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RELATIONSHIP BETWEEN LANDSCAPE MANAGEMENT, LAND USE AND ECOLOGICAL NETWORK IN NAGYKÖRŰ

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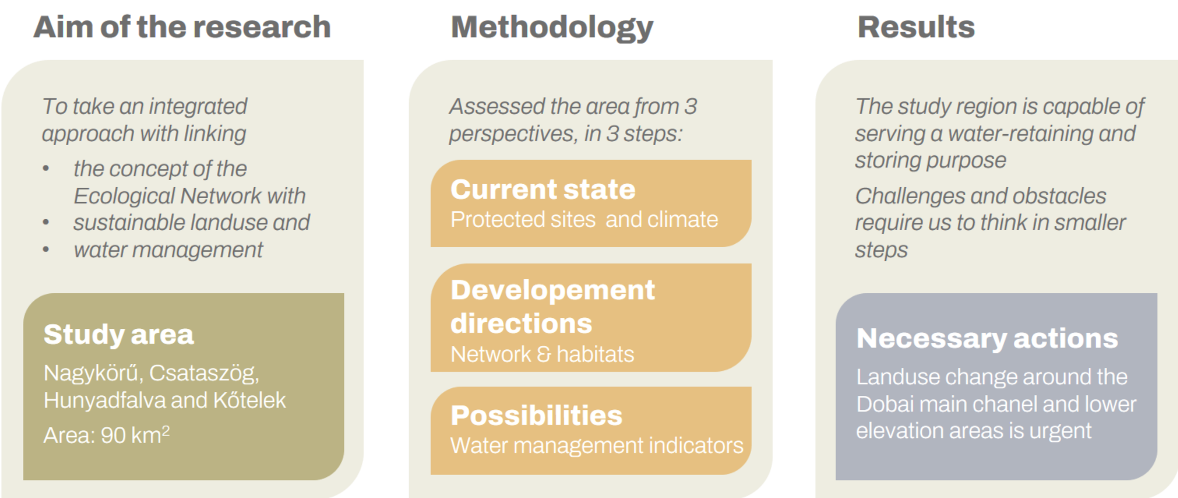
Abstract

In the summer of 2022, we experienced an extreme water shortage in the Great Hungarian Plain and the consequences influenced and still influence our lives in several ways. The long-term solution to the problem of drought is sustainable landscape management, which builds on the natural characteristics of the area – climate, soil, topography, hydrographic conditions and opportunities. The ecological network can provide a suitable framework for this concept, since the original idea intended to create balance between intensive and extensive land use. Our goal was to define the focus areas where the current cultivation is in conflict with the features of the landscape, and we identified the areas where it is necessary to change the cultivation method and those where other water retention proposals can gain space, thus ensuring water even in drier periods. The resulting land use will be in line with the water cycle, thereby increasing the area's resilience against drought. In our research, we chose the municipality of Nagykörű and its surroundings along the Tisza River as our study area, which - like the rest of the Great Plain - was hit by an exceptionally severe drought in the summer of 2022. On the 90 km^2 research area, after fieldwork, we performed various GIS analyses. Based on these we examined the possibilities and suitability of the cultivation methods in the given area and worded our proposals. In the course of our research, we consulted with water management experts and local farmers in order to get a more accurate picture of the area's features, problems, and the feasibility of our proposals. The landscape architecture master students of MATE also helped us in preparing the analyses. The results showed that currently a significant part of the area is not managed in accordance with the geographical conditions. The deeper fields in the middle of the area, which currently are under intensive farming, would belo9ng, under natural conditions to the floodplain of the river Tisza. Here the extensive cultivation methods, such as orchards, gardens, or meadows are recommended. At the same time, the flood-free parts of the sample area are suitable for agriculture. If water retention strategies are used in the suitable areas, these will be more protected against the effects of drought.

Keywords: ecological network, sustainable land use, water management, water retention

Visual Abstract



INTRODUCTION

The concept of the ecological network is mainly applied for the purpose to maintain biodiversity by protecting the existing valuable areas and increasing habitat connectivity (Jongman and Veen 2007, Sedy et. al. 2022). The ecological network (EN), by definition, is a graph-like spatial system where the nodes (cores or source habitats) are connected through links (ecological corridors) forming a network, consisting of natural and semi-natural habitats.

According to studies, the EN usually consists of 4 different types of areas: *core areas*, ecological corridors, buffer zones and restoration areas (Konkolyné 2003, Mander et al. 2003, Jongman et al. 2007, Jongman et al. 2011). Core areas provide the survival and living conditions for natural wildlife and give home for one or more protected or culturally significant species. *Ecological corridors* are mainly linear, continuous, or intermittent habitats that provide the connection between core areas for biodiversity (Báldi 1998). Corridor topology varies; there are linear corridors (usually alongside waterways or roads), landscape corridors (consisting of multiple patches), and stepping-stones (where the habitat patches are not continuous). *Buffer zones* protect the cores and links from negative effects, such as pollution or disturbance that could unfavorably influence the state of the EN. *Restoration areas* are reserve habitats that currently can not function as part of the EN due to their degraded state. However, after rehabilitation, they can potentially have a role in the network (Konkolyné 2003).

