által-ér[24]. Inside the Naszály region, its views to the east of the hinterland are included.

Natural parks are landscape-level collaborations established by local communities with the purpose of protecting, displaying and utilizing the natural and cultural heritage of the relevant landscapes to promote rural development. It covers 9.7% of the country's land and currently contains 17 members. Gerecse Natural Park includes the entire territory of Naszály and several settlements on its east and south sides. Its central part is a relatively low mountain range of limestone and dolomite. The western edge extends to the Târ-ér Valley and the eastern part of the small plain. The loess valley is gently undulating and is dominated by water resources and agricultural landscapes. It is the end of the Gerecse Mountains.

The core areas of the national ecological network are the Ferencmajor fish ponds and the Ex lege swamp area. The buffer zone is mostly the inner area east of the boundary, covering almost the entire Ramsar Tata Lake site. The ecological corridor mainly includes the Naszaly-Grébicsi river channel and other creeks, waterways and their surrounding wetland environments.

The entire territory of Naszály is covered by a rich protection and supervision system. I have found that, based on the superposition of different sub-levels, the Protected moorland and Ferencmajor fish pond provide habitat for wetland birds and are the most natural and ecologically important places in Naszály. Water channels and wetland systems throughout Naszály are ecological corridors that connect the entire habitat.

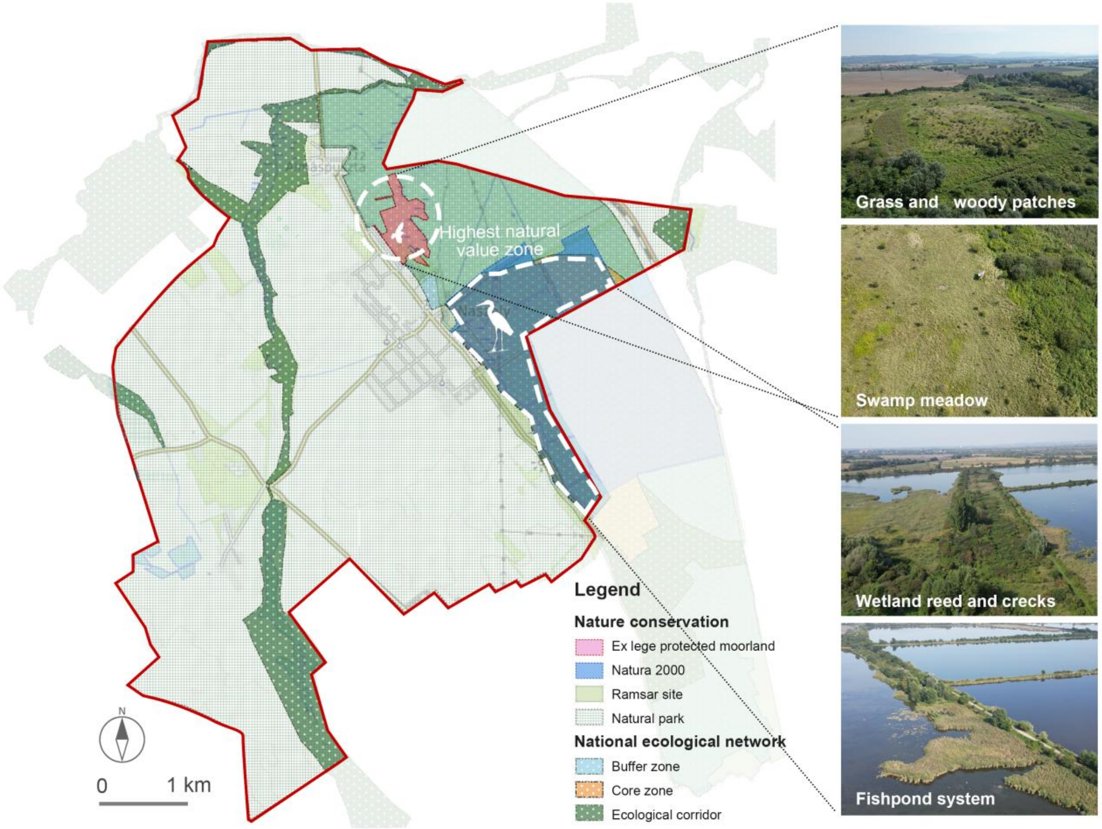


Figure 4.9. National conservation and regulation map
(Image by author, Source: http://web.okir.hu/map/?config=TIR&lang=hu)

4.5. Landscape aesthetics value

Although Naszály is not known as a tourist-rich town, there are many landscape elements of aesthetic value scattered here.

Within Naszály Administrative District, I identified some places with frequent human activities as valuable viewing areas. They include some major transport routes, public and green open spaces and some viewpoints marked on Google Map. These include five main roads, tourism tracks along some waterways, recreational parks and green areas, specific viewing towers and platforms, please see Figure 4.10. for more details.

Inside the Naszály settlement, I found six outdoor activity spaces where residents or tourists often gather, including ① Public lawn, ② Football pitch and event space, ③ Forests inside residential areas, ④ Cemetery, ⑤ Catholic Cemetery and monument, ⑥ Well-organized parks and churches.

Outside the Naszály settlement, I identified three areas of recreational value where residents or tourists often gather.

(1) Watermill and Park, which is a complex of model-renovated historic water mills and a well-preserved park.

(2) Eszterházy Castle and its park. The former Eszterházy Castle has been exemplary renovated and protected by a monument, and its extensive park serves as a center for activity.

(3) Erzsébet Observation Deck The observation deck was created as an investment in connection with the natural park, and offers views of the protected fish pond system and surrounding landscapes.

Among the roads that run through the study area, there are five main roads for passing vehicles, including Road.1, Road.8134, Road.8138, Road.8139, and Road.8141. Moreover, the area encompasses Track ①, ②, and ⑤ along the Naszály-Grébicsi river channel, Track ④, which leads to Grébicspuszta, and Track ③ situated adjacent to the Fényes Stream.

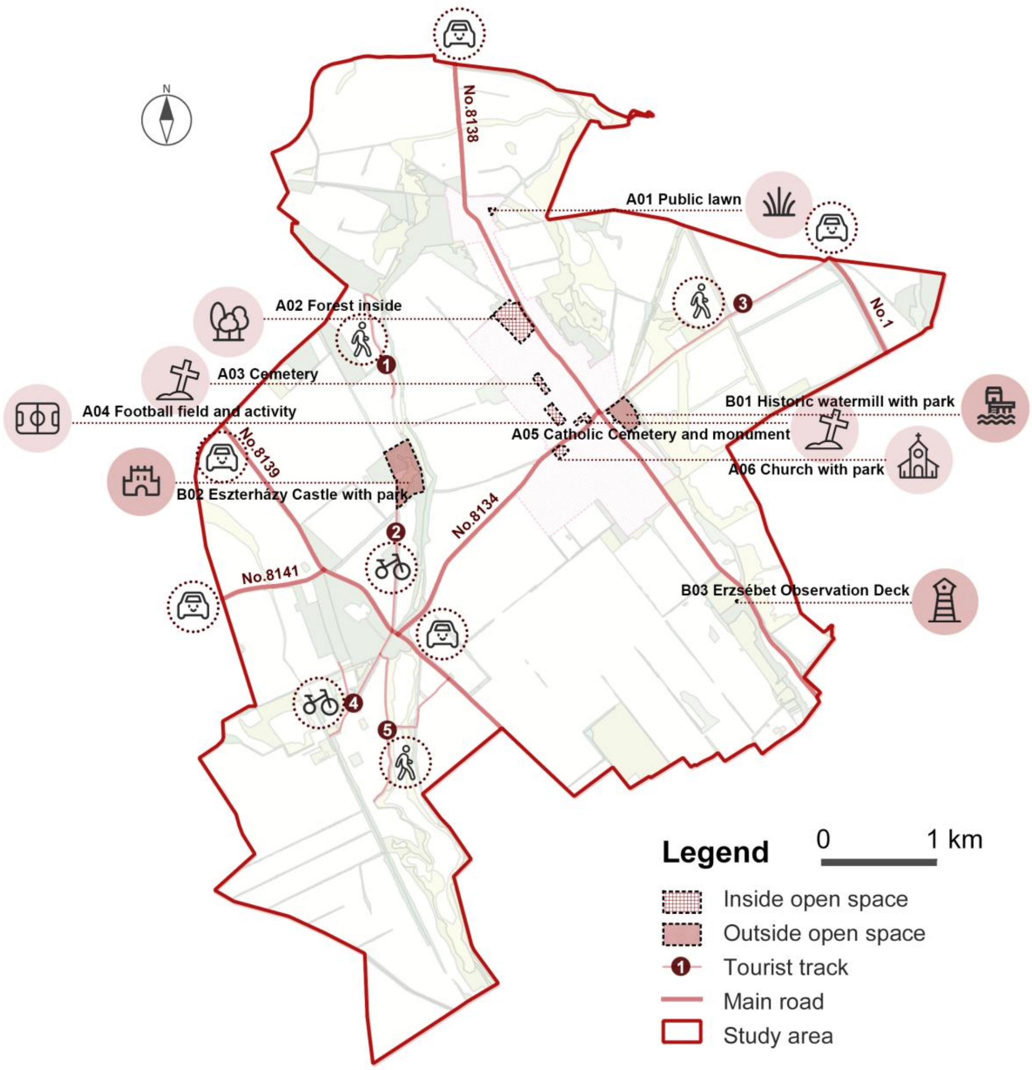


Figure 4.10. Valuable viewing areas/ Gathering points in Naszály

CHAPTER 5

Methodology of Evaluation

The assessment of GI in the Naszály region is the core part of this thesis. Therefore, the five steps of defining the composition categories of GI elements in the area, constructing the geographic information system database of the GI network, establishing the evaluation model of the GI network, collecting and analyzing data, and summarizing the evaluation results will serve as the process of the analysis part of this study, illustrated in Figure 5.1. Among them, Step.01 and Step.02 serve as the basis or background of the evaluation module and will explain the characteristics, proportions and mutual relationships of GI elements as independent constituent units in the network from a qualitative and quantitative perspective. Step.03 and Step.04 are the most important parts of the GI evaluation system. From the perspective of qualitative analysis, comprehensive analysis and evaluation can be carried out by selecting appropriate evaluation indicators and classifying evaluation levels or determining comprehensive evaluation methods, combined with the identification of satellite images, data summary on network data platforms and field surveys. Step.05 is the output of the evaluation results and an empirical expression of the evaluation method. Therefore, it relatively comprehensively summarizes the current status of the selected agriculture-related GI system, and reveals the existing problems and causes of the problems, providing a basis for subsequent Provide theoretical support for the development of the evaluation GI system.

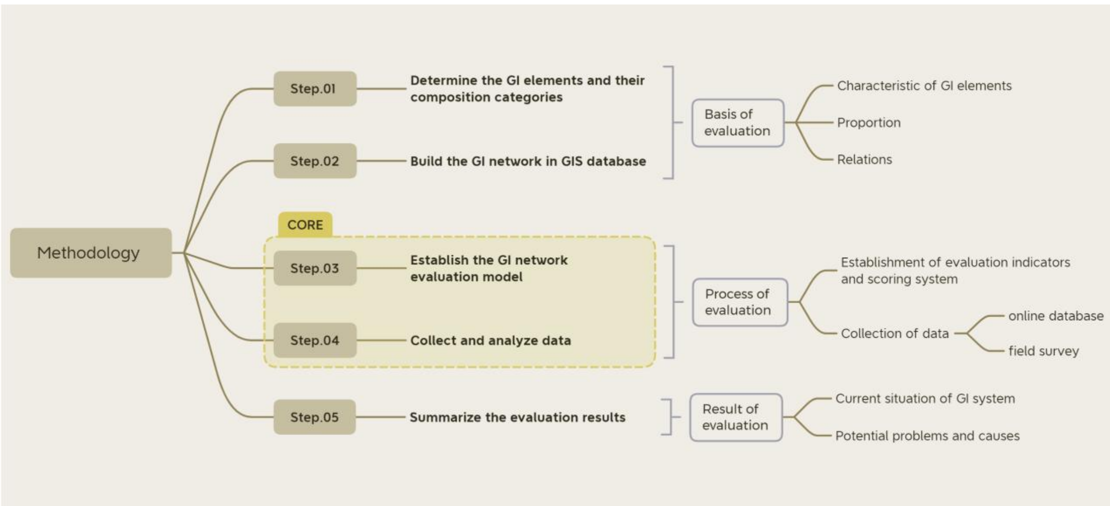


Figure 5.1. Methodology of evaluation (Image by author)

5.1. Determine the GI elements and their composition categories

GI elements are the basic units for detecting and evaluating GI network systems, so determining the types of GI elements and classifying them is the first step in the entire evaluation process. Internationally, there is no unified definition of the concept and element types of GI.

GI refers to areas composed of nature and close to nature and other areas with vegetation coverage or water coverage and areas with ecological functions And the network formed by the ecosystem here. GI exists in rural and urban areas. It is a very grand interdisciplinary concept that includes many nature-related elements. Depending on the research field and research objects, different restrictions can be added to the conceptual expression and element selection of GI. At the settlement scale, GI mainly includes green infrastructure within the settlement to meet daily life needs of park green spaces, rural gardens, institutional green spaces and other facility green spaces. On the periphery of settlements, in agricultural areas connected to the natural ecological environment, GI includes farmland, water bodies, wetlands, forests, grasslands, orchards, pastures and the edges of fields. In this study, taking into account the characteristics of the research site and the subject of the study, the functions and connections of GI between agriculture and the natural environment are emphasized. I give the limitation of GI elements to woody and herbaceous elements with strong ecological characteristics and ecological importance outside of farmland, orchards and water bodies. It includes polygon elements such as forests, woody groups, grasslands, meadows, other striped-like linear elements such as tree-lined hedges, wooded strips, water protection strips, field margins and point-solitary trees, please see Figure 5.2. for more details. Therefore, based on the form and characteristics of GI elements, I divided them into four sets of elements, including Forest, Grassland, Wooden and grass stripe, Solitary tree. Each of them contains different subcategories (sub-elements), as shown in the image below.

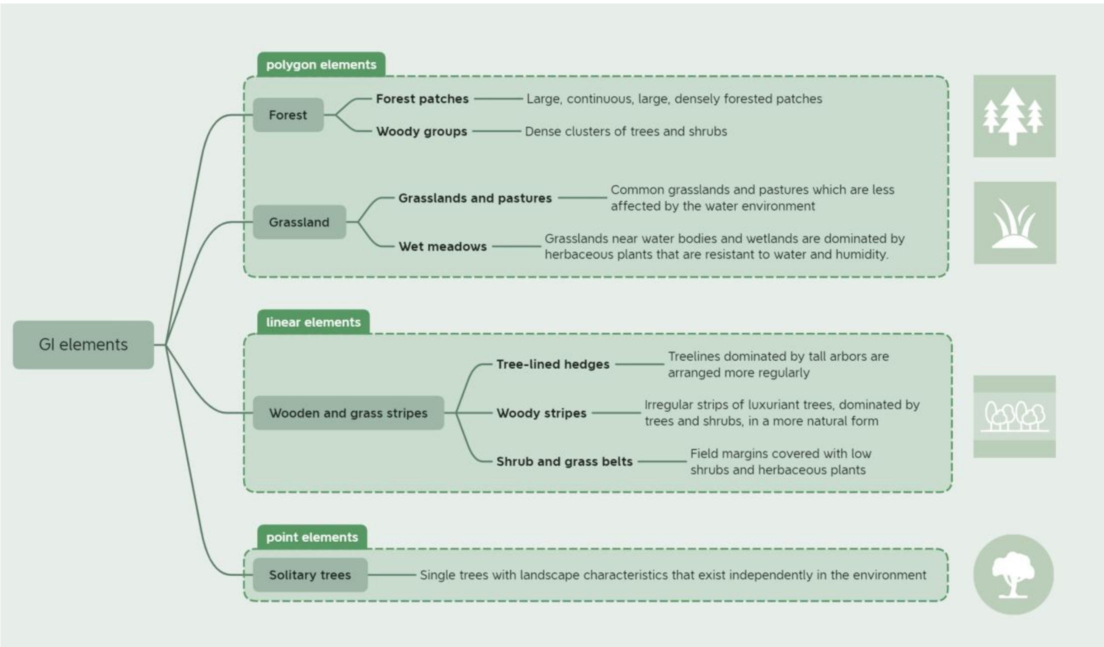


Figure 5.2. The catalog and definition of GI elements (Image by author)

Meanwhile, I combined the relevant concepts in the Hungarian GI Network

Development Guidebook and the MePAR Portál website to put forward my own interpretation of the concept of GI elements in this study.

Forests are natural or artificial habitats characterized by dense groups of trees. Within this group, based on the patch size and vegetation density on satellite images, it can be divided into forest patches (Large, continuous, large, densely forested patches) and woody groups (Dense clusters of trees and shrubs).

Grassland is an open area dominated by grass (Poaceae) and shrub vegetation. Includes grasslands, open areas of herbaceous vegetation (large lawns), pastures, and meadows with a small amount of shrubbery. Considering the impact of water bodies on grassland, based on the soil environment of the grassland, I divided this group into Grasslands and pastures (Common grasslands and pastures that are less affected by the water environment are generally subject to certain human management) and Wet meadows (close to water bodies and wetland grasslands, mainly composed of water-resistant herbaceous plants, which are usually the product of wetland ecosystem degradation).

Wooden and grass stripes are strip-shaped GI elements that can be simplified to linear elements on a large scale. It is a vegetable environmental barrier, including tree forest belts, sparse shrub belts, field margin shrubs and grassland mixed belts, etc. Compared to Polygonal patches, they have a narrower and longer shape and are often located at the junction of different types of land/environment, providing a certain level of connectivity. This group can be divided into tree-lined hedges based on elemental shapes and plant types (tree-lined hedges are mainly tall trees, arranged in a relatively regular manner. They are usually located on both sides of roads and creeks, playing the role of hedge and isolation). Woody stripes (irregular strips with lush trees, mainly trees and shrubs, with a more natural form), Shrub and grass belts (field margins covered with low shrubs and herbaceous plants).

Solitary trees refer to single trees with landscape characteristics that exist independently in the environment. However, considering the particularity and independence of solitary trees as individuals, such elements cannot be used as the basic unit (population or community) to talk about ecological characteristics. Therefore, in this study, only the number and location of solitary trees on farmland were counted, and a more in-depth evaluation of them was not conducted.

5.2 Build the GI network in GIS database

After determining the categories of GI elements, it is particularly important to build a unique GI network database in the study area. It can be used as the basis for GI network analysis and evaluation, supporting the establishment of evaluation systems and the calculation and graphical export of results.

I use the satellite remote sensing digital orthophoto of Google Earth 2022 as the base map and create different GI element layers in the QGIS 2.18.27.

By referring to the stable boundaries of farmland delineated in MePAR, farmland plots and other ineligible areas are distinguished. At the same time, refer to the OpenStreetMap standard map layer for assistance to determine the land area of water bodies, grasslands, residential areas and structures. Use the Hungarian forestry network map to more accurately determine fine forest patches, and combine it with satellite images to identify areas where other woody groups exist. For linear elements, I referred to Wooded lane Layer of Landscape education elements in MePAR, and determined their location and type based on ineligible area (outside agricultural lands) and satellite image.