In the Hungarian National Spatial Plan (MaTrT 2018) only 3 types of zones can be distinguished: core areas, ecological corridors and buffer zones. The concept of restoration areas is completely missing from the legislation. The National Ecological Network (NECONET) was first established in 2000 during the designation of the Pan European Ecological Network (PEEN) and the extent was determined by the local National Parks based on the occurrence of important species and habitats (Érdiné 2002, Kertész 2011). The Natura 2000 Network functions as the 'European Ecological Network' today, all Natura 2000 Special Areas of Conservation (SAC) and Special Protection Areas (SPA) sites are part of the NECONET, mostly as core areas.

In our current interpretation, EN is the most effective tool for the conservation of species, but the original concept was developed for a different purpose. The theory of EN originated in the Baltic countries in the 1970s when they took an integrated approach and aimed to create a sustainably-used environment by balancing intensive and extensive land use according to the landscape's attributes and valuable natural habitats (Bennet and Mulongoy 2006). The concept became known and applied in Western Europe where it was used to attain the ecosystem approach and became a tool for biodiversity conservation. While EN is mainly used to develop habitat-chains and links for the protection of species with paramount importance, it also has recreational, socio-economical value and visual benefits for the community (Mander et al. 2003). In addition, it also helps to perpetuate natural processes, such as the circulation of matter and energy.

According to the literature, EN can be interpreted at any spatial scale (Opdam et al. 2005), from continent to country and to local level. Though several approaches might give valuable results, studies show that the most effective way of mapping and evaluating EN is at landscape scale or regional level which is interpreted as "meso-scale" (Mander et al. 2003, Godfrey 2015, Blasi et al. 2008, Nie et al. 2021). Although this scale has proven to be the most effective, research also shows that the investigation of different levels (especially zooming into local scale) can also provide useful information and help the revision of the mapping methods or add detail to the already revealed network (Nie et al. 2021).

In our research, we aim to revive the original, Eastern European concept of EN by using it as a tool for sustainable land-use. Our goal is to expand the currently legislated NECONET so that it supports the current landuse with modifications and by way of adaptation to the natural water cycle of the study area. We used a local scale example, the area of Nagykörű as our study area which is suitable for determining local conflicts. We aim to complete the network by examining a different scale backed up with a different approach and fieldwork. This also helps to solve the greatest threats and challenges in today's agriculture: the consequences of climate change, lack of water in the summer season and flooding caused by uneven rainfall.

We used GIS methods combined with data collected on site and also included the experience of the local farmers in the area. The research was partly used in the education of the MATE landscape architect master students who participated in collecting data and analysed the area from a similar point of view. Their results were also taken into consideration and were incorporated into the final suggestions.

STUDY AREA

The research area is located in the Great Hungarian Plain, along the river Tisza, in the area of Nagykörű, which is a smaller settlement along the river, between Szolnok and the Lake Tisza. The study area (Fig. 1) lies on the Central Tisza Plain (Közép-Tiszai-síkvidék) (Csorba et al. 2018), specificly on the Szolnok-Tisza Region (Szolnoki-Tisza mente) microregion (Csorba et al. 2018) and contains parts of the administrative areas of the following municipalities: Nagykörű, Csataszög, Hunyadfalva and Kőtelek, and extends just under 90 km^2. The elevation falls between 80-93 meters, the lowest points are naturally in the riverbed, while the highest can be found in the built-up areas and orchards of Nagykörű. The middle part of the area (where the former Laposi-Lake lied along the Laposi-Sulymosi canal) has a lower elevation (under 84 meters) and was part of the historical floodplain. The main reason for choosing this area as a study region was to include the landuse of floodplains (and potential floodplain areas) into the research and help create a network integrated into the eastern EN approach.

The area is mainly intensively farmed agricultural land (66%) divided by narrow vegetation zones (ecotones)

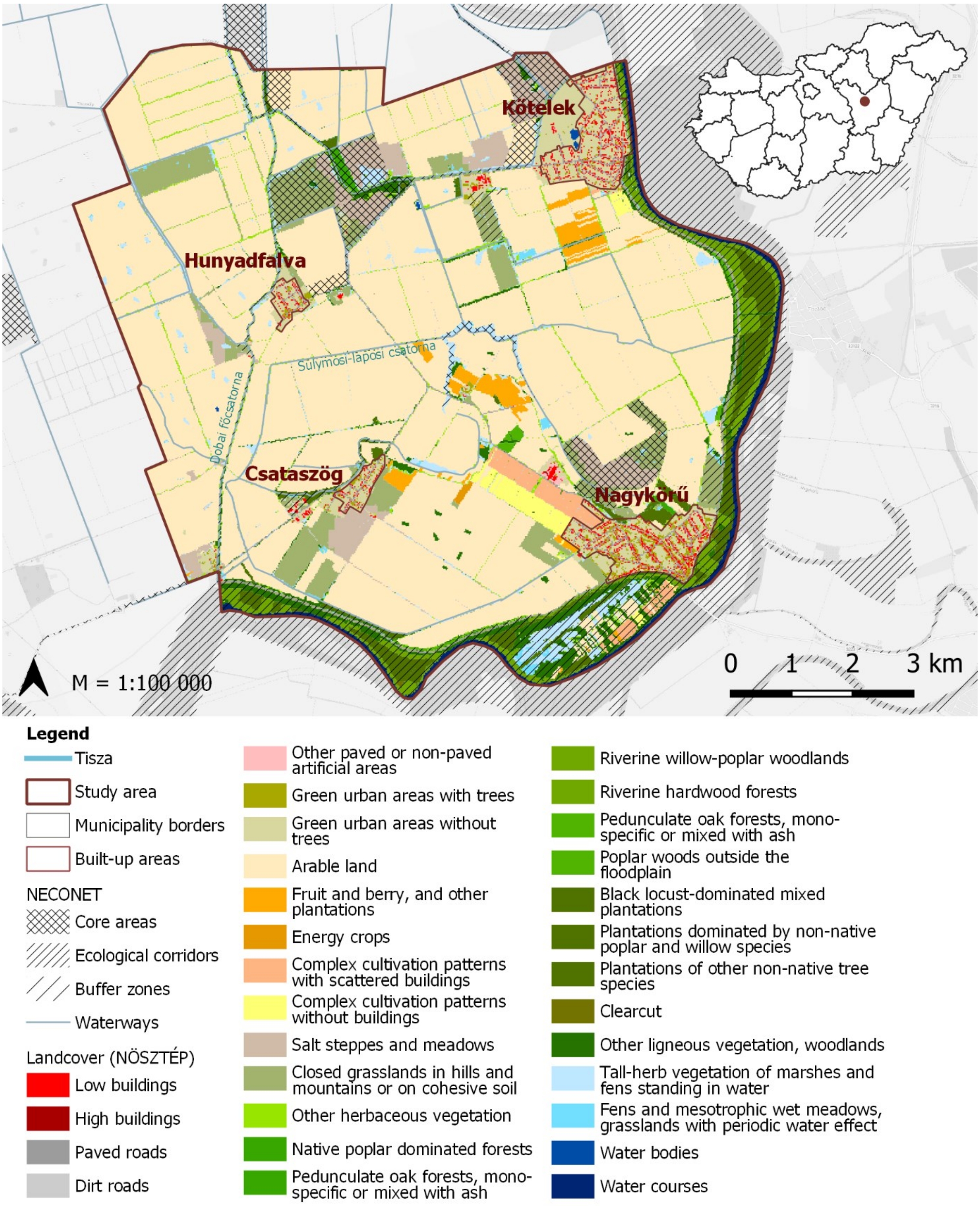


Fig.1 Study area with land cover and the NECONET areas

along canals and trails (13%), as seen on Table 1 and Figure 2. We could also find the remains of the traditional orchards, and extensively farmed land. Grasslands are the most important natural habitats in the area (10%) while forest vegetation (9%) is mostly found in the floodplain of the river. However, they mainly consist of plantations, not naturally occurring alluvial forests with heterogenetic attributes. After the 19th century's regulations, only a narrow floodplain is left along the river, the dam currently lies ca. 500-1000 meters from the riverbank. On a positive note, coniferous forests, which are non-native yet quite common on the Great Hungarian Plain, are not present in the research area.

Regarding EN, 17% of the area is part of the NECONET, which is below the national average value (36,1%). The most important area is the semi-natural forest vegetation along the river which is an ecological corridor. There are some smaller-scale core areas (ca.

2 km^2) with the combination of grasslands, wetlands and water surfaces. The wetland along the Sulymosi-Laposi canal, between the municipality border of Kőtelek and Nagykörű is also an important, yet smaller-size core area. Buffer zones are not present in the research area. The consequence is a conflict, since there are no areas that could protect the links and cores from the negative effects of intensive agriculture. This problem is not unique to this area, it can be observed in the whole country.

If we examine EN in the landscape-level we can state that the area of Nagykörű lies next to a key ecological corridor, the river which connects some of the most important protected areas of the country. The shoreline of the river is part of the Middle-Tisza Protected Area, which belongs to the Hortobágy National Park. Natura 2000 SPA or SAC areas are only present in the floodplains while Ramsari areas are not present.

During our site-visit we discussed the problematic land use and landscape-conflicts with a local expert and farmer, Péter Balogh, who has long been the spokesperson for sustainable land use along the river. He helped us to understand the natural water cycle of the river and we are also grateful for his advice. We used his experience in a number of different projects and research regarding land use and the EN of the river Tisza (Kutnyánszky and Szilvácsku 2022). He confirmed that the summer of 2022 was an extremely hot period and the problem of drought became more severe than during the previous years. He experienced results of this not only on farmed land, where increased irrigation was necessary but also on grasslands, which dried out completely and became unusable for mowing or grazing. According to his opinion, water retention is crucial for our future if we want to continuously utilize our lands and we need to act quickly to avoid such a huge decrease in agricultural production as we experienced in 2022.

Table 1 Land cover of the study area

Land cover	Area (ha)	Ratio
Artficial, built-up areas	224.57	2.5%
Green urban areas	451.14	5.0%
Arable land	5675.45	63.2%
Orchards	120.78	1.3%
Energy crops	4.8	0.1%
Complex cultivation, gardens	154.22	1.7%
Grasslands	1083.75	12.1%
Forests and woodlands	803.1	8.9%
Wetlands	326.02	3.6%
Watersurfaces	142.28	1.6%
Total:	8986.11	100%

METHODS

As presented in the introduction, our goal was to use the concept of EN as a tool for sustainable landuse by identifying the key areas where change in landuse is necessary. For this we analysed the area in 3 steps. The 1st step was to evaluate the current state of the area. In the 2nd step we took the EN concept into account to determine the directions where development is necessary to form a functional network. In the 3rd step we identified those areas that are important from a water management perspective and used the results to determine feasible changes in landuse and farming methods. The visualisation of the summary of our methodology is shown in Figure 3.