In general, the determination of GI elements is the result of comparison, correction and comprehensive overlay of a variety of map data, including Google earth, MePAR, OpenStreetMap and Hungarian forestry network maps. After numbering them, I obtain the amount of element patches, their area, and the proportion they occupy in our study area.

5.3 Establish the GI network evaluation model

Establishing an evaluation system is the most critical step in the evaluation process. Its rigor and logic determine the scientificity and credibility of the research results. Indicators play an increasingly important role in domestic and international landscape assessment. According to the purpose of assessment and the characteristics of the assessment object, appropriate assessment indicators are selected and an indicator system is established to conduct a comprehensive assessment of the landscape. The European Landscape Agreement calls the attention of experts and academics to the importance of landscape assessment and makes the assessment of European landscape conditions and the analysis of landscape shaping impacts a collective task. In the project KEHOP-4.3.0.-VEKOP-15-2016-00001, developed and implemented by the Hungarian Ministry of Agriculture, researchers developed a method to delineate, map and map existing elements of GI networks across the country. The method of complex situation assessment is called the "triple composite" method. It is based on the construction of an ecosystem base map and the results of ecosystem status assessment, including assessment of GI ecological status, ecosystem service composition and spatial relationships (neighborhood and connectivity). The assessment level of this method is relatively macro, and it does not classify specific types and regional characteristics of GI. Therefore, it can only be used as an overall framework to provide a certain degree of reference for this study. Landscape evaluation indicators are quantitative or qualitative indicators that measure landscape characteristics and quality[25]. They are used to describe, define, evaluate and compare the ecological, cultural, economic and social benefits of landscapes, and provide basis and support for landscape planning, design, management and protection. . In order to select landscape indicators suitable for this study, I referred to research literature and works with high recognition. The book Landscape Indicators[26] explains six levels of universal landscape evaluation indicators from a macro perspective, including ecology, history, visual and social perception, land use and economy. For agricultural-related landscape evaluation, the article Overview on Agricultural Landscape Indicators Across OECD Countries[27] reviewed the Agri-environmental indicators and OECD indicators for agricultural landscapes proposed by the OECD in 2001. Environmental policy, agri-environmental indicators and landscape indicators[4][11]. The article compares and introduces OECD landscape indicators, EU landscape indicators and PAIS landscape indicators. Through comprehensive comparison and sorting, I screened out some indicators that fit my research scale, themes and goals, and combined them with Hungary's GI assessment method to build an assessment model suitable for this study. It not only includes ‘typical landscape assessment indicators’, but also considers the limitations of ‘agricultural landscape’ and ‘green infrastructure’. In addition, I also referred to a BS student's publication in 2022 about the evaluation method of the GI network evaluation system. The triple indicator groups (protection, naturalness, and landscape utilization) she chose are very rigorous, which well inspired and promoted the progress of this research[28]. My evaluation system contains 5 levels and 8 indicators, including the aspects of Ecological condition, Ecosystem services, Ecological protection and legal regulation, Land use, Spatial relationship, and Landscape aesthetics. Almost every indicator is a complex result of a mixture of multiple indicators. The first two indicator groups are analyzed from the level of GI elements and score each determined element in the system; while the last four indicator groups are scored overall from the perspective of the system based on the proportion included or spatial relationship features of GI elements. For detailed scoring rules, please see Figure 5.3. for more details.

The final step of the evaluation is the superposition and summary of the scores and relations in different indicator groups, which will give the help for the next final result of planning strategies.

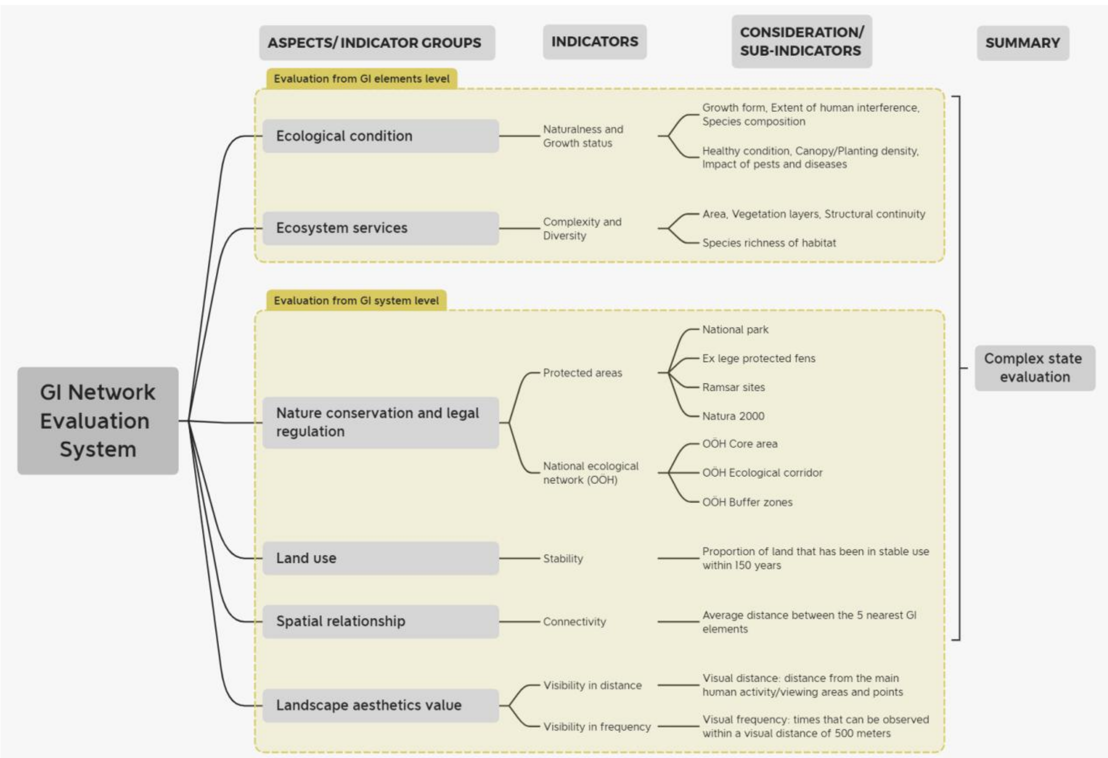


Figure 5.3. GI network evaluation model (Image by author)

5.3.1 Ecological condition

Considering the context of ecology, ecological condition refers to the combination of biological, chemical and physical properties of an ecosystem, habitat or resource at a specific time and place, usually compared to some reference baseline or natural undisturbed conditions. Usually refers to the ecological health and functionality of these areas or structures[28]. The ecological status assessment of national GI is based on the MÉTA vegetation naturalness evaluation[29]. In this study, the reflection is made jointly from the two aspects of Naturalness and Growth status of GI elements. The former mainly considers the species composition of GI elements (Native or Invasive) and the degree of influence by human activities (Natural or Artificial), while the latter takes into account the health status of GI elements (Presence or absence of disease). However, for different types of GI elements, the evaluation characteristics or sub-indexes of Ecological condition are also different according to their planting forms or species life forms. For example, in the case of forests, more attention is paid to whether the species are native and whether the planting model is artificial plantations or other economic forests. For grassland, more attention will be paid to whether it is under human management (being harvested or herded, etc.). For other Linear woody elements, more attention will be given to their health and species composition, and whether the vegetation grows neatly or densely. Because ecological condition is almost the most important of the many indicators for evaluating GI elements, I divided its quantitative table into five grades in detail. The score of 1 represents extremely poor, and the score of 5 represents excellent, which reflects the ecological condition of GI elements' situation.

5.3.2 Ecosystem services

In the EU's strategic planning requirements for GI, the main goal of ecosystem services is to maintain and restore ecological connectivity and continue to ensure ecosystem services[30]. The third level of evaluation of national GI is the multifunctionality of providing ecosystem services, including most regulatory/maintenance and cultural services in addition to the supply of agricultural production[31].

From the perspective of settlement, for small-scale GI elements, it is difficult for us to be precise about the specific service type, scale or timeliness it provides. Therefore, this study started from evaluating the ability of GI elements to provide ecosystem services, and selected the complexity of the GI element structure (vegetation level, patch size and continuity) and species diversity (the habitat provided as a habitat, can The number of species of organisms to be cultivated) is judged by two indicators. Similarly, the evaluation characteristics or sub-indicators of ecosystem services also differ depending on the type of GI element. However, the ecosystem services functions of the three GI elements are mainly evaluated from their spatial structure (horizontal area scale and vertical vegetation level).

In terms of scores, the strength of the ecological service function of GI elements depends on the quality of ecological conditions to a certain extent, and there is not a large gap in the quantitative levels. Therefore, I divided the evaluation results of this indicator group into three levels from low to high. A score of 1 represents a weak ability to provide ecosystem services, and a score of 3 represents a strong ability.

It should be noted that in the evaluation quantification table, there are specific values for the definition of the size of the three types of GI elements: Forest, Grassland and Wooden and grass stripe. They are 3 ha, 1 ha and 500 m respectively, which are the results based on a comprehensive study of relevant literature and statistical experience at the settlement scale.

5.3.3 Nature conservation and legal regulation

Areas affected by nature protection are the basis for building an agricultural landscape GI network. Because this is the most effective means of protecting areas of natural value and preventing the encroachment of agricultural land. This study area has certain particularities and includes four Ex lege protected areas, Natura 2000, Ramsar site, and Natural park. I assign different values to these sub-indicators based on the strength and importance of conservation conventions or normative regulations. The score index is calculated per hectare. The larger the protected area covered by the GI element, the higher the index score. The score for this indicator is the sum of four sub-indicators.

Ex lege protected area is a swamp that is explicitly protected by law. It has the same strict protection restrictions as the area protected by the Ramsar Convention. Taking into account the importance of ecological benefits, I classify them in the highest category, receiving 3 points/ha. Natura 2000 is the European Union's protection system, which belongs to a larger regional protection standard. The evaluation conditions are not as stringent as the first two, but it still has extremely high protection intensity, so it received 2 points/hectare. Natural park, as a national regulation, covers a wide area and includes the entire study area, so it received 1 point/hectare.

Another indicator group, the National Ecological Network (OÖH), reflects more of its regulatory benefits on the ecological environment. Compared with the designated protected area, its binding capacity is weaker, but it still represents part of the landscape protection and regulation area. Within this indicator group, based on the ecological importance of different management and control levels in the network, and with reference to the indicators of protected region, I calculated the Core area as 3 points/ha, the Ecological corridor as 2 points/ha, and the Buffer zone as 1 points/ha, while areas not covered by ecological networks are counted as 0.

5.3.4 Land use

Landscape characteristics change dynamically due to human influence over the course of historical development. Therefore, it is particularly important to study landscape development changes at different historical stages or nodes. By analyzing different legends in historical maps, stable land use and GI elements, which are vital in GI network evaluation, can be identified. Components that form a constant GI network are indicative of stably existing GI elements, allowing for an inference about the stability of the GI network structure and function from the perspective of historical development, based on their proportion in the elements. Therefore, I have compiled in detail the historical maps related to Naszály that can be found on Arcanum Maps, including military survey maps, survey maps, restored space images and satellite images dating back 150 years, from 1869-1887 The Third Military Map's Google Earth Image to 2022 has a total of six historical image layers. But I take into account the results of military surveys from the late nineteenth century, even though they reflect landscape use before nationwide water management projects. In QGIS, I overlaid six historical maps with divided land use types on my Land use base map, focusing on the location, status, and scale of the GI elements in each layer. By stacking multiple layers, I found stable elements (probably partial) that haven't changed over the years, as shown in Figure 5.4. I counted the percentage of stable GI elements among existing elements and ranked them (every 20% is a level). The higher the proportion, the more stable the properties of this element are. However, this method exists, and only larger GI polygon elements (forests, lawns and big tree groups) will be recognized. For some GI linear elements such as street trees or tree strips, I need to select and outline their boundaries by comparing the maps individually to obtain the stability results of all types of GI elements.

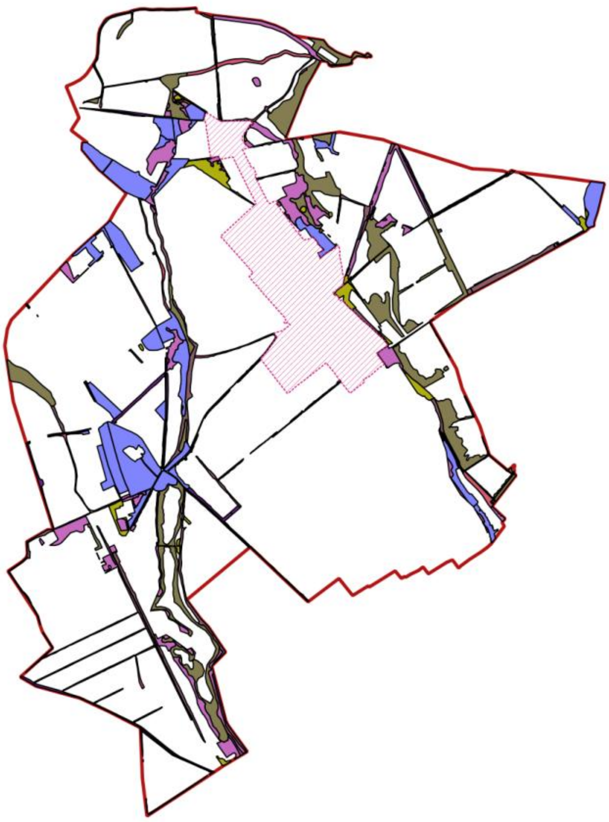


Figure 5.4. Stabled GI elements in Naszály (Image by author)

5.3.5 Spatial relationship

The spatial relationship of GI elements is more reflected in the connection and impact on each other due to different positional relationships between patches (distance, strength of communication, ability to exchange resources, etc.), so it is used as 'Connectivity' representation. Analysis on connectivity in QGIS is slightly computationally complex. I used the tool 'Distance to Nearest Point on feature' to filter out the 5 closest other elements to the selected GI element, create the shortest line between them and get the corresponding distance data. After that, I used the average of their five shortest line distances as the basis for dividing connectivity categories, and based on the top 25% and the bottom 25% of this set of data as the dividing points for connectivity strength (22 m and 475 m respectively)). The further the average distance, the worse the connectivity.

However, due to differences in size and shape of GI elements, the position of the shortest line connecting them has certain particularities, and this particularity may lead to deviations in the results. In addition, the simple distance in space does not completely represent the strength of the connectivity of GI elements. There may be obstacles from geographical structures (etc. roads, water systems and built elements) between adjacent GI elements, which increases the difficulty of communication between patches.

5.3.6 Landscape aesthetics

As part of the landscape elements, the GI network also provides certain aesthetic value. Internationally, landscape evaluation usually attempts to determine the aesthetic value of the landscape and the size of the space seen by rating the landscape. However, people's views and understanding of beauty are often highly subjective and difficult to express objectively. In addition, in agricultural landscapes, individual GI elements do not have the primary task of providing aesthetic value in appearance, so it is difficult to define their aesthetic and ecological service value functions. Therefore, the aesthetic characteristics of GI elements can be quantified through the visual differences of the landscape. In this study, the degree of visibility (being seen) of GI elements is used to determine the level of their landscape aesthetic value, including two evaluation indicators: distance and frequency.

Important viewing areas (gathering points) within the administrative scope of Naszály, characterized by extremely high accessibility and dense human gatherings, have been identified according to the discussion in Chapter 4.5. Within Naszály, paths with frequent human activities, green public open spaces, and some scenic spots marked on Google Map were selected, as stated in this study. They include five main roads, five tourism tracks along waterways, six recreational green areas inside the settlement area and 3 outside public green spaces.

Then I use these elements with important visual viewing properties as the observation area, and then determine the two indicators of the distance of the GI elements that can be observed in this observation area and the number of times the element is observed. Based on that, a quantitative table of different grading was set up, which is scored according to the visual importance of the landscape (3 - high importance, 1 - low importance, 0 - not seen).

5.3.7 Complex state

The complex state evaluation of the GI network is the result of superimposing the evaluation of the above indicators.

I select the following indicator groups, including 'ecological value', 'natural protection', 'connectivity' and 'visual importance', and summarized their results. It is worth mentioning that the evaluation result of 'ecological value' is a combination of ecological condition and ecosystem service.

Therefore, I will get the combined results of the four indicator groups and get the areas with high (strong) and low (weak) rating levels (strength) of them.

5.4 Collect and analyze data

This section consists of two parts: Online data collection+Field survey and application of QGIS tool set and Excel statistics analysis, illustrated in Figure 5.5.

I mainly collected resources from the following four open databases, including Forest Map, MePAR, TIR and Arcanum Maps, to obtain more basic evaluation information. At the same time, I conducted a survey of the distribution, status, species composition, visual importance of GI within Naszály area. Due to the large area of the area and the imperfect road system in agricultural land, I used UAV to assist me in observing and evaluating GI elements. I also left behind many important aerial photos, which were very helpful to my research.

The processing of data is built in QGIS attribute tables and Microsoft Excel tables. I used the calculation toolkit in QGIS including area, shortest line distance, intersection, summation, etc. (detailed use in the previous section), and createda a series of statistics tables about various types of GI elements for data Statistical and visual analysis, please see Appendix II for details.

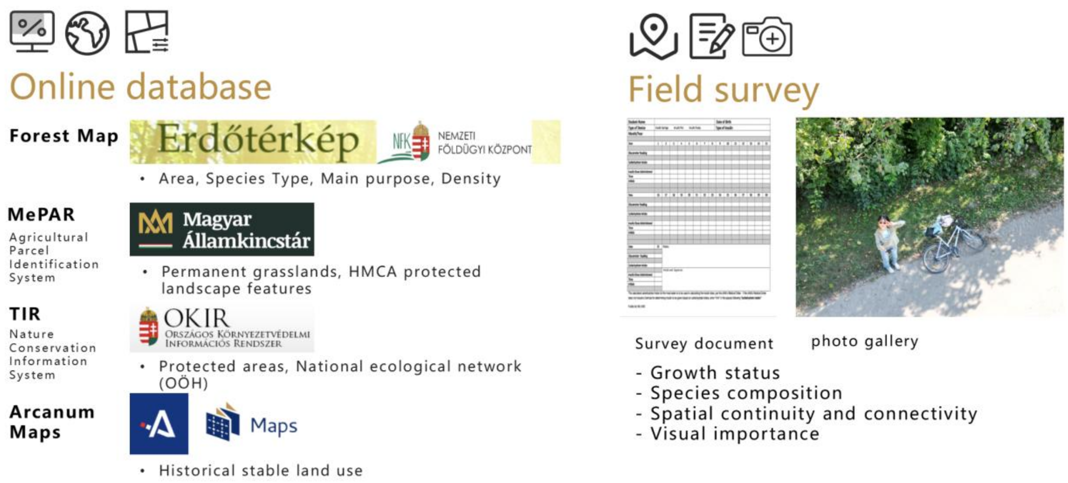


Figure 5.5. Method of collecting and analyzing data (Image by author)

5.5 Summarize the evaluation results

At this stage, I will obtain 8 maps with score rating differences, which show the evaluation results of the 8 indicator subgroups of the GI system. At the same time, a comprehensive summary of the strengths resulting from the four indicator groups is presented in detail in Chapter 7.

As a reason that GI is a part of the natural environment, it has high ecological value. Based on the above results, I chose the evaluation results of 'Ecological value' as the basis and made decisions based on its value. By superposing the data from the three additional indicator groups, six different results can be obtained, shown in Figure 5.6.

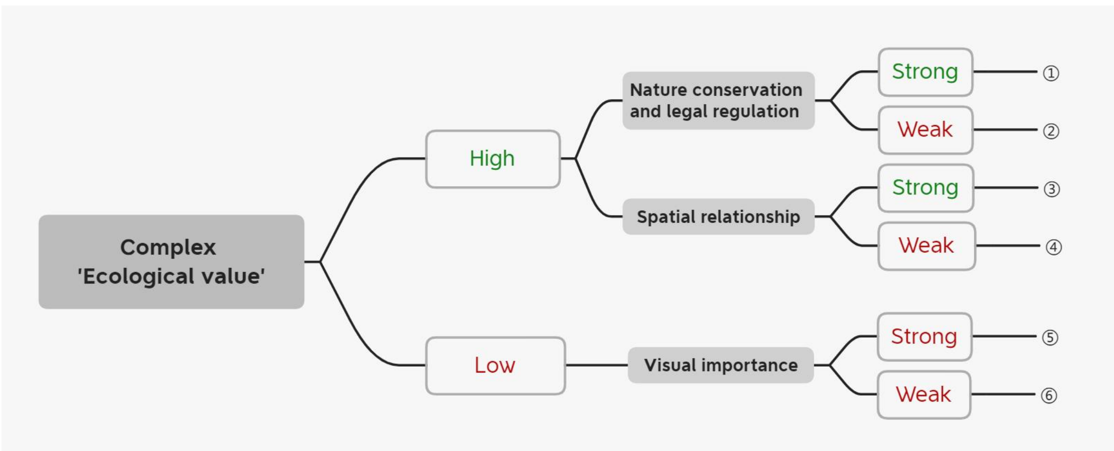


Figure 5.6. Decision tree for potential planning areas (Image by author)

①High ecological value, strong protection, could be continuously maintained;

②High ecological value, low protection, could be included in protection;

③High ecological value, strong connectivity, could be continuously maintained;

④High ecological value, weak connectivity, could be enhanced connectivity;

⑤ Low ecological value, high visual importance, could be functionally redesigned;

⑥ Low ecological value, low visual importance, could be ecologically restored.

Among them, the green ①, ③ areas will continue to maintain their structural and functional characteristics as high-quality GI elements; while the red ②④⑤⑥ areas are determined to be disadvantaged areas with problems, and then determine the need for planning (providing protection and development measures) in the GI network) area in Naszály.

CHAPTER 6

The Elements of the GI Network

This chapter summarizes the positions, characteristics and attributes of GI elements, and counts the number, area and proportion of each type of GI elements. This is a display of the quantification results of GI elements in Naszály.

In the methodology, the GI elements and their composition categories have been determined, as illustrated in Fig.1. GI elements are divided into point, linear and polygon elements by type. In this chapter and the following, considering the scale of the research area and the feasibility of macro planning, only the linear and polygon elements in the GI network are analyzed and discussed, with the position of the elements within Naszály's inner area being standardized. Outside, there is an outer area that is closely connected with the agricultural landscape.

I built the GIS database of the GI network in QGIS software, checked and verified the elements in the study area through field surveys to obtain sufficient picture information and data on the number, area and proportion of GI elements, the results are shown in Figure 6.1.

Figure 6.1. GI element sets and elements' photos (Image by author)

The results are shown in Figure 6.2. I have created a total of 208 plots of GI elements in the database. This includes 122 polygon elements and 86 linear elements. Among all child elements, the 'Forest' element set contains 58 (29+29) plots, the 'Grassland' element set contains 64 (47+17) plots, and the 'Wooden and grass strips' element set contains 86 (31+32+23) plots.

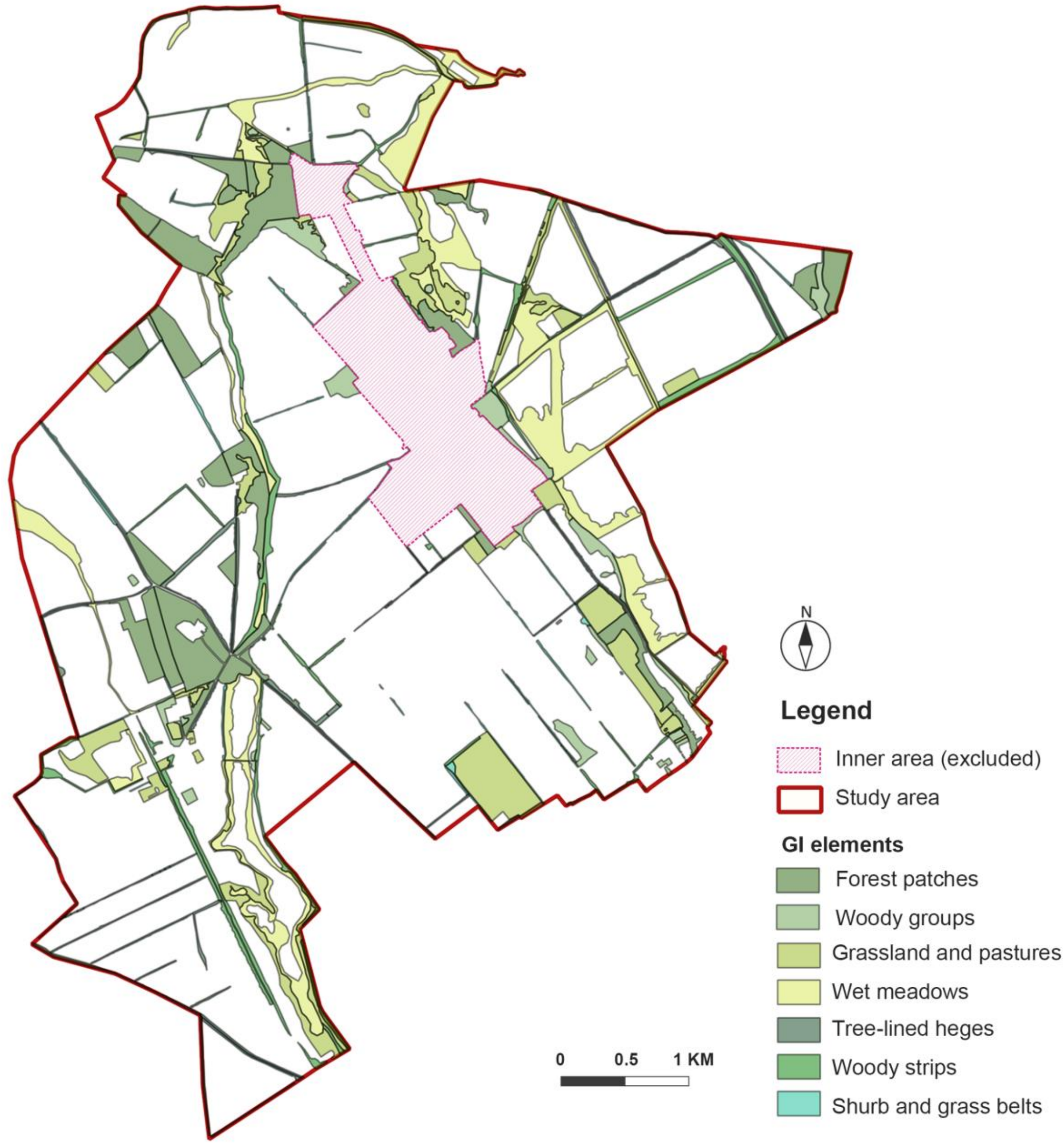


Figure 6.2. GI network related with agricultural landscape in Naszály (Image by author)

Within the scope of our study, the total area covered by GI is 652.72 ha, accounting for 21.60% of the Naszály area, as detailed in Table 6.1.

The total area of the 'Forest' element set is 213.81 ha. Among them, Forest patches and Woody groups accounted for 26.17% and 6.59% of the total GI elements respectively, with areas of 170.82 ha and 42.99 ha. The total area of the 'Grassland' element set is 315.52 ha. Among them, Grassland and pastures and Wet meadows respectively account for 23.30% and 25.04% of the total area of GI elements, which are 152.1 ha and 163.42 ha. These two element sets constitute GI polygon elements, accounting for 81.10% of the total area of GI elements and 17.51% of the total area of the Naszály study area.

For GI linear elements, namely Wooden and grass strips, account for 18.90% of the total area of GI elements and 4.08% of the entire Naszály study area. Among them, Tree-lined hedges, Woody strips and Shurb and grass belts each account for 6.45%, 10.25% and 22.21% of the total GI elements, with areas of 42.09 ha, 66.89 ha and 14.41 ha respectively.

Table 6.1. Statistic table of GI elements (Image by author)

GI polygon elements	Forest		Grassland		Total
GI subelement	Forest patches	Woody groups	Grassland and pastures	Wet meadows	
Area (ha)	170.82	42.99	152.1	163.42	529.33
Percentage in GI elements	26.17%	6.59%	23.30%	25.04%	81.10%
Percentage	32.76%		48.34%		81.10%
Percentage in study area	5.65%	1.42%	5.03%	5.41%	17.51%
GI linear elements	Wooden and grass strips				Total
GI subelement	Tree-lined hedges	Woody strips	Shurb and grass belts		
Area (ha)	42.09	66.89	14.41		123.39
Percentage in GI elements	6.45%	10.25%	2.21%		18.90%
Percentage	16.70%		2.21%		18.90%
Percentage in study area	1.39%	2.21%	0.48%		4.08%
Total area of GI elements (ha)					652.72
Total percentage of GI elements					21.60%

In general, from the perspective of quantitative analysis, the proportion of GI in Naszály is not high. In particular, Forest, a wooden GI element with a rich and stable structure, occupies a very small area.

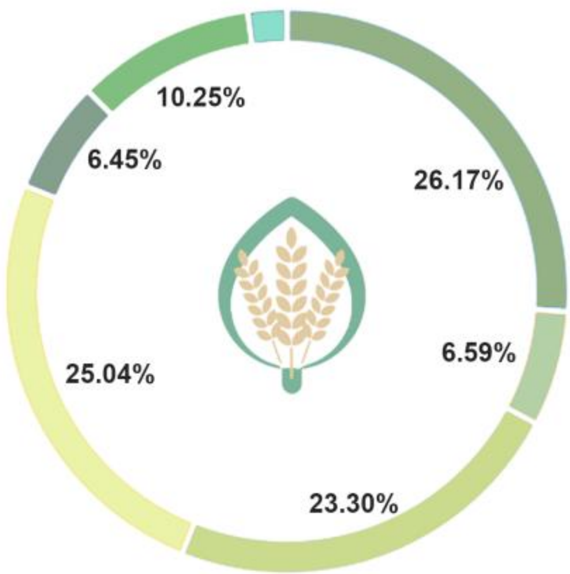


Figure 6.3. Proportion of each GI element(Image by author)

CHAPTER 7

Evaluation of the GI Network

This chapter shows the 7-level evaluation results of the GI network in Naszály, including 6 evaluation indicators and 1 summary part, which is one of the core results of this research. Areas with GI protection and GI development value will be identified in this chapter, providing theoretical support for the subsequent improvement of the GI network system. In the subsequent sections, each GI element is referred to in the format of "category_ID," for example, Forest patches_11, with their specific information recorded in Appendix II.

7.1 Ecological condition

In general, the ecological condition of GI in the study area is relatively average, with scores mostly concentrated at 2-3, but they show high diversity, detailed in Figure 7.1. Most of the GI elements with good ecological condition are distributed in the wetland areas in the northwest corner and east of the residential area, and some are distributed on the east bank of Naszály-Grébicsi Watercourse. These areas, where access is challenging and human disturbance is less frequent, mostly retain their original natural features.

Forest: Most forests have low ecological condition scores, ranging from 1 to 2 points. The reason is that they are mostly artificially planted forests, dominated by invasive species, and at the same time severely homogenized species. Such as Canadian poplar (Populus x euramericana) and black locust (Robinia pseudoacacia), eg. Forest patches_23/26/29. Elements with higher scores are derived forests with better growth status, dominated by native species, such as native poplar forests (eg. Forest patches_22) and other mixed broad-leaved forests (eg. Forest patches_29).

Grassland: The ecological condition scores of lawns showed clear differences between the two subgroups. Grasslands and pastures are lawns that are highly disturbed by humans. They are pastures that are mowed regularly every year or grazed as planned. Most of them score below 3 points. Some of these lawns were over-managed or completely degraded and received 1 point, eg. Grasslands and pastures_22/26. While wet meadows mostly received a higher rating (4), such as the protected Kovacs meadow and the reed marshes next to the fishpond system. The grassland with the best ecological condition is Wet meadows_2, which is an almost ignored natural marshland at the junction of Naszály and Dunaalmás.

Wooden and grass strip: The score of this type of GI element mostly depends on its species type and its density. In general, according to the different categories of GI elements, the ecological condition order of linear elements is: Woody strips (around 4)>Tree-lined heges (around 3)>Shurb and grass belts (around 2).

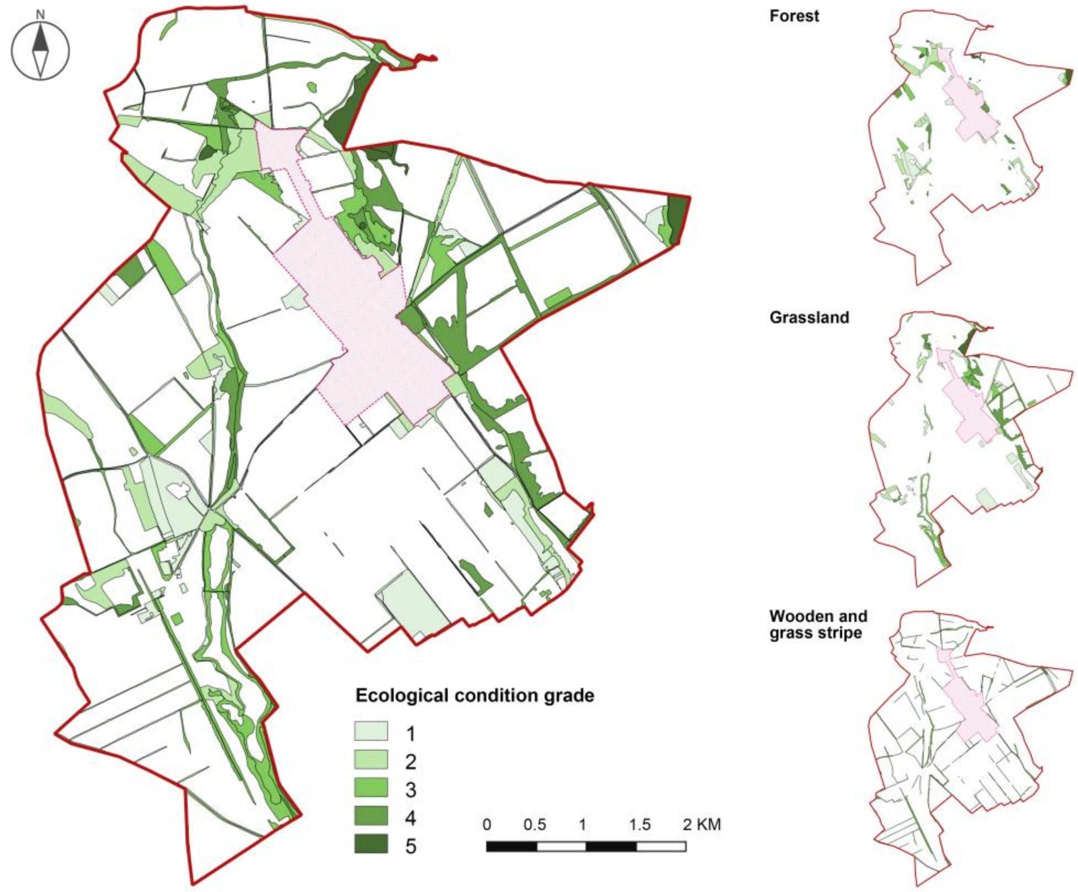


Figure 7.1. Result of 'Ecological condition' indicator (Image by author)

7.2 Ecosystem services

Basically, larger patches have higher ecological service value, and the capacity of ecological services is positively related to the quality of ecological conditions.

Forest: The larger the area and the richer the plant layer, the stronger the ecological service capacity of forest patches. For example Forest patches_7, it is a mixed forest composed of Canadian poplar and black locust. Such GI elements can provide habitats for many birds, insects and small mammals, while also helping to regulate microclimate and improve soil. Most GI elements in forest elements have high scores, while some smaller scale or sparsely vegetated patches receive lower scores.

Grassland: Wet meadows all scored 3 points. The reason is that they have high ecological value as transition zones between blue and GI elements. For Grasslands and pastures, they have a relatively single community structure. Especially those lawn elements that are under artificial management all year round have low ecological value.

Wooden and grass strip: The ecological service value of Linear elements is greatly affected by the plant community structure and the length of the elements. Generally speaking, Woody strips have the highest naturalness and ecological value, with scores (around 3) > Tree-lined heges (around 2-3) > Shurb and grass belts (around 1-3).

However, some GI elements with low ecological service scores have great potential for improvement, such as improving their ecological service capabilities by improving their ecological conditions or increasing their continuity.