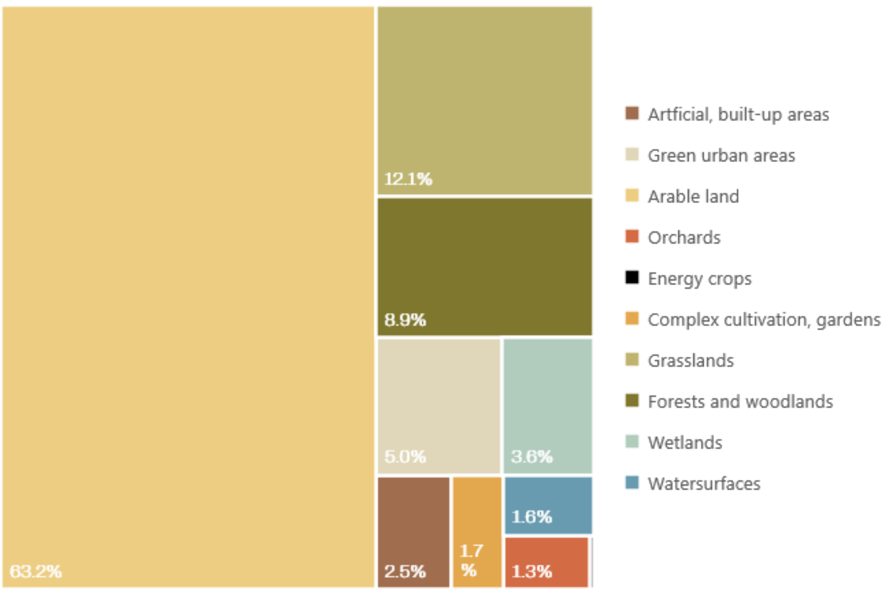


Fig.2 Land cover of the study area

Input layers and data

For land cover we used NÖSZTÉP (National Ecosystem Basemap downloaded from http://alapterkep.termeszetem.hu/) which has a resolution of 20x20 meters and provides more accurate information than Corine Land Cover database. In addition, NÖSZTÉP includes more land cover categories, resulting in an up-to-date habitat description. The land cover dataset is based on Sentinel satellite images from 2015 and 2017. For the DEM, NDVI and surface temperature analyses we used the satellite images of Landsat 8 (downloaded from Earth Explorer https://earthexplorer.usgs.gov/) which has a 30 m/px spatial resolution. We also included the result-maps of our previous research, referenced above. Water management related data (flooding, inland excess water) were provided by the professionals of BME (Budapest University of Technology and Economics, Department of Hydraulic and Water Resources Engineering), the cadastre of waterways was shared with us by OVF (General Directorate of Water Management) and the extent of the NECONET and other nature protection areas were digitalized from OKIR (National Environmental Information System). For the GIS analyses and map visualization we used QGIS 3.10 'A Coruña'.

1st step – Current state

For the purpose to further inspect the current state of the area we examined EN and other nature protection areas presented in the introduction. We analysed the land cover data supplemented with experience from our fieldwork to determine the state of these habitats. The fieldwork was accomplished in September 2022, when the results and damage of the extreme drought could be observed.

We also accomplished an NDVI and surface temperature analysis for the area to determine the changes in climate, biological activity and their interconnection during the last 10 years. We evaluated four satellite images on four different dates (2013, 2015, 2018, 2022) all taken in the month of June using the Land Surface Temperature plugin in QGIS. We chose this month because this is when most of the farmed lands are also normally covered with vegetation. Usually, July is the hottest and driest month and according to experience some level of drought is observed then every year. While data collected in June show the first signs of an extremely dry summer, it also shows the results of the lack of rainfall and natural flooding in spring.

2nd step – Direction of development

We aimed to develop EN for an integrated approach, taking connectivity into account as well as sustainable landuse possibilities. To expand the network in the standpoint of connectivity we incorporated some of our results from previous research (Kutnyánszky and Szilvácsku 2022) Then we analysed the whole catchment area of the river Tisza to determine the key habitats and corridors for protecting biodiversity in a landscape-level using the least-cost-path method. We used the resulted links and corridors for grassland, forest and wetland preferring species to determine the directions where the connection of habitats can be improved. In order to determine the groups' attributes and ecological needs, we considered bird species that are native along the Tisza. Birds are commonly used indicators (Sandstrom et al. 2006, Larsen et al. 2010, Jongman et al. 2011), since they are sensitive to intensive agriculture (Bíró et al. 2009, Németh et al. 2017), while also make mapping EN in a larger scale easier because linear barriers (roads, railways or rivers) do not affect them as much as mammals.

To add valuable habitat patches to the network we further examined the biodiversity potential in land cover data of the area of Nagykörű. We distinguished natural (forests, grasslands, wetlands, meadows, and watersurfaces) and semi-natural habitats (such as orchards, gardens, forest plantations, extensive farmlands and parks) according to their level of hemerobiotic state. The natural habitats were valued for 2, while the semi-natural, extensively cultivated areas were valued for 1. Built-up areas and intensively farmed lands were given

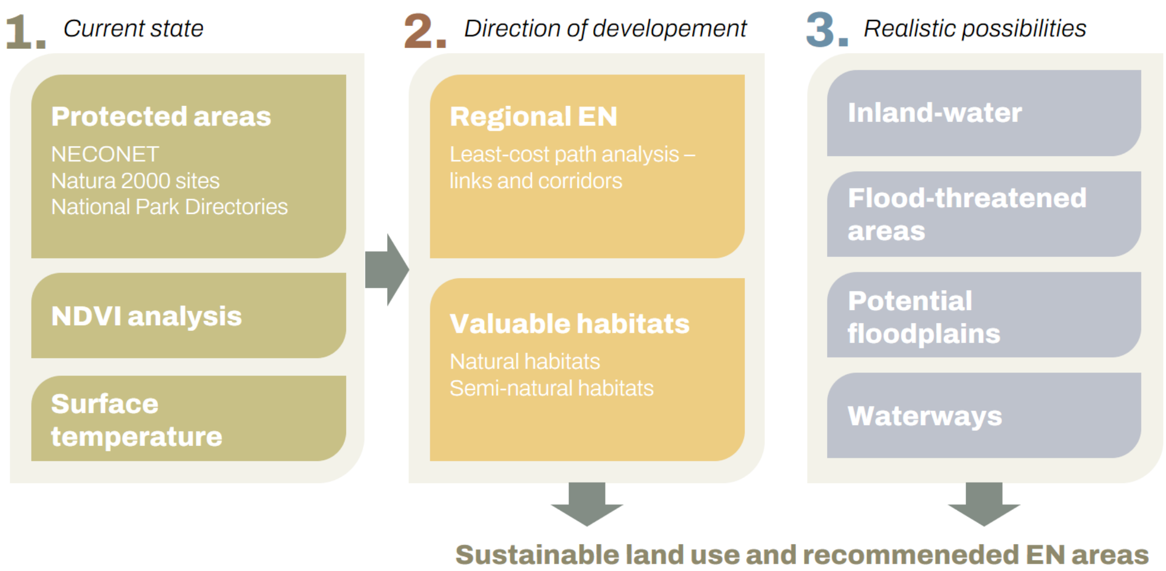


Fig.3 Steps of the methodology

the value of 0. We visualized these values on a map, and compared the results with the outputs of the formerly conducted least-cost-path analysis and distinguished valuable habitats in the study area that can serve as a link or steppingstone at the regional scale.

3rd step – Realistic possibilities

After determining the development directions and already existing valuable habitats, we tried to identify those patches that need a change in landuse. We examined the area in the context of natural water cycle to define the plots that are currently farmed or used according to capabilities. We searched for those places that were formerly part of the floodplain, and still could be rehabilitated accordingly. Usually, also based on fieldwork, these areas are not suitable for farming, they have inland excess water or are endangered by flood, yet they are used as agricultural lands. This results in the imbalance of water which without water retention activities causes the reduction of ground-water and drought.

First, we examined the areas that are threatened by *flooding* and *inland excess water*. The spatial data was provided for us by the researchers of BME. Both categories were classified equally when determining the incorrectly used areas.

We also examined the rivers natural (and potential) *flood system* with creating a DEM for the area. In the model we distinguished 4 elevation categories: under 83 meters the area was considered to be a potential deep floodplain, and between 84 and 83 elevations the area was considered low floodplain, whereas between 84 and 85 meters lies the high floodplain. Over 85 meters the area was considered a flood-free zone. These thresholds were identified in consultation with water management professionals and local farmers. According to their observations, above 85 meters the land is completely safe from flooding.

The difference between the threatened and potential floodplain lies not only in the approach to the problem but also in the methodology applied in these areas. The potential areas were specified according to elevation while the threatened ones were delineated in a more complex way, taking into account also the soil, landcover, waterways, and actual flooding. They both show different sides of flooding, one takes it as a conflict and danger and the other defines it as an opportunity, and both approaches should be included to get finer and more accurate results.

Our final goal was to create areas where water retention is possible and feasible. The main potentials for this purpose are the waterways: the already existing *streams and canals* that create a network through the area. According to our field work we noted that most of the canals were dry and were not maintained properly; the waterbed was covered with vegetation, sediment was collected in them and occasionally we also found waste there. All of this led to the dysfunction of the canals. We created a 20-meter buffer zone around the waterways, to give them a spatial extent. This buffer zone can also be used to protect the water from pollution and can serve as an ecological link with vegetation.

Summarizing results

After the GIS modelling, we compared the results of the 2nd step – EN development directions - with the results of the 3rd step – water-management-caused landuse conflicts. This way we could define those areas that could be part of the NECONET in a larger scale and, if correctly used, help water management in the area. This way the landuse adapts to the landscape's attributes and creates a system that operates the water as an ally, not as a threat and this way can function in a long term.