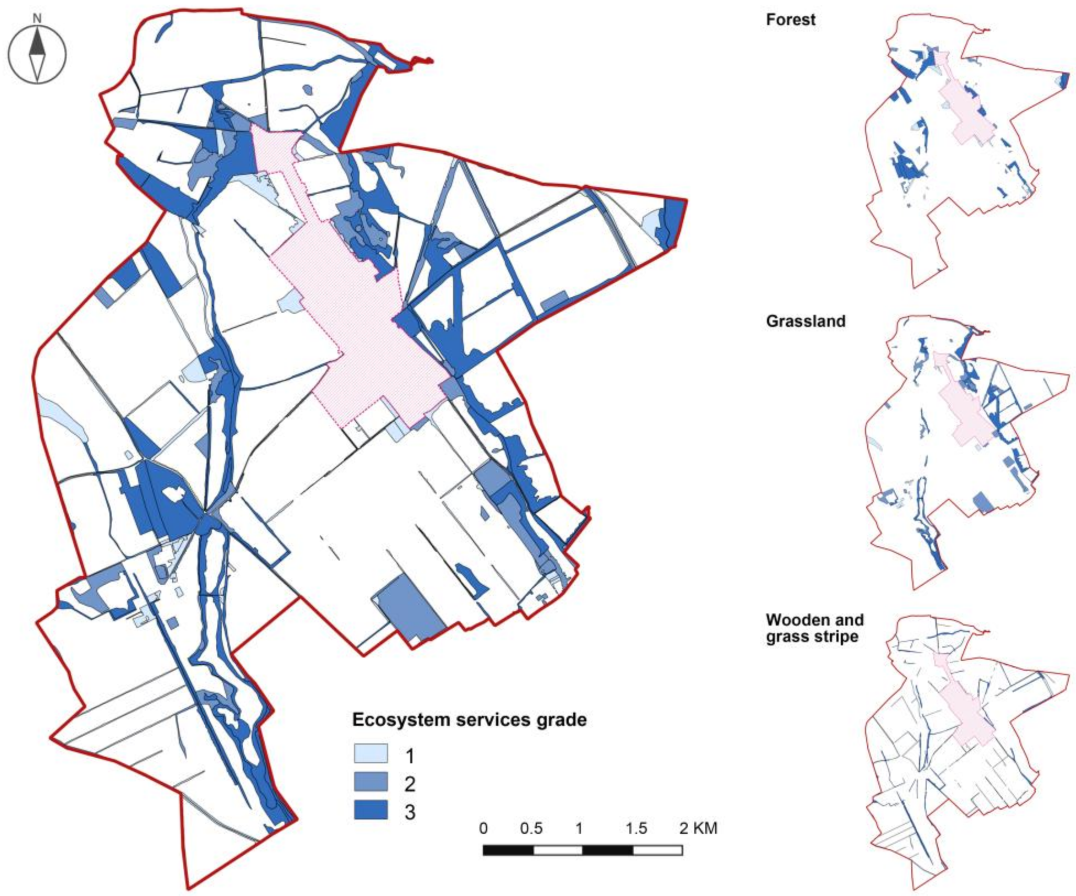


Figure 7.2. Result of 'Ecosystem service' indicator (Image by author)

7.3 Nature conservation and legal regulation

7.3.1 Protected region

According to the categories of natural protection areas in Chapter 4, the scoring range of GI elements on this indicator is very concentrated and clear, and most GI elements are completely included in the protected areas, as shown in Figure 7.3. The Kovacs meadow area, which belongs to the Ex lege protected moorlands (EX area), received the highest score, 7 points. Because they are not only protected by the EX area, but also within the protection limits of Ramsar sites and Natural Park. The one with 6 points is the Ferencmajor fishpond system belonging to the Natura 2000 network. The difference between it and the previous scoring area is because the value assigned to Natura 2000 is one point lower than the value assigned to the EX area. The entire territory of Naszály is covered by the protected area of the Natural Park, so all GI elements receive a result of at least one point on this indicator. However, except for the two areas with high intensity protection mentioned above, most of the GI elements in the west of Naszály only received one point, shown in pale yellow patches.

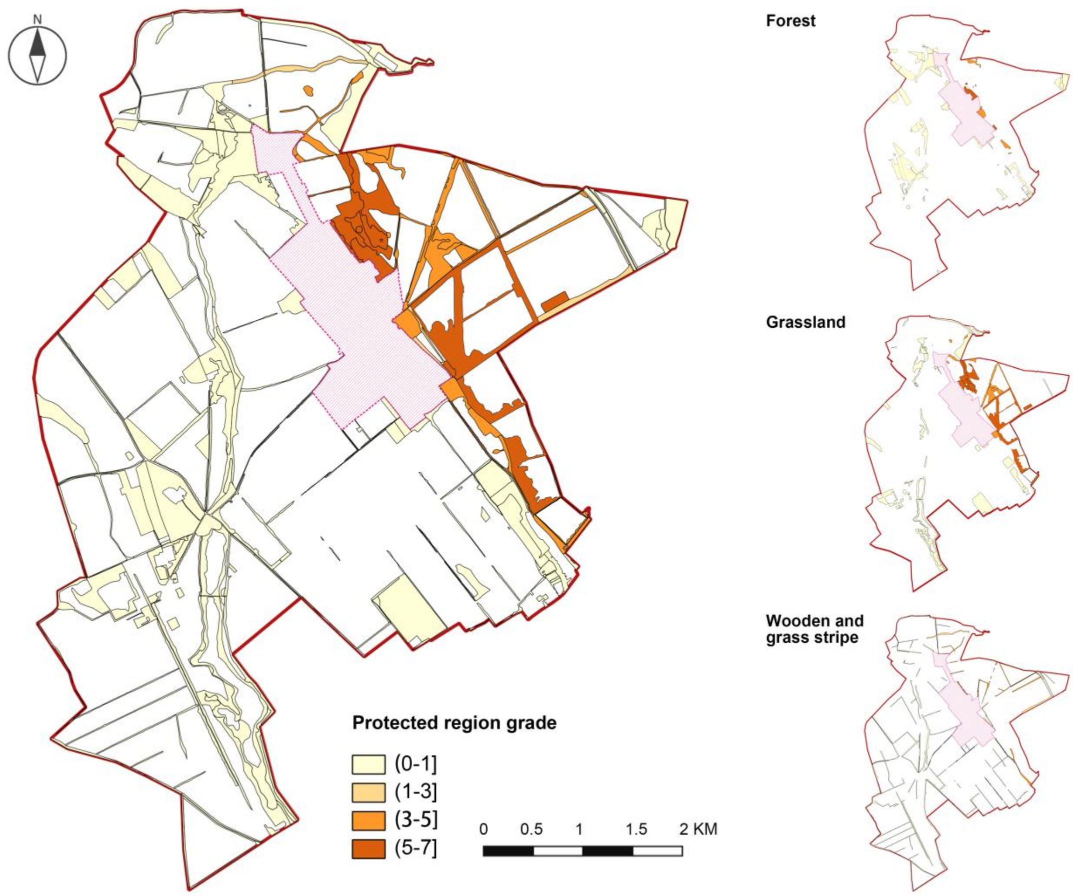


Figure 7.3. Result of 'Protected area' indicator (Image by author)

7.3.2 National ecological network (OÖH)

The score range of GI elements on the National ecological network (OÖH) indicator is also very clear, and the results are highly coincident with those of the protected area indicator. Figure 7.4. shows that the highest scores were obtained for the GI elements within the Kovacs meadow and Ferencmajor fishpond system areas, which are also covered by the OÖH Core area. What's more, GI elements distributed on both sides of the Naszály-Grébicsi Watercourse and nearby creeks, which fall within the scope of the OÖH Ecological corridor. Most of them received a score of 2 based on the area they encompassed. The areas covered by the OÖH Buffer zone and the Ramsar site (except for the two key protected areas) roughly overlap, and they received 1 point. The GI elements located in the center and west of Naszály are not within the scope of OÖH supervision and therefore received 0 points in this indicator group.

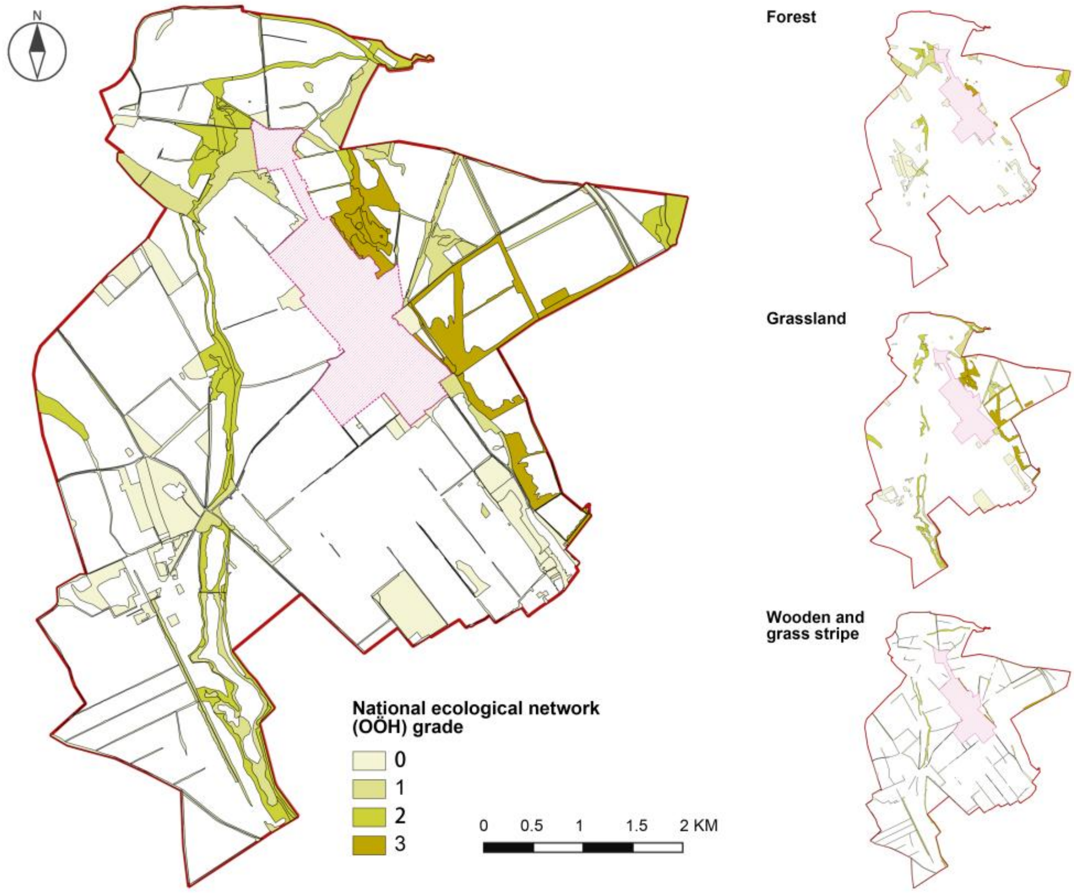


Figure 7.4. Result of 'National ecological network (OÖH)' indicator (Image by author)

7.4 Landscape use

In the study area, most of the GI elements defined as stably used were gradually formed based on the original Naszály wetland system. These areas are covered with dense vegetation and retain their natural/semi-natural character. Therefore, within 150 years, any GI element that continues to exist on the map as a wetland/meadow/forest/treeline will be rated as having high stability. Although their status in the landscape may be "unstable" (even though they were not used), their presence as GI elements is stable. In the results, it can be observed that elements with high scores within the stability indicator group, which are close to watercourses or creeks, still exist as part of the Naszály wetland system, detailed in Figure 7.5.

Forest: The forest element with a score of 0.8-1.0 has been marked as grassland or woodland in historical maps from 150 years ago. Most of them may be densely wooded patches in wetlands. However, through the influence of afforestation, it has gradually become a forest with a stable structure. The forests with lower scores are derived forests that have gradually appeared in recent decades. The areas where they are located were agricultural or other abandoned lands before, so their stability is not high, eg. Forest patches_7/25/26. It is worth mentioning that on the east side of the intersection of Road.8134 and Road.8139, there used to be a stable forest here in the mid-to-late 19th century. In the 1941 survey, this forest was converted into farmland, leaving only the outermost tree lines as the boundary. Therefore, this is a GI element with great historical restoration value.

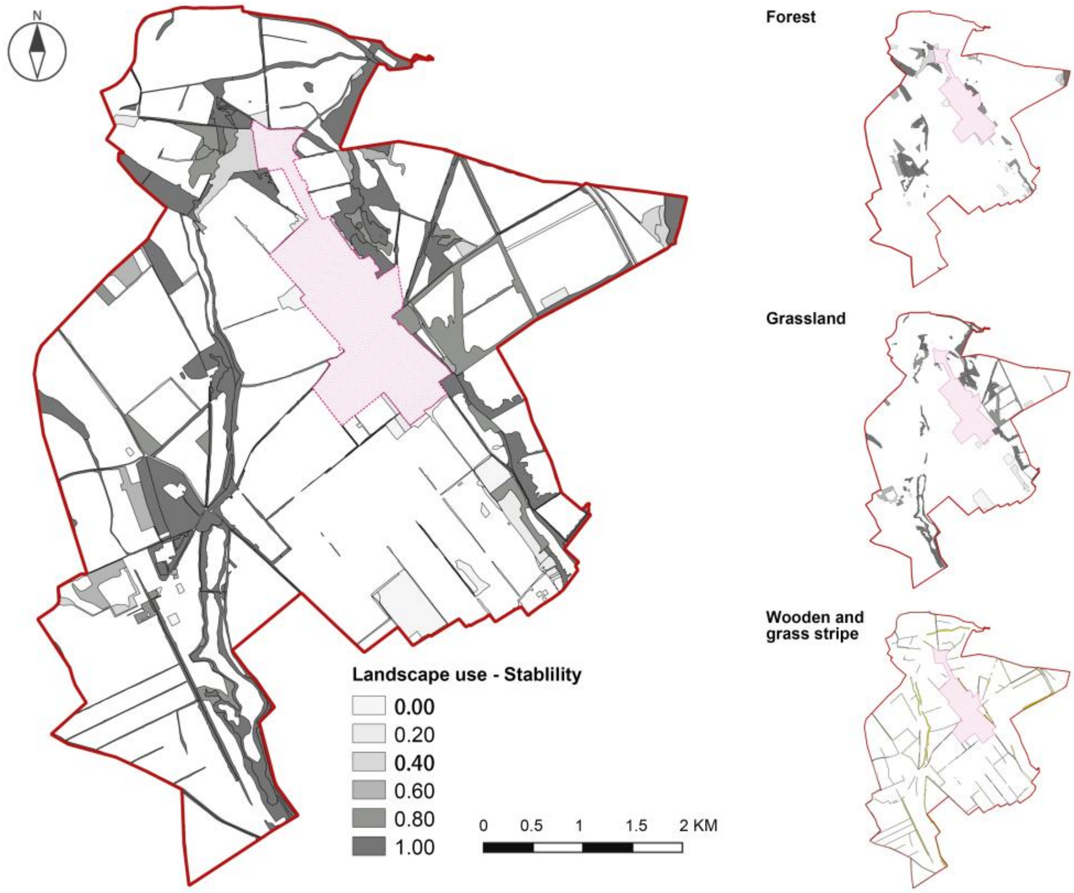


Figure 7.5. Result of 'Stability' indicator (Image by author)

Grassland: The stability of grassland elements is distinguished by category. As elements within the Grasslands and pastures category, they generally score poorly. Fundamentally speaking, artificial grasslands do not have strong stability. They often rely on human needs for use, so it is difficult to exist stably in history(eg. Grasslands and pastures_22/23/26). However, GI elements within the wet meadows category are highly stable. Because they themselves are part of the original wetland system, they also exist as wetland meadows today.

Wooden and grass strip: Among linear GI elements, elements with higher stability are mostly located on both sides of main roads. They are street tree barriers that support the road structure. Especially in the 1941 military map, the existence of these green lines, such as Woody strips_25, can be clearly observed. Elements with low stability are mostly located in the middle of agriculture, which are the boundaries of newly formed agricultural plots. There are also some Wooden and grass strips that existed in history but have disappeared for some reason. However, the ecological restoration or reconstruction of these GI elements can be considered to increase the connectivity of the GI network.

7.5 Spatial relationship

From the data results, GI elements with strong aggregation usually have stronger connectivity. They are often surrounded by nearby elements, so the five average results calculated are all short. Some GI elements are immediately adjacent to five other elements, so the average distance of the five closest GI elements to it is 0m. It has extremely strong connectivity. For example, Wet meadow_19/20 is located in the center of the wetland. They are all in direct contact with other GI elements. However, some GI elements located in remote areas scored lower, eg. Wet meadows_17 and Forest patches_29. Because they are located on the borders of the Naszály administrative district, their spatial relationship with GI elements outside the borders was not taken into account. Therefore, the connectivity results of this part of GI elements may have large errors. In addition, there are some GI elements located in the hinterland of agricultural land (eg. Grasslands and pastures_3) and GI elements adjacent to residential areas (eg. Woody groups_6), which also have poor connectivity. What's more, if the divided linear elements are longer and they span a wider range in space, the connectivity is stronger, and vice versa.

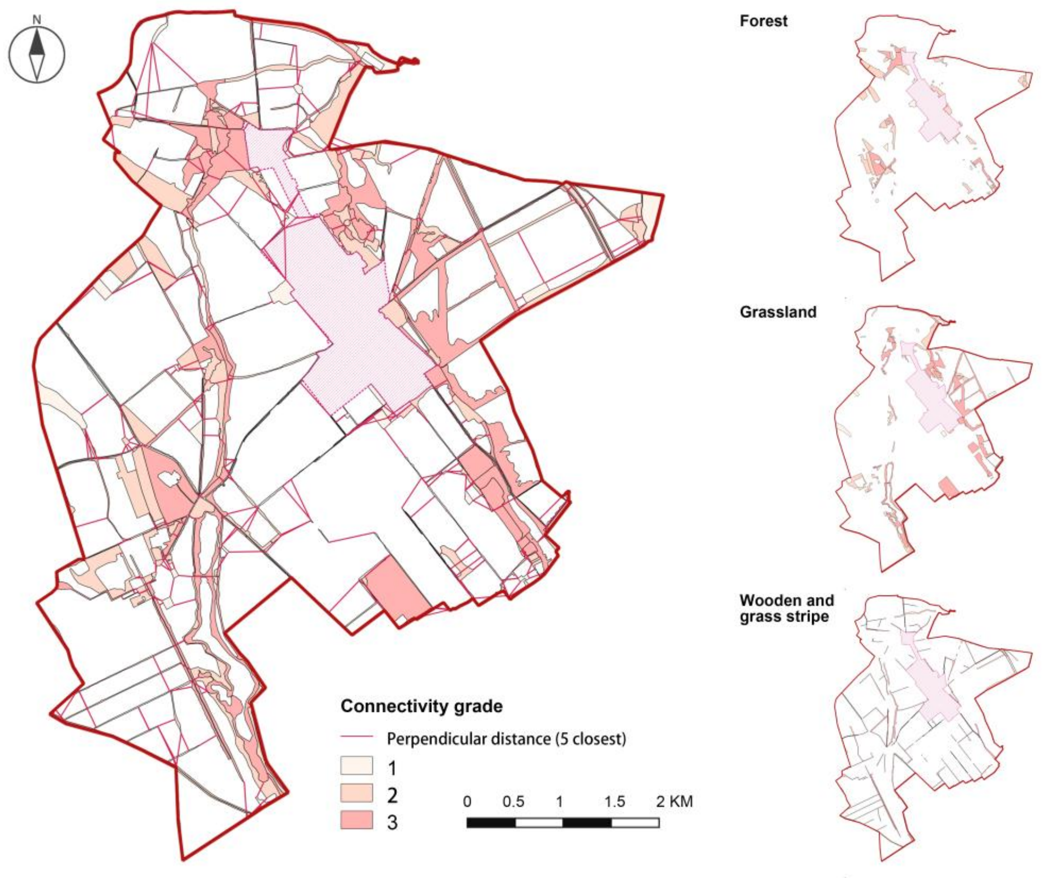


Figure 7.6. Result of 'Connectivity' indicator (Image by author)

From the overall structure, the connectivity of GI elements within Naszály is average. In the north-south direction, the GI network is connected through Naszály-Grébicsi Watercourse and Naszály-Grébicsi Watercourse. The connectivity is more obvious, showing extremely strong connectivity. In the east-west direction, due to the interception of large areas of agricultural land, there are only thin linear elements as corridors connecting GI elements, and no strong and stable ecological network system is formed. Therefore, in subsequent planning, solutions to this disadvantage can be proposed, increasing the possibility of new connectivity.

7.6 Landscape aesthetics

The areas obtained for GI elements with high aesthetic value almost coincide with the demarcated important visual areas. Figure 7.7. shows that they appear concentrated along the Naszály-Grébicsi watercourse and Ferencmajor fishpond systems, as well as linear elements near main roads. Since Naszály is dominated with a flat terrain, except for the viewing tower with a higher line of sight, it is difficult to use the height difference to obtain more viewing pleasure, so the line of sight on the horizontal plane is relatively closed.