RESULTS

We present our results using the same structure described in the methodology part of this article. The outputs of the steps are shown separately and in the end we synthesize the unified results to reach the final conclusions.

1st step – Current state

As stated in the description of the study area, the most important EN areas are the floodplain forests (Table 2 and Fig. 4). They are also protected by national law, as the part of the Middle-Tisza Protected Area and the Natura 2000 network both as a SPA and a SAC area, but in EN are only considered as ecological corridor zones and not as core areas. They mainly consist of mixed deciduous forest and plantation forest of poplar (Populus sp.) and willow (Salix sp.) species. Some areas remained natural alluvial forests and we could also observe some wetlands. Next to the settlement of Nagykörű in the floodplain we located smaller parcels of farmland, which were confirmed during our fieldwork. Cornfields were found inside the forest way below the dam, where the land is threatened by flood.

The grasslands are also worth mentioning as part of EN. There are 3 patches, about 2 km^2 in size that are considered core areas and 2 smaller patches that are ecological corridors. All of the patches have mainly meadow landcover, but saline grasslands, wetlands and water surfaces and agricultural areas can be found in the patches as part of the NECONET. The watersurface in the middle of the area, formed from the Sulymosi-Laposi channel is also a key core area.

Two important ecological corridors could be observed: the Dobai main channel and the unnamed channel around Kőtelek. The latter links the 2 core areas in the northern part of the study area, while the Dobai channel links these grasslands with the floodplains. Both links are accompanied with vegetation and the protection of EN is 20 meters wide.

When examining the relationship between the results of vegetation cover and surface temperature analysis (Fig. 5) we found that the areas that have a higher NDVI value are also cooler areas. This can especially be observed on the floodplain of the area at any time. This result was expected since it has been long proven that vegetation cover positively impacts heatwaves. This relation can also be observed in the settlements in reverse: these areas have lower vegetation cover, and the built-up areas have higher temperature.

Table 2 Land cover data of NECONET areas

Landcover	Area (ha)	Ratio
Artficial, built-up areas	34.27	2.1%
Green urban areas	19.79	1.2%
Arable land	99.23	6.2%
Orchards	2.37	0.1%
Energy crops	0	0.0%
Complex cultivation, gardens	24.25	1.5%
Grasslands	481.02	30.0%
Forests and woodlands	664.06	41.3%
Wetlands	143.4	8.9%
Watersurfaces	138.43	8.6%
Summarized	1606.82	100%

The NECONET areas are not significantly different in terms of vegetation cover and temperature from the areas around them. The only exception is the floodplain where woody vegetation is mainly present. The grasslands and wetland surfaces do not show any difference in temperature or vegetation from the farmlands. It means that the biological activity of these land cover categories do not differ at the chosen dates (which also means that in these time periods the arable lands were mainly covered with vegetation the same way as the grasslands).

According to the NDVI and surface temperature analysis during the sampling we found out that vegetation slightly decreased in the area while the temperature drastically increased in recent years. While in the summer of 2013 only a few hotspots over 40°C can be found, in 2022 the surface temperature in almost all of the area is over 40 °C. Cooler blue spots can be observed in the year 2015 which are not areas covered with excess inland water but the results of clouds on the satellite image. The

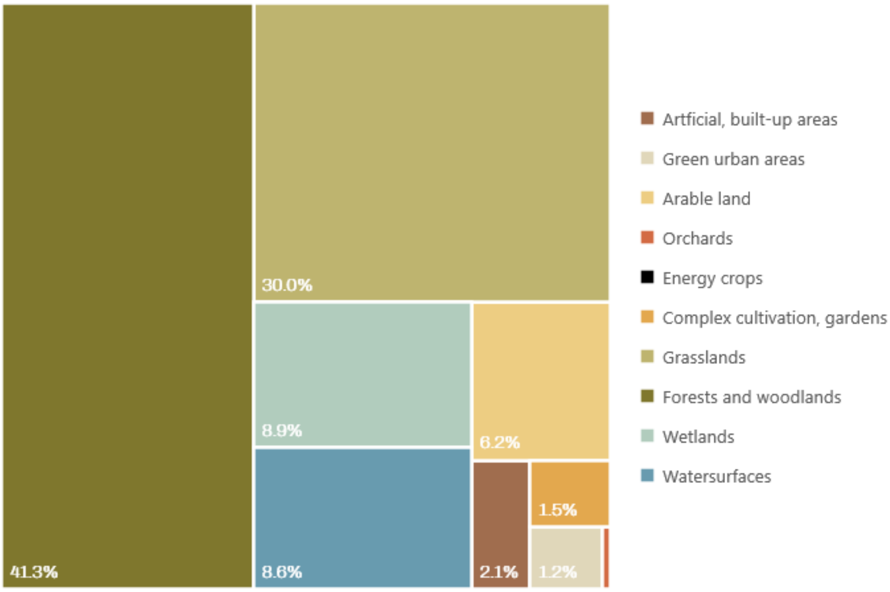


Fig.4 Land cover data of the NECONET areas

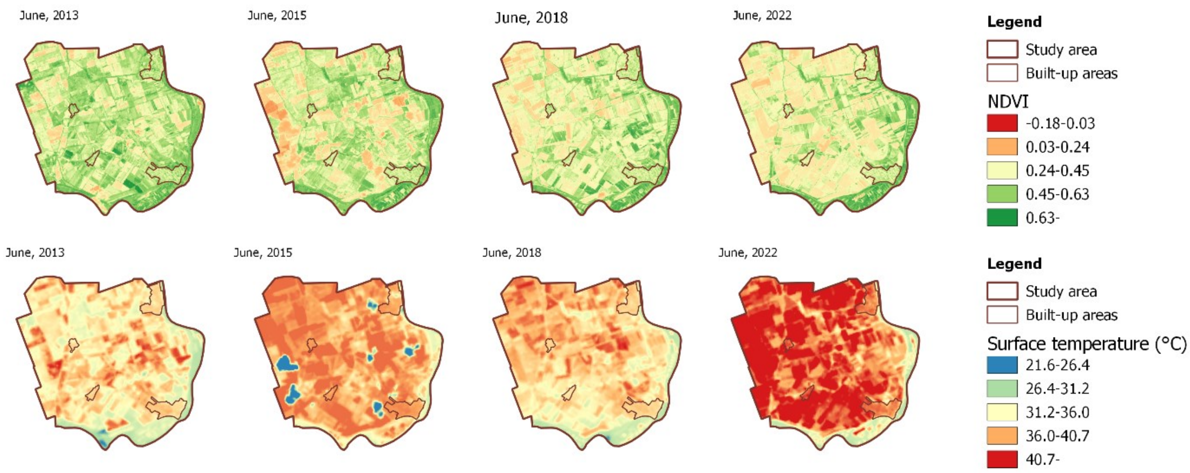


Fig.5 NDVI and surface temperature analysis between 2013–2022

difference between the first and last year is both remarkable and frightening. This also supports the experience of the farmers and reflects a problem that needs to be remedied effectively and in the long-term.

2nd step – Direction of development

Using our regional-scale research results, we identified the links and potential corridors for three indicator species groups (Fig. 6 and 7). The least-cost-path analyses showed one link passing through the research area for each of the indicator groups. The wetland preferring species link lies along the river, and the forest preferring species path follows the river on the right side of the riverbed, along the floodplain forests. The grassland preferring species links are located on the southern side of the area, connecting smaller grassland patches together. Three biodiversity corridors were outlined after the analyses. One that follows the river and the forests in the floodplain, one that connects the southern grasslands and one that links the grasslands together on the northern side of the area. These corridors overlap for the indicator species group which shows the importance of Tisza and the habitats along for grassland, wetland and forest preferring species.

The modelling also showed the area's role in the landscape-scaled network. The meadow patches are part of the stepping-stone patches that connect the Hortobágy National Park with smaller protected areas on the other side of the river, like the Tápió-Hajta Nature Protection Area (Duna-Ipoly National Park) or the larger core areas next to Nagykőrös. The river and its surroundings have a key role as ecological corridors in the larger scale as they connect the remaining natural protected areas along the river, like the areas of Lake Tisza in the Hortobágy National Park or the Central-Tisza Landscape Protection Area.

The assessment of natural and semi-natural land cover categories showed that there are some other valuable natural habitats that are not part of the NECONET. These patches are mostly meadows and saline grasslands. We could identify a sizeable patch southeast of Csataszög, just next to the built-up areas, and one southwest from Nagykörű surrounded by orchards, extensive and intensive farmlands. The EN cores in the northern part of the study area are actually bigger than the EN extent, the meadows continue beyond the legal border of the protection zone. Some other smaller grassland patches could be identified that can possibly serve as stepping-stone areas at local scale.

The least-cost-path analyses highlighted those natural habitats that are not part of the NECONET as part of the corridors for grassland preferring species (Fig. 7). Also, the orchards, gardens and extensive agricultural areas are significant in the area, the modelled links follow these semi-natural habitats and those which lie next to important meadows could serve as buffer zones.

The map (Fig. 6.) also shows the importance of ecotones. These linear elements, mainly along canals, waterways and trails, have vegetation cover and serve as smaller-scaled corridors for species inside the intensively farmed lands. The frequency of these ecotones – compared to other parts of the Great Hungarian Plain – is higher which makes this area suitable for EN development with the already existing green infrastructure elements.

3rd step – Realistic possibilities

We used data related to water management and the natural water cycle to determine the key areas for water retention