Forest: It can be clearly observed that the forest around the abandoned mine (Forest patches_16/28) has high visibility due to its location at a road intersection with dense traffic. GI elements with a score of 0 are distributed in remote areas with less human traffic (eg. Forest patches_26/29), or deep forests that are difficult to reach, eg. Forest patches_2/3/4 and Woody groups_4.

Grassland: Because the height of lawn elements is limited, they are usually easily obscured by woody vegetation. Only grass elements in open areas of view will be visible. Grassland with a higher score is a GI element near a water body, and most of them are wet meadows, eg. Wet meadow_3/10/12/13. Grasslands rated 0 include Kovacs Meadow, which is covered by nature reserves, and meadows near Grébics Pond, which are hard-to-reach remote areas, eg. Wet meadow_2/5/6/7.

Wooden and grass strip: Owing to their linear characteristics and frequent parallel alignment with roads, these elements have a strong correlation with the transportation network. Some GI elements that serve as isolation belts between agricultural lands are difficult to see and therefore score very low, eg. Wooden and grass belts_18/19/22/24.

Figure 7.7. Result of 'Visibility in distance' indicator (Image by author)

For the Visibility in frequency indicator, GI elements with higher scores usually have two characteristics. On the one hand, they are distributed around important visual areas, especially where multiple viewing lines of sight meet, which makes them more likely to be seen. On the other hand, they are distributed in places with more open views, where there is no obstruction by tall forest trees. These places are mostly near the water, in the center of the farmland plot and around the Observation Deck.

On the whole, there is only one GI element that gets three points, a small patch of forest at the intersection of multiple roads (eg. Forest patches_16), which has the highest visual frequency. In addition, grasslands usually do not score highly because of their height and are often obscured by other elements, while Wooden and grass strips often act as visual barriers that block other elements due to their linear characteristics.

Figure 7.8. Result of 'Visibility in frequency' indicator (Image by author)

7.7 Complex state

In the methodology, it is mentioned that the way to evaluate the complex state is through the comprehensive superposition of different indicator layers. This approach allows for an overall understanding of the comprehensive situation of the GI system by identifying good/strong and poor/weak areas in the four aspects of ecological states, natural protection, connectivity, and visual importance.

Figure 7.9. shows the areas of good/strong complex state in Naszály. For different indicator aspects, the results of complex state have different expressions.

High ecological value areas: forests and wetland meadows of high ecological quality, as well as linear elements along watercourses and creeks.

Strong natural protection areas: grassy elements near Kovacs meadow and Ferencmajor fishpond system in eastern Naszály.

Strong connectivity areas: Naszály-Grébicsi Watercourse covered by the National ecological network (OÖH) and the forest on its north side, GI elements near Naszály-Grébicsi Watercourse and the Ferencmajor fishpond system, and linear elements along some roads.

High visual importance areas: GI elements near intersections, linear GI elements along farmland edges and along tour tracks, and GI elements within the visual range of the observation deck.

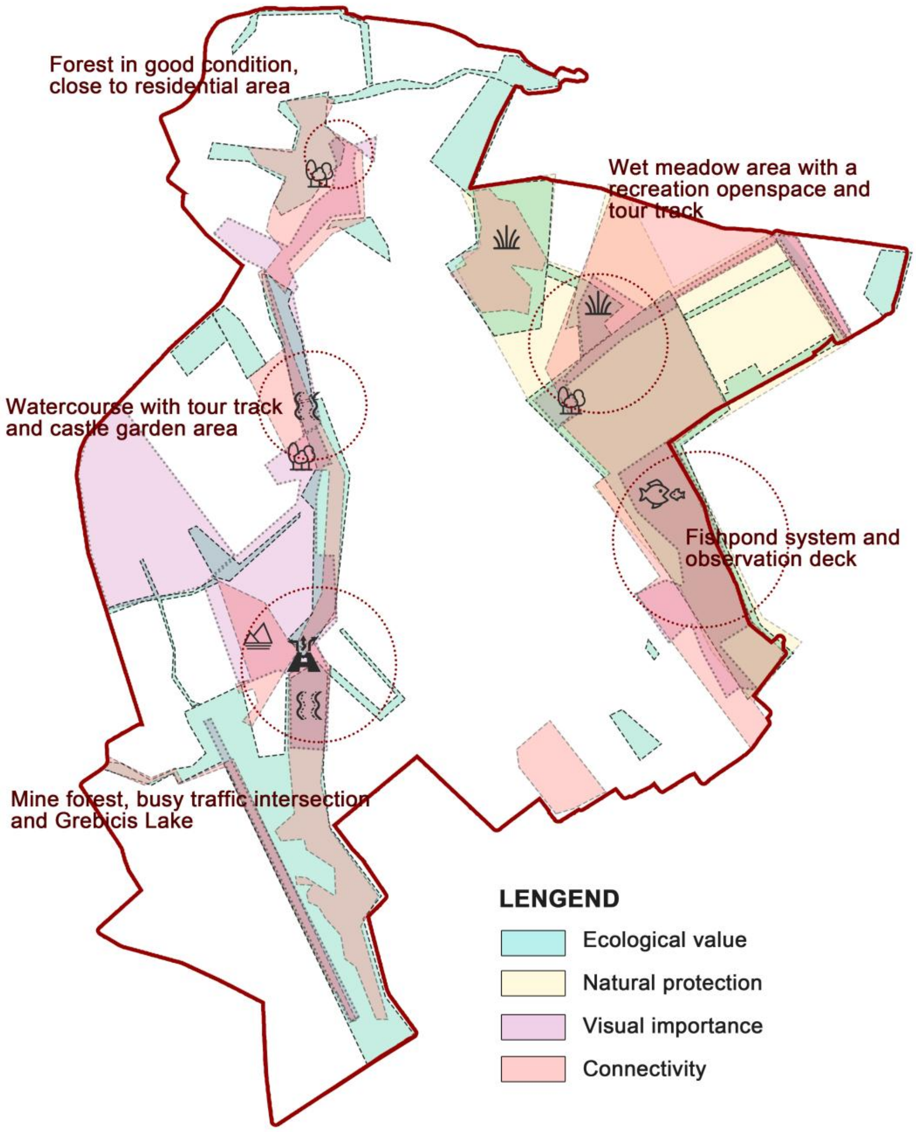


Figure 7.9. Complex state in high/strong result (Image by author)

In addition, the red dotted circles are the key areas of layer overlay, which represent GI element with strong advantages, which will not be described here.

Figure 7.10. shows the poor/weak complex state areas in Naszály. As the previous figure, the complex state reflects the sum of the results of different indicator aspects.

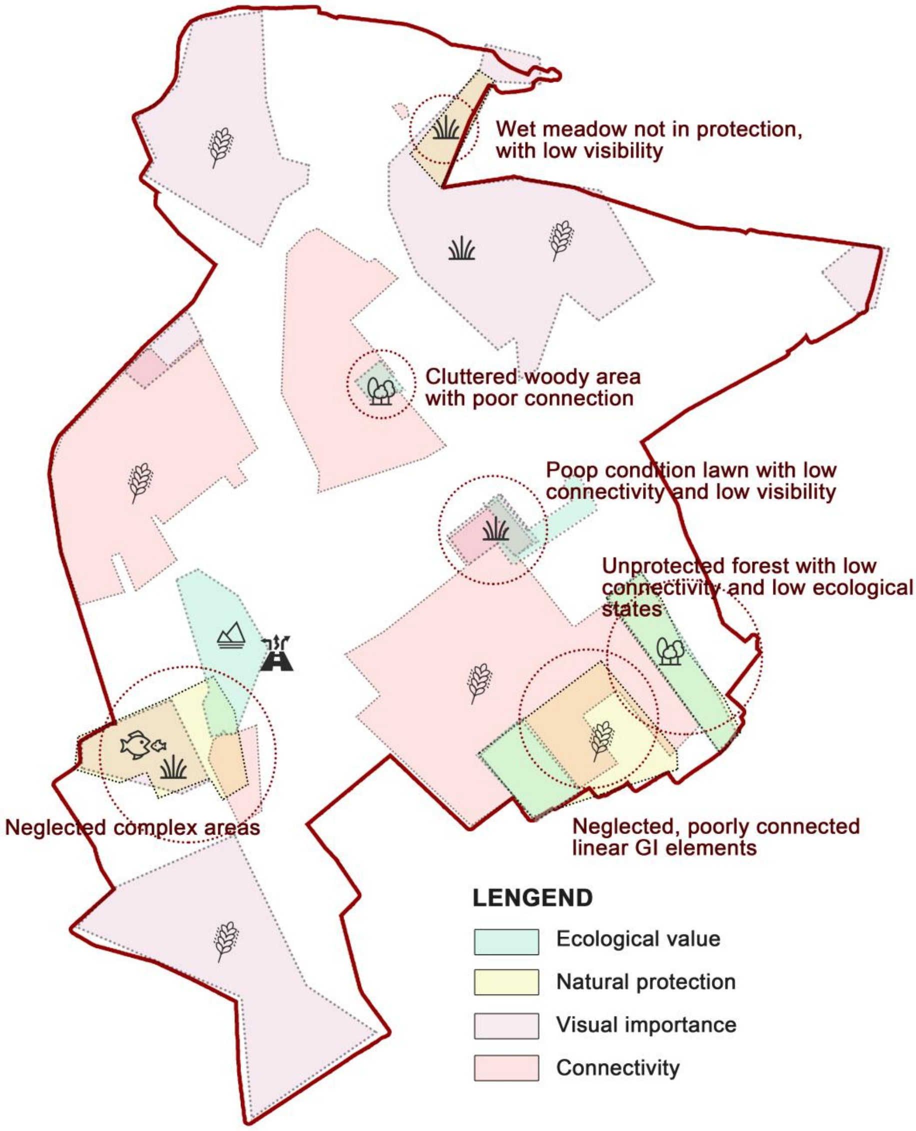


Figure 7.10. Poor/weak complex state areas (Image by author)

Poor ecological value areas: man-made forests around mines, abandoned and over-harvested grasslands next to residential areas, over-managed pastures in the southeast, and some linear elements with poor continuity not marked in the Figure 7.10.

Poor natural protection areas: meadows on the eastern border of Naszály, grasslands around Grébics fishpond, overmanaged pastures in the southeast and GI elements in much of the farmland.

Weak connectivity areas: Large tracts of farmland in central, western and southeastern Naszály.

Low visual importance areas: farmland areas away from main roads, inaccessible protected wetlands and meadows and marginal Naszály areas.

The red dotted circles are the focus area of the layer overlay, which indicate GI elements with multiple disadvantages. These areas are marked by great challenges and conflicts, and also where GI network planning measures need to be taken seriously.

7.8 Summary

According to the discussion of decision trees in the methodology and based on the evaluation results of 8 indicator subgroups, I summarized 6 types of areas as the base map for GI network system supervision and planning, detailed in Figure 7.11.

Figure 7.11. Potential managing areas in separated(Image by author)

①High ecological value, strong protection, could be continuously maintained, including Kovacs meadow and Ferencmajor fishpond systems;

② High ecological value, low protection, could be included in protection, including wetland meadows in the northeast and northwest of the residential area, the periphery of the Grébics fish pond, the eastern boundary of Naszály, and a small woodland in the farmland to the south.

③High ecological value, strong connectivity, could be continuously maintained, including the Kovacs meadow, the Ferencmajor fishpond system, as well as the northern wetlands covered by the OÖH ecological corridor and the Naszály-Grébicsi Watercourse.

④ High ecological value, weak connectivity, could be enhanced connectivity, including some small GI patches in the center of agricultural land.

⑤ Low ecological value, high visual importance, could be functionally redesigned, including the forested area surrounding the mine and its walkway, as well as the meadows and forests surrounding the observation tower.

⑥Low ecological value, low visual importance, could be ecologically restored, including two untidy lawns on the east side of the living area.

In the next step, our planning will be based on these areas (where), improve or solve their existing problems (why), and provide protection and development strategies for Naszály's GI network system (how).

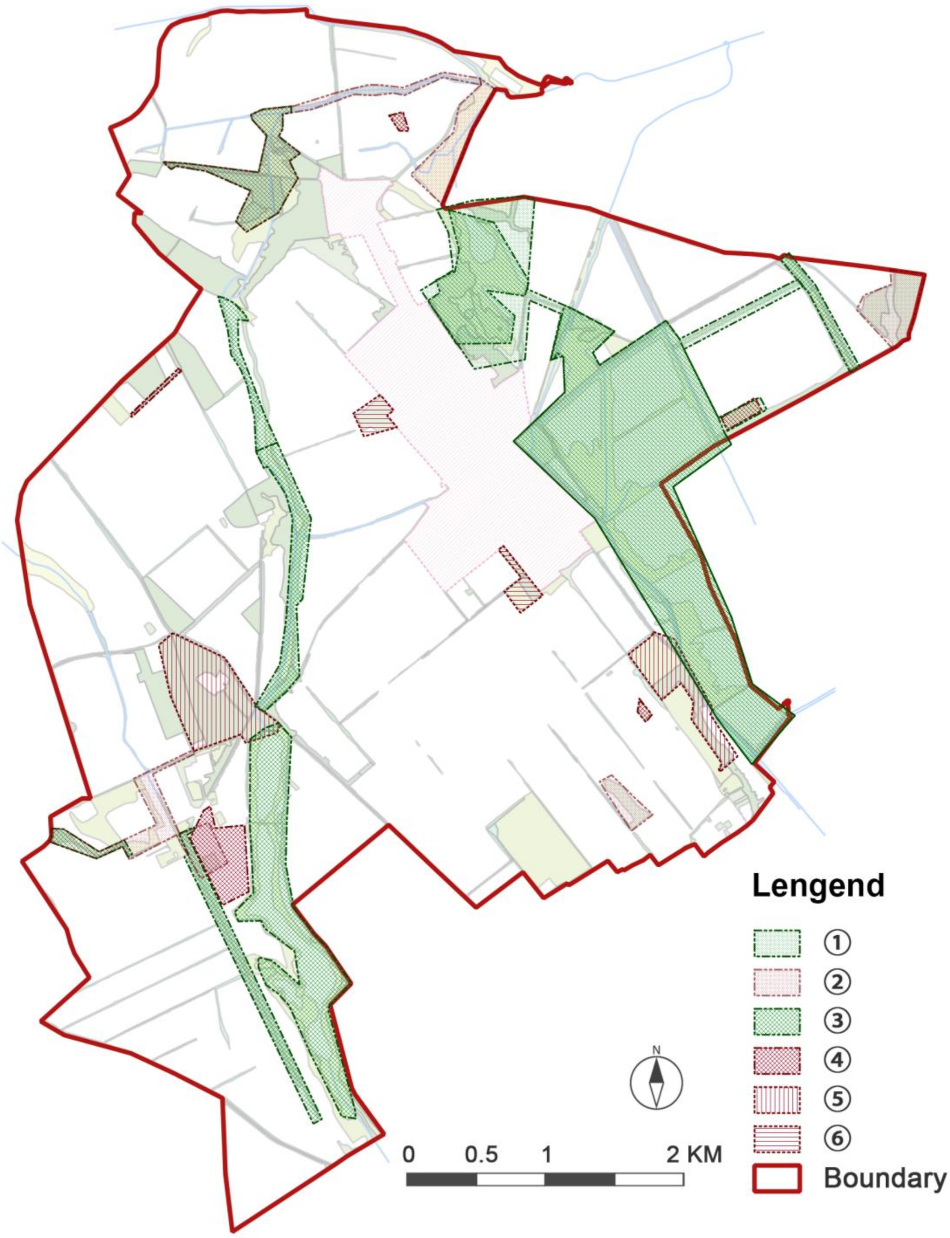


Figure 7.12. Evaluation summary in total (Image by author)

CHAPTER 8

Strategic Assumption

The recommendations for the development of national GI highlight that the tasks of GI development involve identifying objectives for maintenance, restoration, and functional enhancement, as well as ensuring the implementation of measures to improve the condition of ecosystems, thereby guaranteeing or enhancing human well-being[7]. Based on the assessment results obtained in the final section of Chapter 7, it was identified that there are GI elements in good condition, along with regions that hold potential planning value.

Based on these thoughts, I created a decision tree. It deals with planning measure assumptions for the GI network in the Naszály study area. This tree has two main parts: preservation and development, as detailed in Figure 8.1.

In the preservation decision, I identified areas with high ecological value and good ecological characteristics. These areas should maintain their original ecosystem properties without improvement, even if the goal is to enhance ecosystem services or connectivity. Within the identified range of similar elements, the main aim is to protect good ecological conditions through maintenance management, such as habitat management. These areas are the most valuable for protection, forming the backbone of the GI network and representing its core zones.

Category ① includes areas with high ecological value and strong protection. They have clear norms and restrictions, so it's important to continue their existing protection or strengthen management of these GI elements.

Category ② consists of areas with high ecological value but not under strong protection. This includes areas not yet protected or regulated, as well as those included in protection or regulation but not adequately preserved. These areas should receive more attention, and local municipalities should provide new management plans to improve their protection.

Category ③, which encompasses areas with high ecological value and strong connectivity, is not discussed here. This is because the GI elements in these regions are usually in a good ecological state and possess robust ecosystem service capabilities. Most have already been incorporated into the protection and regulation systems, eliminating the need for their separate categorization in GI network development recommendations.

In the development decision, areas requiring planning measures have been categorized into three types. These include regions in the GI network needing to address existing disadvantages, areas requiring a reduction in land use conflicts, and zones needing restoration of historical value. Primarily, physical interventions through the improvement of existing elements and the addition of new GI elements have been emphasized, aiming to construct a more harmonious and high-quality GI network system.

Category ④ encompasses GI elements with low ecological value and poor connectivity ratings. Additionally, agricultural lands lacking GI network connectivity have been considered as an adjunct area in Category ④. Development suggestions focus more on how to increase connections between different GI elements, such as adding new linear GI elements as links (or corridors), thereby achieving higher GI network coverage. The continuity within individual GI elements, such as improving the ecological condition and connectivity of highly fragmented patches, has also been taken into account.

Category ⑤ includes GI elements with low ecological value but high visual importance. These areas have been significantly impacted by human activities, with their original natural states almost entirely lost. Therefore, development measures for these areas can consider not only their ecological value but also the functional services they provide, such as offering scenic beauty and recreational value.

Given that Category ⑥ consists of GI elements with low ecological value and low visual importance, it is advocated to focus on the ecological value of these elements. Improvements can be made by enhancing habitat conditions and eliminating factors leading to habitat degradation, thereby improving the ecological condition of the GI elements.

Discussion about Category ⑦ and Category ⑧ does not appear in the results of Chapter 07. This is due to the land use assessment in Chapter 7.4 being limited to existing GI elements, without considering historical GI elements that were present in the past (as referenced in Chapter 4.2). Additionally, conflicts among land use types are summarized in Chapter 4.3.

Category ⑦ is identified as areas with land use conflicts, typically found at the intersections of agricultural lands with settlement areas, water elements, and main roads, where transitional elements as buffers are lacking. Hence, the focus of planning strategies will be placed on the construction of buffer zones in these boundary areas, utilizing GI elements to enhance ecosystem resilience.

Category ⑧ encompasses GI elements that were once present in historical maps but are now partially or completely absent. Their past existence was intricately linked with the GI network system of the Naszály region. Thus, restoring their presence plays a crucial role in supporting the development of original habitats. Particularly for locations where the integrity of GI elements has been disrupted, intervening and changing land use is an important and challenging task.

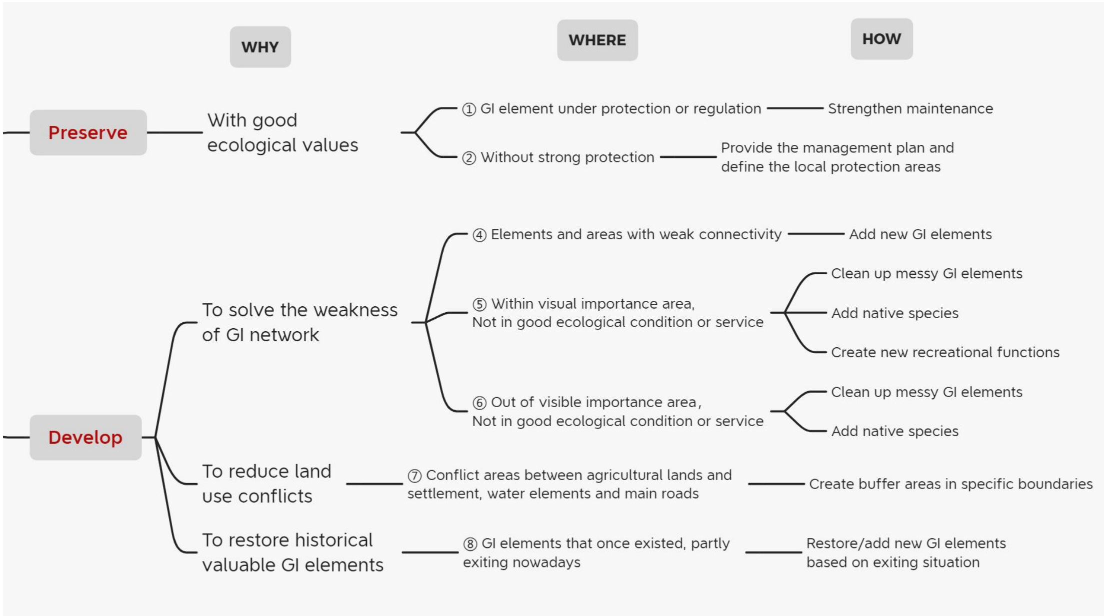


Figure 8.1. Planning strategy (Image by author)

8.1 Preservation strategy

According to the research findings, the envisioned protection strategy for the GI network in Naszály primarily focuses on five areas, involving three types of protection systems applicable to the locale (Figure 8.2.). These mainly address the issues present in Category ②.

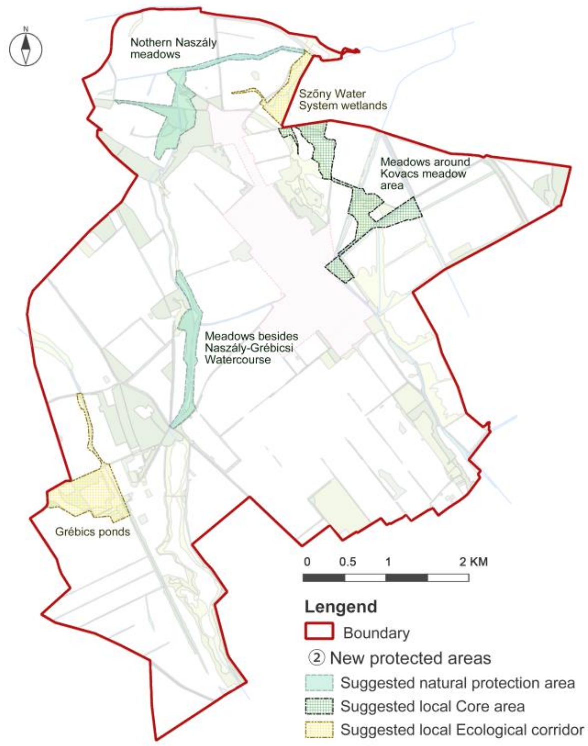


Figure 8.2. New preservation areas in Naszály (Image by author)

Suggested local natural protection areas include the northern Naszály meadow area, which is derived from the minor branches of the Szőny Water System, and the meadows beside the Naszály-Grébicsi Watercourse, currently part of the OÖH Ecological corridor. However, the level of protection in these areas is somewhat weak, thus it is advocated that more attention and management be provided to these regions.

Suggested local core areas include the Meadows around the Kovacs meadow area, which form part of a Ramsar site. These are GI elements with good ecological quality but are notably fragmented. Therefore, it is advocated to increase their designation as local core areas in the GI system, which can be linked with the OÖH Core area.

Suggested local ecological corridors include the Grébics pond areas and the Szőny Water System wetlands. These are new GI elements that are intended to be protected, aimed at enhancing their ecological condition while increasing the connectivity and influence of the OÖH Ecological corridor.

The protective measures proposed include, but are not limited to: establishing clear boundaries for protection or management, converting marginal farmland into forest or grassland, employing ecological restoration techniques with native plants, and setting up protective signage while advocating for public educational activities, please see Figure 8.3. for details.

Compared to the existing Nature conservation and legal regulation systems, the Grébics pond areas are being listed for natural protection for the first time, despite their ecological state not being sufficiently natural. However, it is advocated that the government should pay more attention to this area of high ecological value and potential, in order to build a more robust GI network system. As can be seen in the section, the implementation of the protection plan is predicated on the conversion of some agricultural lands into forests or meadows, requiring the joint efforts of the agricultural sector and local government.

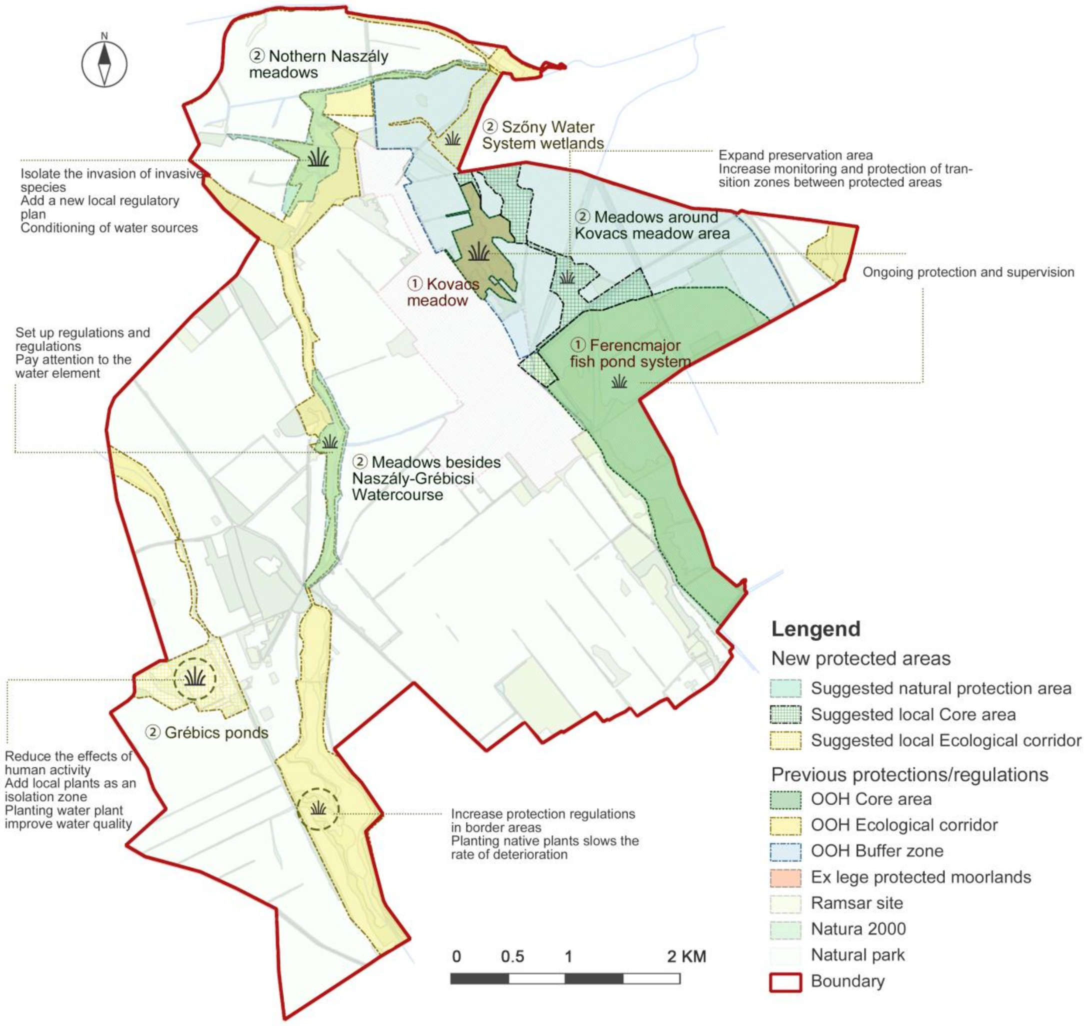


Figure 8.3. Preservation strategy in Naszály (Image by author)

8.2 Development strategy

The development strategy for the GI network in Naszály is comprised of two parts: the improvement and addition of the GI network. In the plan, it is proposed that measures be taken to improve 20 existing GI elements and to add 22 new GI elements that will support the GI network system, as shown in Figure 8.4.

The improvement of the GI network primarily targets Categories ④, ⑤, ⑥, and ⑦ in the planning decision tree, aiming to enhance network connectivity, improve visual characteristics, ameliorate ecological conditions, and alleviate land use conflicts. Meanwhile, the addition of new GI elements is intended to supplement support for the GI network, achieving the goals of enhancing connectivity, alleviating land use conflicts, and restoring historical values in Categories ④, ⑦, and ⑧.

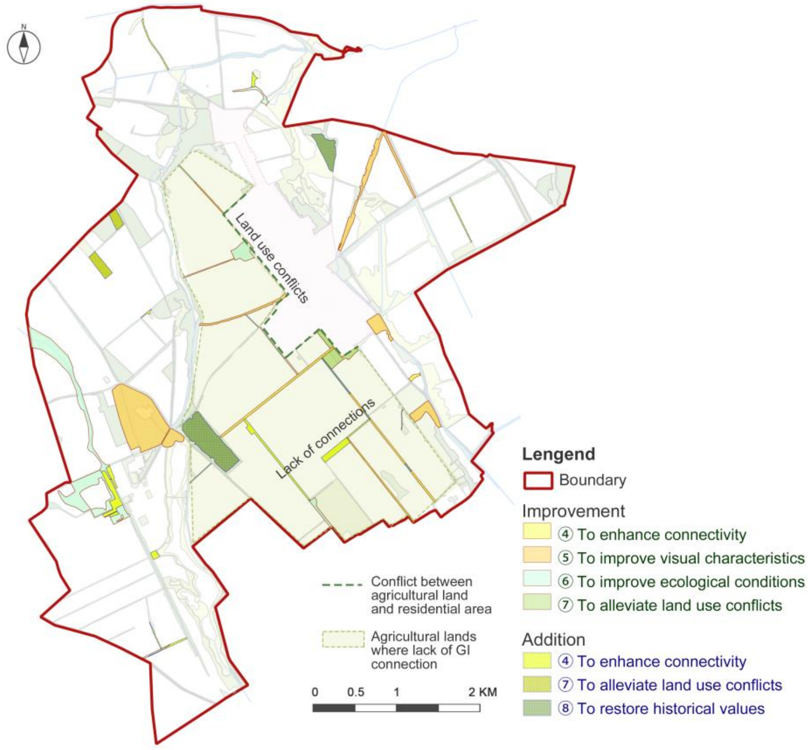


Figure 8.4. New improved and added areas in Naszály (Image by author)

Considering that a detailed description of the planning strategies for each individual GI element within the system (totaling 42) might result in high repetitiveness and excessively lengthy content, a different approach is taken. Since GI elements, as units of the green network, often interact with each other, discussing them in interconnected groups may yield a synergistic effect greater than the sum of their parts. Therefore, 14 areas where GI elements are concentrated have been selected for development, illustrated in Figure 8.5.

(1) Large Agricultural Lands Without GI Elements(④⑥)

Set up new linear GI elements, increase the connection of Szőny Water System and medows.

(2) Large Agricultural Lands and Disorganized Sites in Contact with Settlements(④⑤⑧)

Extension of the existing GI elements, adding native plants (eg. Corylus colurna) to enhance the aesthetics of both sides of the road. It once existed as a row of street trees in history, and its historical value has been restored. Improve the ecological character and aesthetic properties of cluttered sites.

(3) Artificial Forest Areas Located at the Boundaries(⑦)

Artificially planted mixed forest to increase the area of Naszály forest.

(4) Neglected Wetland Water Sources(④⑥)

Protect wetland resources and increase their ecological vitality with aquatic plants. Plant native trees along both sides of the creek to increase their ecological resistance.

(5) Mine Pit Sites and Surrounding Artificial Forests(⑤⑥)

Carry out ecological restoration of the mine pit and set up hiking routes.

(6) Disorganized Grébics Pond(④⑥)

Strengthen supervision capabilities, restore the natural vitality of wetlands, and build ecological fish ponds. Increase the area of meadow, improve the messy site environment, and increase the integrity of GI patches.

(7) Large Agricultural Lands with Poorly Conditioned Wooden and Grass Belts(④⑥⑦)

Use GI elements to divide plot boundaries, increase tree coverage, improve the fragmentation of grass strips, and establish new GI network connections.

(8) Isolated GI Patches and Barren Water Corridors in Farmlands(④⑥)

Increase new connection between the isolated meadow patch in the farmland center and the other GI elements. Protect water element and plant local trees as ecological barriers on both sides of the creek.

(9) Agricultural Lands Adjacent to Kovacs Meadow(④⑥⑧)

Delineate new regulation area to restore agricultural land to wetland meadows with ecological value. Increase the integrity of the GI element patch while restoring its historical value.

(10) Ecological Corridors Along Fényes Stream and Mikovinyi Ditch(⑤⑥)

Carry out standardized planting design and plant native trees to increase the aesthetics while protecting water resources.

(11) Unused Lawns and Mil Park Near Residential Areas(⑤⑥⑦)

Improve the quality of green space and create parkland that can be used by residents and visitors. Strengthen the management and protection of Mill cultural landscape and local botanical garden.

(12) Forests Near the Observation Tower(⑤)

Make full use of the observation tower to enhance the recreational value of the landscape. Arrange ornamental plants and add outdoor recreational facilities to build a forest park that serves residents and tourists.

(13) Large Agricultural Lands Lacking GI Elements (④⑤⑥⑦⑧)

Plant Turkish hazel (Corylus colurna) and Tilia (Tilia L.) with local characteristics, set up isolated green belts on both sides of the road, enhance its ecological value, ornamental value and historical value, form the landscape axis of Naszály, and improve roads and agricultural land buffering capacity.

(14) Historical Forests Existing Only at Boundaries (④⑥⑧)

Restored historic forest. Increase forest coverage in Naszály.

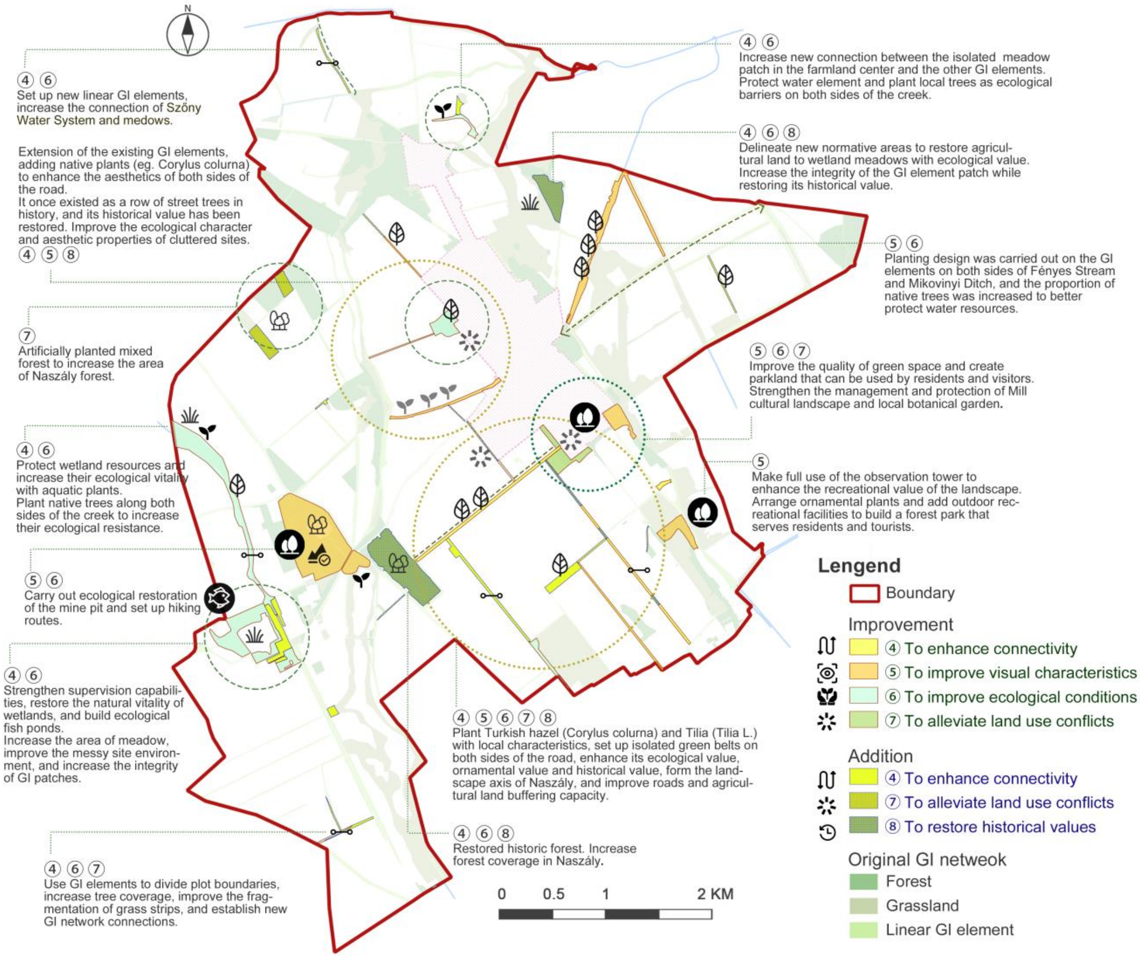


Figure 8.5. Development strategy in Naszály (Image by author)

Compared to the existing GI system, the total area involving improved GI elements is 112.03 ha, and the total area of new GI elements is 50.56 ha. This significantly consolidates and promotes the stable development of the Naszály GI network system.

This planning concept thoroughly considers the feasibility of improving ecological conditions, increasing spatial connectivity, and enhancing ecosystem service capabilities. It also positively impacts by providing recreational functions and aesthetic services, preserving historical and cultural values, and alleviating land use conflicts.

CHAPTER 9

Conclusion and Reflection

9.1 Conclusion

This thesis, based on the interpretation of satellite imagery, organization of network databases, and field surveys, summarizes the regional condition of Naszály at a large scale. It constructs a database and assessment model for Naszály's GI network system, obtaining qualitative and quantitative analysis results of eight indicators within the GI network system of the study area. Finally, potential optimization categories for the GI network system are organized, leading to the proposition of preservation and development strategy concepts.

In detail, the main findings of this study are as follows:

(1) Naszály is an administrative settlement dominated by agricultural land, rich in wetland resources. The total area of Naszály is 3021.8 ha, of which 64.43% is arable land.

(2) The GI network coverage in Naszály is relatively low (Appendix III). This study counted a total of 229 GI elements, covering an area of 652.72 ha, accounting for 21% of Naszály's total area. Among these, grassland covers 315.52 ha, accounting for 48.34% of the total GI elements in Naszály. Forests cover 213.81 ha, accounting for 32.76% of the total GI elements. Linear GI elements, wooden and grass strips, cover 123.39 ha, accounting for 18.90% of the total GI elements.

(3) The study constructed a GI network assessment system and index group applicable to Naszály (Appendix I) and obtained quantified results for different elements (Appendix II).

(4) The ecological condition of Naszály's GI network varies greatly by type, while the overall level of ecosystem service is high. Protected regions are concentrated in distribution, with the national ecological network covering almost all wetland resources in Naszály. Most elements have a stable landscape use. In terms of spatial relationship, the connectivity of existing elements is strong. In landscape aesthetics, the visibility in distance and frequency of GI elements is average, with scenic value often found at road intersections. In the final complex state assessment, I summarized six categories about focus areas.

Based on the assessment results and the planning decision tree, the planning concept for the GI element network in the Naszály area includes both preservation and development parts, providing corresponding strategies for different GI element clusters (Appendix IV).

9.2 Reflection

The study shows that it is feasible to assess settlement-scale study areas based on satellite imagery, network, and actual measurement data. The results and recommendations obtained from the research are also rigorous and scientific.

However, there are certain limitations in the methodology, content, and expected objectives of this study. Therefore, in subsequent research, I propose the following improved methods:

(1) Establish a more comprehensive GI network database. In selecting GI elements, this study did not include orchards, crop plantations, or ecologically valuable farmlands, nor did it assess solitary trees within the study area. Missing types of elements can be added to make the types of GI elements counted more comprehensive and more aligned with the themes of agricultural services and development.

(2) Increase public participation in assessment and planning content. The evaluation of the Landscape aesthetics indicator group is somewhat subjective; questionnaires or interview activities can be conducted in collaboration with the municipality.

(3) Provide more detailed design plans as examples. For different regions or elements' planning objectives, specific design plans can be provided, showcasing the concepts or techniques used for ecological restoration, or the types of plants used or public facilities added.

(4) Develop a sustainable strategic plan. The GI element development concepts provided in this study do not have clear time limits and gradations. In the next step of the research, development goals can be set according to the priority of potential problems of different elements. Improving ecological conditions may be the most important step, with subsequent landscape enhancement based on this. Therefore, a long-term plan for 3/5/10 years can be formulated to achieve self-regulation and self-prosperity of the GI network.

Finally, this study aims to call on planners and landscape architects to pay more attention to the monitoring and development of the current state of GI element networks in agricultural lands, to protect the skeleton of our natural environment, and to face the unknown changes in the earth's climate and environment together. Figure 9.1. shows the logo I designed for the aim of the GI network preservation and development in Naszály, symbolizing our sustainable and resilience vision to enhence GI networks within agricultural landscape.

Figure 9.1. Project logo in proposal (Image by author)

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Appendix

Appendix I. GI network evaluation model - Grading

GI element level

Aspects/ Indicator groups	Ecological condition		Ecosystem service	
Element types	Grades	Naturalness and Growth status	Grades	Complexity and Diversity
Forest	5	Natural forests without human influence, with native species, in healthy condition	3	Large and continuous forest with multiple vegetation layers, high species richness
	4	Semi-natural forest and shurbs, with some alien species and invasive species, in good condition		
	3	Semi-natural forest and shurbs, mixed with native and invasive species, or partly exists pests/diseases	2	Middle and small forest and woody group, with multiple layers
	2	Forest wiht shurbs or invasive species dominated, or in sparse planting density or exists pests/diseases		
	1	Artificial forest or plantation under sever human influence, with invasive species dominated, or in bad health condition	1	Forest patches with single layer, poor species richness
Grassland	5	Natural and lush grassland, without management and influence	3	Wet meadows with high species richness
	4	Semi-natural grassland, in good condition, dominated with native species		
	3	Atypical grassland, with moderate management, or sparse lawn with some invasive species	2	Large and continus grasslands and pastures
	2	Severely degraded or over managed/grazed lawn, dominated with invasive species		
	1	Completely degraded lawn or artificial lawn (e.g. broken or plowed lawns)	1	Small or fragmented grasslands and pasture patches
Wooden and grass stripe	5	Natural and health vegetation strips, without human influence	3	Long and integrated strips with multiple vegetation layers, or the strips close to water
	4	Natural and healthy vegetation strips adapted to surroundings, with native species dominated		
	3	Semi-natural vegetation strips, mixed with native and invasive species in different ages	2	Short strips or fragmented strips with multiple vegetation layers
	2	Artificial strips, dominated with invasive speciess, discontinuous or in poor condition		
	1	Artificial strips, made up with invasive species , low consistency, young or in poor health condition	1	Strips with single vegetation layer

GI system level

Nature conservation and legal regulation			
Grades	Protected region	Grades	National ecological network (OÖH)
3	Ex lege protected moorlands	3	OÖH Core area
3	Ramsar sites	2	OÖH Ecological corridor
2	Natura 2000	1	OÖH Buffer zone
1	Natural park	0	Not included

Landscape aesthetics			
Grades	Visibility in distance	Grades	Visibility in frequency
3	High importance, local view in 200 m	3	High visual importance, could be seen from more than 5 points
2	Middle importance, middle view between 200-1500 m	2	Middle visual importance, could be seen from 2-4 points
1	Low importance, far distance view beyond 1500m	1	Low visual importance, could be seen from 1 point
0	could not be seen	0	could not be seen

Landscape use	
Grades	Stability
1	In stable use
0	Not in stable use

Spatial relationship	
Grades	Connectivity
3	Strong, distance within 0-22m
2	Moderate, distance within 22-475m
1	Weak, distance 475-2568m

Appendix II. GI elements statistical table

a. Forest patches

Forest patches																				
id	Aare(m2)	Ecological condition score	Ecological service score	ex-area(ha)	ra-area(ha)	na-area(ha)	Na park-area(m2)	pro OOH1 area(ha)	pro OOH3 area(ha)	pro OOH2 area(ha)	Visual-D score	Visual-F score	Protection 1 score	Protection 2 score	Stable use area(m2)	Stable use proportion(%)	Stable use score	5 average distances	Connectivity score
1	22626.211	2	2				22626.211				0	0	1	0	2162.236601	0.1	1	78.6388	2
2	50793.902	3	3				50793.902			4.810516	0	0	1	1.89	38797.8069	0.76	4	1.9844	3
3	15208.193	5	2				15208.193			1.520819	0	0	1	2	10942.63107	0.72	4	32.8754	2
4	18111.231	4	1				18111.231			1.811123	0	0	1	2	14982.34114	0.83	5	5.5004	2
5	26677.008	2	2				26677.008			2.634808	2	1	1	1.98	26677.00783	1	5	0.9226	3
6	17882.181	2	2				17882.181				3	1	1	0	2910.784826	0.16	1	22.8462	2
7	169284.042	2	3				169284.04			1.551105	2	1	1	0.18	47595.66317	0.28	2	0.0714	3
8	164536.63	2	3				164536.63			1.60018	3	1	1	0.19	164397.2627	1	5	16.8066	2
9	91033.332	3	3				91033.332				2	1	1	0	85598.38337	0.94	5	38.79	2
10	62606.241	4	3				62606.241				0	0	1	0	37687.90627	0.6	3	87.273	2
11	55558.251	3	3				55558.251				3	1	1	0	44193.00054	0.8	4	4.6322	2
12	37992.453	2	1				37992.453				3	2	1	0	37711.12538	0.99	5	18.7384	2
13	52715.935	2	3				52715.935			5.109467	3	2	1	1.94	52715.93624	1	5	0	3
14	19144.994	1	2				19144.994				3	2	1	0	13557.47407	0.71	4	136.86	1
15	66302.599	4	3				66302.599			6.447514	3	1	1	1.94	66302.59925	1	5	6.7442	2
16	33099.588	2	3				33099.588			0.408636	3	3	1	0.25	33099.58788	1	5	4.532	2
17	23807.141	1	1				23807.141				3	1	1	0	23807.14092	1	5	2.8072	3
18	62883.888	2	3	3.63487	6.26638		62883.888	2.7555	3.531675		0	0	5.72	2.12	53817.00279	0.86	5	4.329	2
19	11224.147	1	1				11224.147				3	2	1	0	949.4798551	0.08	1	132.8384	1
20	25344.923	2	1				25344.923				0	0	1	0	708.3394443	0.03	1	100.2546	1
21	33774.482	2	2				33774.482			1.635414	3	2	1	0.97	33772.02294	1	5	0	3
22	37100.971	5	2		3.71009		37100.971	3.71001			0	0	4	1	22117.38302	0.6	3	80.8772	2
23	76583.03	2	3				76583.03				3	2	1	0	47865.40261	0.63	4	0.671	3
24	22899.208	2	2				22899.208				0	0	1	0	22501.43176	0.98	5	0	3
25	88960.574	2	3				88960.574				3	1	1	0	40341.94619	0.45	3	23.563	2
26	39954.241	1	1				39954.241			3.193091	0	0	1	1.6	11268.70418	0.28	2	65.8004	2
27	86833.017	1	3				86833.017				3	2	1	0	86833.0173	1	5	7.7128	2
28	223245.171	1	3				223245.17				3	2	1	0	223213.8695	1	5	3.2546	3
29	71975.661	5	3				71975.661			7.195469	0	0	1	2	67306.18456	0.94	5	143.1532	1

b. Woody groups

Woody groups																			
id	Aare(m2)	Ecological condition score	Ecological service score	ex-area(ha)	ra-area(ha)	na-area(ha)	Na park-area(m2)	pro OOH1 area(ha)	pro OOH3 area(ha)	pro OOH2 area(ha)	Visual-D score	Visual-F score	Protection 1 score	Protection 2 score	Stable use area(m2)	Stable use proportion(%)	Stable use score	5 average distances	Connectivity score
1	6637.861383	4	2				6637.86138			0.663786	0	0	1	2	6637.861383	1	5	13.0502	2
2	3301.274124	5	2	3301.27	0.330127		3301.27412		0.33012		0	0	7	3	3301.274124	1	5	52.373	2
3	4049.445054	2	1		0.404945		4049.44505	0.16663			3	2	4	0.41	1749.491823	0.43	3	59.387	2
4	61630.18974	3	1				61630.1897			0.503078	0	0	1	0.16	61591.282	1	5	27.2894	2
5	420.8688598	2	1	420.869	0.042086		420.86886		0.04208		0	0	7	3		0	0	52.535	2
6	41723.24799	1	1				41723.248				2	1	1	0		0	0	387.3794	1
7	3425.301826	3	2		0.339614		3425.30183	0.3425			3	2	3.97	1	3425.301826	1	5	5.5796	2
8	46558.02967	4	3		3.216196		46558.0297	0.034205	0.038439		3	2	3.07	0.03	30234.34231	0.65	4	8.2104	2
9	9217.287084	2	2		0.921729	0.91634	9217.28708		0.921728		0	0	5.99	3	4419.653565	0.48	3	6.6012	2
10	14845.51529	2	1				14845.5153				3	1	1	0	0.016620868	0	0	34.3048	2
11	32858.45357	4	3		3.285845	0.288369	32858.4536		0.48181		3	1	4.18	0.44	23636.71915	0.72	4	27.1198	2
12	2562.380337	4	2		0.256238		2562.38034				3	2	4	0		0	0	34.8624	2
13	7659.445632	2	2				7659.44563				2	1	1	0		0	0	19.019	2
14	661.7710353	1	1				661.771035				2	1	1	0		0	0	146.6292	1
15	6424.15662	4	2				6424.15662	0.156752			0	0	1	0.24		0	0	119.0068	1
16	268.8862455	4	1				268.886246				0	0	1	0		0	0	145.6246	1
17	307.2931303	2	1				307.29313				0	0	1	0		0	0	26.3138	2
18	11461.2708	1	1				11461.2708				0	0	1	0	1022.29871	0.09	1	8.1288	2
19	433.0354979	3	2				433.035498				0	0	1	0		0	0	230.8332	1
20	5965.547603	3	2				5965.5476				0	0	1	0		0	0	117.942	1
21	35895.71475	4	3				35895.7148				2	1	1	0		0	0	80.5486	2
22	2041.142648	3	1				2041.14265				2	1	1	0	2041.142648	1	5	131.7066	1
23	4074.498019	2	1				4074.49802				3	2	1	0		0	0	94.5838	2
24	24150.68091	3	2				24150.6809				3	1	1	0	24150.68091	1	5	4.8684	2
25	2496.64539	2	1				2496.64539				3	1	1	0	2496.64539	1	5	133.8524	1
26	9193.367555	3	2				9193.36756				2	1	1	0		0	0	137.783	1
27	5073.292477	4	1				5073.29248			0.507329	3	2	1	2	5073.292477	1	5	71.3992	2
28	32621.62523	3	3				32621.6252			2.836515	0	0	1	1.74	11897.72109	0.36	2	90.2044	2
29	1647.939181	2	2				1647.93918				0	0	1	0		0	0	29.2328	2
30	1595.820808	4	2	28.3034	0.159582		1595.82081		0.159582		0	0	4	3	1595.820808	1	5	37.3594	2
31	2646.154253	2	1				2646.15425				3	1	1	0		0	0	44.2826	2
32	6199.541769	3	3				6199.54177			0.31096	0	0	1	1	5800.961077	0.94	5	122.5894	1

c. Grasslands and pastures

Grasslands and pastures																			
id	Aare(m2)	Ecological condition score	Ecological service score	ex-area(ha)	ra-area(ha)	na-area(ha)	Na park-area(m2)	pro OOH1 area(ha)	pro OOH3 area(ha)	pro OOH2 area(ha)	Visual-D score	Visual-F score	Protection 1 score	Protection 2 score	Stable use area(m2)	Stable use proportion(%)	Stable use score	5 average distances	Connectivity score
1	56986.92123	2	2		0.05747		56986.9212			5.357315	3	1	1.03	1.88	56457.81385	0.99	5	1.4182	3
2	6724.545942	4	2		0.67246		6724.54594	0.67245			0	0	4	1	2506.731741	0.37	2	69.7894	2
3	6767.250366	3	2		0.67673		6767.25037	0.6767			2	1	4	1	6018.591264	0.89	5	253.4774	1
4	252.4076917	1	1				252.407692				2	1	1	0		0	0	131.6944	1
5	12588.17768	4	3				12588.1777			1.258818	0	0	1	2	12588.17768	1	5	7.0036	2
6	5468.954134	1	2				5468.95413			0.212	0	0	1	0.78	5468.954134	1	5	15.4686	2
7	696.1501323	1	1		0.06962		696.150132				0	0	4	0	696.1608452	1	5	41.2124	2
8	18790.46869	2	3				18790.4687			1.795034	3	1	1	1.91	18452.32989	0.98	5	0	3
9	8061.193358	1	1				8061.19336			0.262217	3	1	1	0.65	3836.708928	0.48	3	33.7348	2
10	23243.76837	2	2		2.32438		23243.7684	2.303463			0	0	4	0.99	23225.22712	1	5	9.64	2
11	4129.563245	1	1		0.41296		4129.56324	0.41284			0	0	4	1	4114.057091	1	5	127.6784	1
12	23011.57459	2	2	1.24523	2.30115		23011.5746	1.055926	1.245229		0	0	5.62	2.08	12178.50758	0.53	3	12.7182	2
13	88959.43424	2	2		8.89594		88959.4342	8.895943			0	0	4	1	78940.85809	0.89	5	0	3
14	22518.73411	1	2				22518.7341				0	0	1	0	17156.99259	0.76	4	312.8694	1
15	27909.9605	1	2		2.791		27909.9605	2.790996			0	0	4	1	17181.37573	0.62	4	14.131	2
16	19893.79031	1	2		1.98979		19893.7903	1.989379			0	0	4	1	6278.599046	0.32	2	53.0058	2
17	26773.52276	3	2		2.67735	2.67735	26773.5228		2.677352		0	0	6	3	1651.545668	0.06	1	397.9286	1
18	5840.174022	2	2				5840.17402				3	1	1	0	5840.178769	1	5	54.0676	2
19	38221.05502	2	2		3.82211	0.37917	38221.055		0.365755		3	1	4.2	0.29	35857.58427	0.94	5	1.4198	3
20	10525.28925	1	2				10525.2892				0	1	1	0		0	0	90.4378	2
21	21274.00352	1	1				21274.0035				0	0	1	0	66.57082229	0	0	109.031	1
22	76149.2677	1	2				76149.2677				3	2	1	0	732.7624843	0.01	0	1.9972	3
23	97176.2254	1	2				97176.2254				0	0	1	0	11155.95497	0.11	1	0.4124	3
24	15192.4746	1	2				15192.4746				0	0	1	0	2869.210415	0.19	1	0	3
25	2301.032456	1	1				2301.03246				0	0	1	0	428.019506	0.19	1	42.842	2
26	253461.8312	1	2				253461.831				2	1	1	0		0	0	2.0406	3
27	6690.402308	1	1				6690.40231				0	0	1	0	6690.402308	1	5	121.4678	1
28	110145.782	3	3				110145.782			10.997593	0	0	1	2	104069.2383	0.94	5	26.3166	2
29	52277.35508	2	2				52277.3551			5.227736	0	0	1	2	31850.29006	0.61	4	12.756	2
30	14439.38501	1	2				14439.385			0.857847	3	1	1	1.19	11046.63013	0.77	4	16.416	2
31	4792.62147	1	1				4792.62147				0	0	1	0		0	0	118.5542	1
32	4448.15476	1	1				4448.15476				3	1	1	0	2272.061964	0.51	3	21.0366	2
33	8003.081185	1	1				8003.08118				0	0	1	0	8003.081185	1	5	32.3876	2
34	9828.934482	2	1				9828.93448				0	0	1	0	9828.934482	1	5	1.5424	3
35	11268.02436	1	2				11268.0244				0	0	1	0	11268.02436	1	5	44.1714	2
36	22946.50945	1	1				22946.5094				0	0	1	0	17239.29522	0.75	4	11.2434	2
37	6286.767518	1	1				6286.76752				3	1	1	0	4272.958116	0.68	4	20.1968	2
38	93681.8542	2	2				93681.8542				0	0	1	0	51769.53982	0.55	3	15.7662	2
39	33174.81407	1	2				33174.8141			2.121926	3	2	1	1.28	33174.81407	1	5	7.5926	2
40	94599.67173	2	2				94599.6717			7.316503	0	0	1	1.55	75064.67542	0.79	4	0	3
41	127992.8954	3	2	11.8639	12.7993		127992.895	0.953316	11.84597		0	0	6.78	2.85	115765.9277	0.9	5	0	3
42	4375.392684	2	1				4375.39268				0	0	1	0	4375.392684	1	5	93.2792	2
43	17584.85683	2	2				17584.8568				3	1	1	0	1141.014007	0.06	1	21.8574	2

d. Wet meadows

Wet meadows																			
id	Aare(m2)	Ecological condition score	Ecological service score	ex-area(ha)	ra-area(ha)	na-area(ha)	Na park-area(m2)	pro OOH1 area(ha)	pro OOH3 area(ha)	pro OOH2 area(ha)	Visual-D score	Visual-F score	Protection 1 score	Protection 2 score	Stable use area(m2)	Stable use proportion(%)	Stable use score	5 average distances	Connectivity score
1	49429.83787	4	3				49429.8379			4.705765	0	0	1	1.9	49402.36517	1	5	98.996	1
2	139041.5319	5	3		1.390297		139041.532	13.6685			0	0	1.3	0.98	124307.1097	0.89	5	5.5172	2
3	338463.1617	4	3		3.384632	32.74826	338463.162	4.1266	29.69924		3	1	6.88	2.75	223254.1785	0.66	4	0	3
4	28581.72574	4	3				28581.7257				0	0	1	0	8991.684402	0.31	2	26.1776	2
5	15883.26363	5	3		1.588326		15883.2636	1.5883			0	0	4	1	15119.93292	0.95	5	164.0528	1
6	128623.5251	4	3	8.01349	12.86235		128623.525	4.8488	8.013485		0	0	5.87	2.25	110349.2728	0.86	5	0	3
7	41678.51323	4	3	3.53434	4.167851		41678.5132	0.8805	3.287322		0	0	6.54	2.58	30785.13054	0.74	4	6.714	2
8	1777.340995	3	3		0.177734	0.177734	1777.341		0.177734		0	0	5	3	1777.340995	1	5	197.114	1
9	4463.204841	2	2				4463.20484				0	0	1	0	4463.204841	1	5	114.3344	1
10	203657.1038	4	3		2.036571	20.26201	203657.104		20.28462		3	2	7	2.99	189639.2582	0.93	5	0.629	3
11	9981.468049	3	3		0.998147	0.998147	9981.46805		0.928502		0	0	5	2.79	9981.468049	1	5	5.0878	2
12	232798.9456	3	3				232798.946			2.320182	3	1	1	0.2	222532.5596	0.96	5	0	3
13	65706.96159	3	3				65706.9616			4.293337	3	2	1	1.31	65706.9616	1	5	1.5338	3
14	10717.35844	4	3		1.071736	1.071732	10717.3584		1.071735		0	0	5	3	10717.35689	1	5	20.728	2
15	12223.52792	4	3				12223.5279			1.222353	0	0	1	2	12223.52793	1	5	43.0204	2
16	35467.03513	3	3				35467.0351			3.206632	3	1	1	1.81	35175.91815	0.99	5	0	3
17	78759.72207	2	1				78759.7221			7.683202	2	2	1	1.95	78759.71242	1	5	255.0662	1
18	10854.1438	3	3				10854.1438				0	0	1	0	10679.05228	0.98	5	513.7274	1
19	83412.5967	3	3		8.34126		83412.5967	8.34126			3	1	4	1	76635.20907	0.92	5	0	3
20	63952.58017	4	3				63952.5802			6.182835	2	1	1	1.93	61412.72389	0.96	5	0	3

e. Tree-lined hedges

Tree-lined hedges																			
id	Aare(m2)	Ecological condition score	Ecological service score	ex-area(ha)	ra-area(ha)	na-area(ha)	Na park-area(m2)	pro OOH1 area(ha)	pro OOH3 area(ha)	pro OOH2 area(ha)	Visual-D score	Visual-F score	Protection 1 score	Protection 2 score	Stable use area(m2)	Stable use proportion(%)	Stable use score	5 average distances	Connectivity score
1	15568.11691	3	3				1				0	0	1	0	14622.52766	0.94	5	2.8036	3
2	27999.69839	2	3		2.76241		1	2.774			0	0	3.96	0.99	11058.53278	0.39	4	17.8144	2
3	18544.59242	1	1		1.763233		1	1.814			0	0	3.85	0.98	16672.06886	0.9	5	3.547	3
4	22788.82386	2	1				1	0.63215			3	1	1	0.28	582.0313348	0.03	1	0	3
5	5145.104789	3	2				1				3	1	1	0	5125.494123	1	5	20.528	2
6	6284.179786	3	1				1				3	1	1	0	3043.863093	0.48	3	31.0196	2
7	8827.954778	1	1				1				3	1	1	0	253.8246851	0.03	1	9.7384	2
8	22714.54266	3	1				1				3	2	1	0	22291.54446	0.98	5	2.7134	3
9	28735.33909	2	3				1				3	2	1	0	26886.04953	0.94	5	0	3
10	9601.654329	1	1				1				2	2	1	0	8312.430326	0.87	5	17.274	2
11	15158.33993	3	3				1				3	1	1	0	14170.59676	0.93	5	73.7368	2
12	7741.138185	1	1				1				3	2	1	0		0	0	2.243	3
13	6322.181306	2	2				1				3	2	1	0	6322.181306	1	5	9.8726	2
14	11046.8254	1	1				1				3	1	1	0	10532.52361	0.95	5	120.4056	1
15	20830.13409	4	3				1				3	2	1	0	20123.24181	0.97	5	4.8228	2
16	9021.447145	2	3				1				3	2	1	0	9021.452793	1	5	6.372	2
17	6353.606344	2	3				1				3	1	1	0	1490.056159	0.23	2	126.2838	1
18	21848.85998	2	2				1				0	0	1	0	21848.84911	1	5	2.817	3
19	25513.56156	2	1				1				0	0	1	0	22183.76065	0.87	5	40.3246	2
20	12325.65878	2	3				1				0	0	1	0	2414.976447	0.2	1	91.2032	2
21	6667.330889	1	1				1				0	0	1	0	6450.501581	0.97	5	173.2192	1
22	9990.889409	3	3				1				3	2	1	0	4796.005479	0.48	4	4.2432	3
23	3744.409019	1	1				1				0	0	1	0	3424.739317	0.91	5	252.9928	1
24	8258.494207	2	2				1				0	0	1	0	8258.489393	1	5	37.1592	2
25	9768.199753	1	1				1				0	0	1	0	9768.199753	1	5	139.2908	1
26	3064.606215	1	1				1				0	0	1	0		0	0	200.4028	1
27	5646.592242	2	1				1				2	2	1	0	4935.715765	0.87	5	191.8534	1
28	4912.978237	2	3				1				3	1	1	0	4807.14921	0.98	5	31.3648	2
29	5755.316628	2	3		0.575532		1				3	2	4	0	5152.757612	0.9	5	2.5588	3
30	4748.972469	2	2		0.574597		1				3	2	4.63	0		0	0	4.29	3

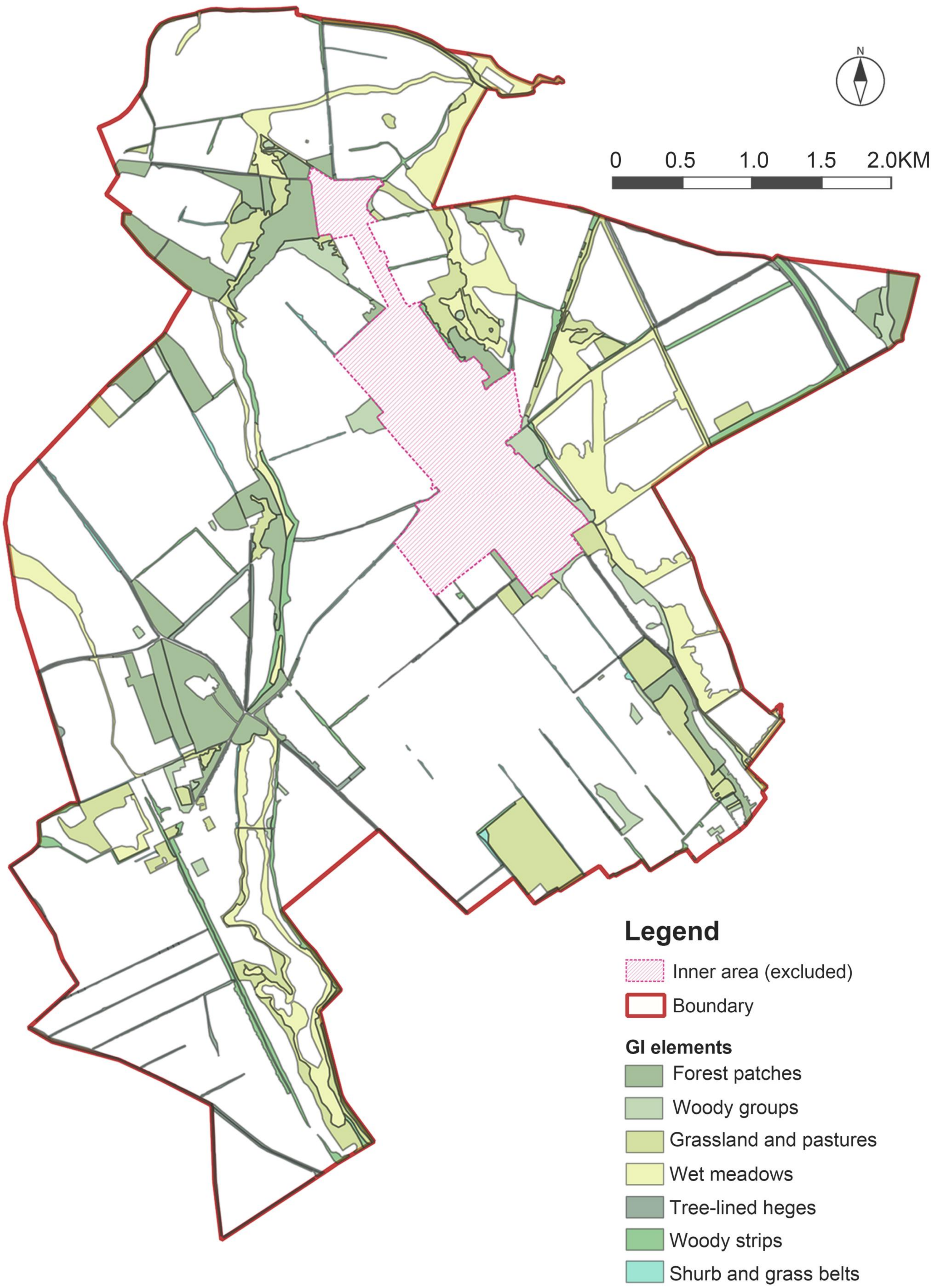
f. Woody strips

Woody strips																			
id	Aare(m2)	Ecological condition score	Ecological service score	ex-area(ha)	ra-area(ha)	na-area(ha)	Na park-area(m2)	pro OOH1 area(ha)	pro OOH3 area(ha)	pro OOH2 area(ha)	Visual-D score	Visual-F score	Protection 1 score	Protection 2 score	Stable use area(m2)	Stable use proportion(%)	Stable use score	5 average distances	Connectivity score
1	32118.50172	3	3				1			1.354463	3	1	1	0.84	31566.11661	0.98	5	1.9984	3
2	22959.62051	3	3		2.225891		1	2.2316			1	1	3.91	0.97	17651.50623	0.77	4	1.7646	3
3	3388.972272	1	1		0.338897		1	0.33889			0	0	4	1	3388.972272	1	5	39.403	2
4	5719.139692	3	3	0.25378	0.564521		1	0.31813	0.25377		0	0	5.29	1.89	5673.421168	0.99	5	98.618	1
5	3343.573228	2	2				1				0	0	1	0	3180.657606	0.95	5	98.8842	1
6	1643.514079	3	3				1				0	0	1	0		0	0	161.9708	1
7	6431.610424	1	2				1				0	0	1	0		0	0	159.9572	1
8	29193.60136	3	3		2.564912	0.217627	1	2.9193			3	1	3.71	1	1175.305683	0.04	0	40.817	2
9	13320.47627	3	3			0.674942	1		0.91554		0	0	1.51	2.06	13281.78361	1	5	4.1596	3
10	12103.43397	4	3			1.161669	1	0.059089	0.90572		3	2	1.96	2.29	4959.575206	0.41	3	0.5402	3
11	14251.94952	3	3		1.425195	0.159075	1		0.47689		0	0	4.11	1	14008.39957	0.98	5	0	3
12	2685.287212	2	1				1				3	2	1	0	1043.670618	0.39	2	2.8936	3
13	2177.403816	3	2				1				0	0	1	0		0	0	115.5854	1
14	16141.94015	3	3				1				0	0	1	0	40.902508	0	0	3.5854	3
15	27307.44805	4	3				1				0	0	1	0	10844.09102	0.4	2	2.8062	3
16	13811.7221	4	3				1				0	0	1	0	13811.7221	1	5	58.4654	2
17	75317.65088	4	3				1			5.772242	3	1	1	1.53	68756.38858	0.91	5	0	3
18	21777.87242	4	3				1			1.562137	3	1	1	1.43	21777.87242	1	5	33.2612	2
19	4065.495041	1	1				1				3	1	1	0	1229.358421	0.3	2	103.3386	1
20	5899.044673	2	1				1				3	1	1	0	1740.281215	0.3	2	73.2424	2
21	6771.908539	4	3				1				3	2	1	0	2820.619856	0.42	3	56.6954	2
22	8625.485871	4	3				1				3	1	1	0	8625.485871	1	5	24.892	2
23	4382.899936	4	2				1				3	1	1	0	4382.899936	1	5	11.8684	2
24	8238.779921	3	3				1				3	1	1	0	8238.779921	1	5	23.6	2
25	99496.18175	3	3				1			3.44504	3	1	1	0.69	81448.82771	0.82	5	0.6764	3
26	25649.15342	4	3		2.564915		1	2.5649			0	0	4	1	20729.08072	0.81	5	3.4152	3
27	53764.07317	4	3			3.771031	1	1.0589	4.180785		0	0	1.7	2.53	51989.82722	0.97	5	9.8226	2
28	13833.52829	4	3				1				3	1	1	0	993.5485293	0.07	1	9.0414	2
29	3187.699398	3	3		0.31877		1	0.318769			3	1	4	1	1707.667837	0.54	3	4.8746	2
30	70417.77867	4	3				1			5.460542	3	1	1	1.55	70388.34939	1	5	0	3
31	12742.11352	2	1	1.03818	1.273557		1	0.21047	1.038184		0	0	6.44	2.61	3568.130337	0.28	2	94.955	2
32	3530.944578	1	1				1				0	0	1	0	148.5350274	0.04	1	199.447	1
33	7642.142141	2	1		0.764211		1	0.76421			0	0	4	1	6390.739345	0.84	5	16.5466	2
34	2320.508586	3	2		0.232051		1	0.23205			0	0	4	1	1.51138928	0	0	188.3338	1
35	10374.72313	4	3		1.037472		1	1.037472			3	1	4	1	3415.195266	0.33	2	2.905	3
36	4817.189943	2	1				1				0	0	1	0		0	0	122.5098	1

g. Shrub and grass belts

Shrub and grass belts																			
id	Aare(m2)	Ecological condition score	Ecological service score	ex-area(ha)	ra-area(ha)	na-area(ha)	Na park-area(m2)	pro OOH1 area(ha)	pro OOH3 area(ha)	pro OOH2 area(ha)	Visual-D score	Visual-F score	Protection 1 score	Protection 2 score	Stable use area(m2)	Stable use proportion(%)	Stable use score	5 average distances	Connectivity score
1	5992.770426	4	2				1			0.552663	2	1	1	1.84	5466.176495	0.91	5	0	3
2	11872.77701	1	1				1				3	1	1	0	11872.77701	1	5	64.9866	2
3	52643.16692	4	3		2.091089		1	0.300146		4.380995	3	1	2.19	1.72	48648.90596	0.92	5	9.9596	2
4	8551.04733	2	1		0.230433		1				3	1	1.81	0	8551.04733	1	5	0	3
5	11500.36424	4	3				1				0	0	1	0	8384.12967	0.73	4	9.6614	2
6	5131.725467	2	3				1				0	0	1	0		0	0	114.0552	1
7	22160.56581	2	1				1			2.023912	3	2	1	1.83	22160.56581	1	5	3.5676	3
8	2636.93071	1	1				1				0	0	1	0	98.84075152	0.04	1	273.945	1
9	13768.71568	2	1				1				2	1	1	0	11340.43149	0.82	5	0	3
10	15195.34046	2	3				1				3	1	1	0	11837.13638	0.78	4	57.4132	2
11	26013.66081	4	3		2.601366	0.222945	1				3	1	4.09	0	26013.66261	1	5	0	3
12	21035.13161	2	1				1			0.063	3	1	1	0.06	1175.534215	0.06	1	138.4772	1
13	1572.10657	1	1		0.157211		1	0.157211		0.026106	0	0	4	1.33	1569.264239	1	5	50.9046	2
14	3253.904414	3	1				1				2	1	1	0	3245.639069	1	5	14.1542	2
15	13648.38545	3	3				1				3	1	1	0	13648.38545	1	5	1.1242	3
16	6574.811425	3	3				1				3	1	1	0	6574.811425	1	5	15.72	2
17	1071.584506	4	2				1				0	0	1	0	311.9291026	0.29	2	55.0512	2
18	10716.92399	2	1				1				0	0	1	0	10716.924	1	5	54.756	2
19	14269.24123	2	1				1				0	0	1	0	14122.29528	0.99	5	88.5628	2
20	2272.906405	1	1				1				0	0	1	0	37.64420395	0.02	1	154.3936	1
21	7124.59778	1	1				1				3	1	1	0	191.1360905	0.03	1	34.6616	2
22	10649.74847	3	2				1				0	0	1	0	8990.016343	0.84	5	59.4498	2
23	6763.747225	1	1		0.676375		1				3	1	4	0	66.47723848	0.01	1	2.2722	3
24	4251.169701	2	1				1				0	0	1	0	3812.593819	0.9	5	112.4252	1
25	2564.096685	1	1				1				0	0	1	0	2331.256769	0.91	5	204.7726	1
26	6569.358307	2	1				1				2	1	1	0		0	0	175.3634	1
27	7917.069222	2	1				1				0	0	1	0		0	0	157.8916	1
28	11813.9067	1	1				1				0	0	1	0		0	0	85.3244	2
29	1844.959736	4	3				1			0.184496	0	0	1	2	1844.959736	1	5	35.0812	2
30	7912.363792	1	1				1				2	2	1	0		0	0	16.5012	2
31	3823.644771	2	1				1				2	1	1	0		0	0	67.3632	2
32	1352.607951	2	1				1				3	1	1	0	1352.607951	1	5	4.7864	2
33	1470.354077	1	1				1				3	1	1	0		0	0	172.8608	1
34	2522.418914	3	2		0.252242		1	0.252242			0	0	4	1	1209.351776	0.48	3	16.4774	2
35	1401.065314	2	1				1				0	0	1	0		0	0	411.3684	1
36	2330.061251	1	1				1				0	0	1	0		0	0	223.701	1
37	6512.783825	1	1				1				3	1	1	0	6496.489318	1	5	48.4128	2
38	7090.189718	1	1				1				3	1	1	0		0	0	128.494	1
39	6458.534144	3	3				1				0	0	1	0		0	0	256.2756	1

Appendix III. Preservation and development plan of GI network



Appendix IV. Preservation and development plan of GI network