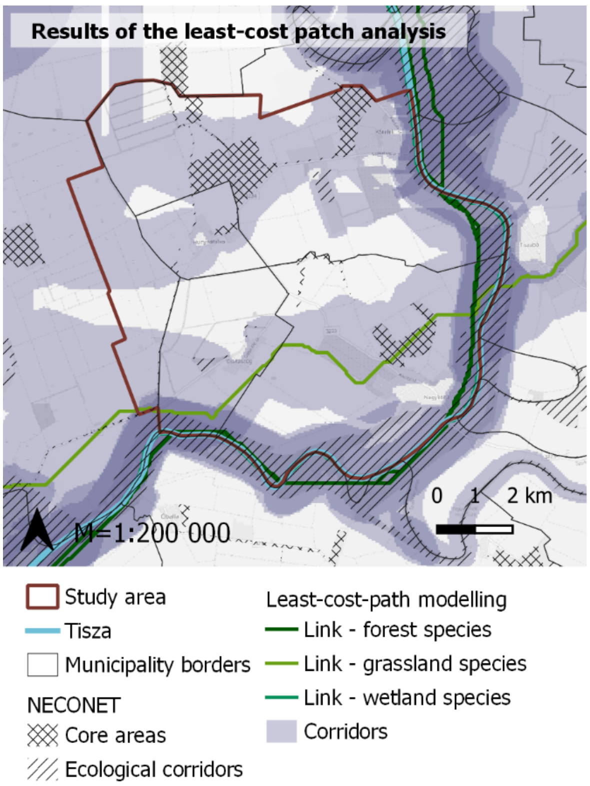


Fig.6 Regional network analysis

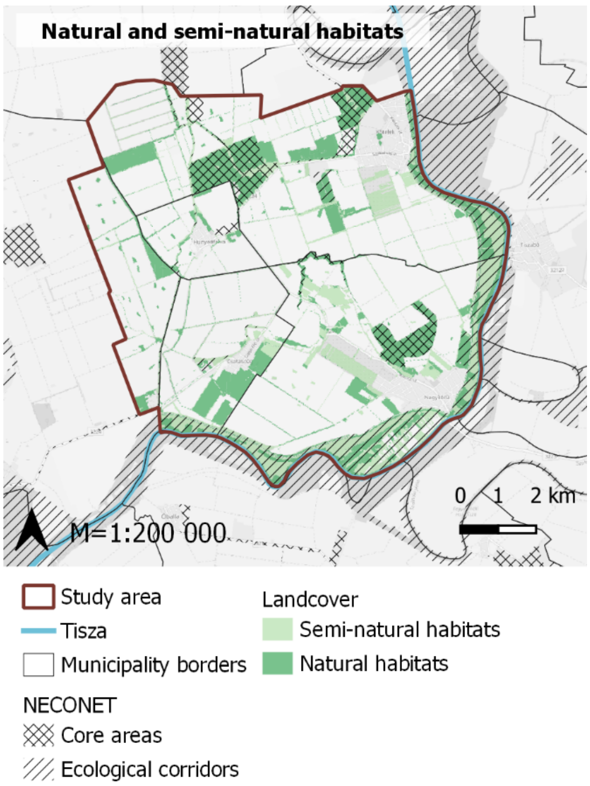


Fig.7 valuable habitats

possibilities. First, we considered areas where *inland excess water* causes problems for farming. As can be seen on Figure 8, these smaller patches occur on almost all of the area, but are denser on the western and middle part of the study region. The threatened agricultural lands are fragmented, but in these areas almost every farmland is affected at least partially. Regarding elevation, inland excess water appears on every flood-plain category, which leads to the conclusion that this conflict is caused by incorrect landuse.

The ratio of *flood risk* areas outside of the floodplain is significant. Approximately one quarter of the farmlands is endangered by flood (Fig. 9). Most of these areas can be found in the middle of the region but also follow the line of the Dobai main channel and Sulymosi-Laposi canal, along the already existing wetlands accompanying the canals. The reason why the canals overlap with the flooded areas is the topography of the landscape: the water flows to the areas with the lowest elevation (mostly under 84 m elevation, but some areas appear on the flood-free zone). There are no settlements in these conflict-areas which shows that originally, these villages were built on the higher ground, safe from flooding.

When classifying the DEM model into the *potential floodplain* classes we found that the lowest part of the area is the floodplain and the middle of the study region (Fig. 10), along the Sulymosi-Laposi channel. Deep and shallow floodplains occur in the southern and middle parts of the region and along the canals, while flood-free zones can be found in the northern part and between the built-up areas of Csataszög and Nagykörű. The deep and shallow floodplains are mainly agricultural lands, while grasslands and other cultivated areas can be found on the flood-free and high floodplain areas. This means, that according to the topographical attributes, those agricultural lands that lie in the deep and shallow floodplain categories and could occasionally be flooded, are intensively farmed today.

Comparing the topographical floodplain with the flood-threatened areas we found that there is an overlap between the layers in the middle part of the area, along the Sulymosi-Laposi channel. While these areas align from the perspective of flood also regarding the Dobai main channel, its surroundings show a somewhat different picture. In the northern part of the area some farmlands are threatened by flood which - according to our DEM model - should be considered a flood-free zone. This shows that if water is not let out on the area, it needs to be retained and it flows where it has possibilities, endangering areas that otherwise should be safe from flooding.

Due to its agricultural character the *waterways* weave through the whole area, providing the possibility of irrigation while also having an ecological value, as presented above. The canals and streams make up altogether 88 km in length which is a surprisingly high number of 0,97 km/km^2 in density. This ratio is higher on the northern side of the study area, and lower as we get closer to the river (Fig. 11). Most of the canals have vegetation along them but not all ecotones are related to waterways - some are along trails or numbered roads.

We could observe that most of the canals cross through or are close to areas threatened by inland excess water. The reason for that could be that these canals are not only used for irrigation but for channelling the inland excess water away from the agricultural fields. Comparing the waterways with the potential floodplains and conflicting flood-threatened areas we could observe some relation. For example, in the case of the Sulymosi-Laposi channel and the Dobai main channel, as we explored earlier in relation to other situations, we could not find any relationship between canal distribution and flooding.

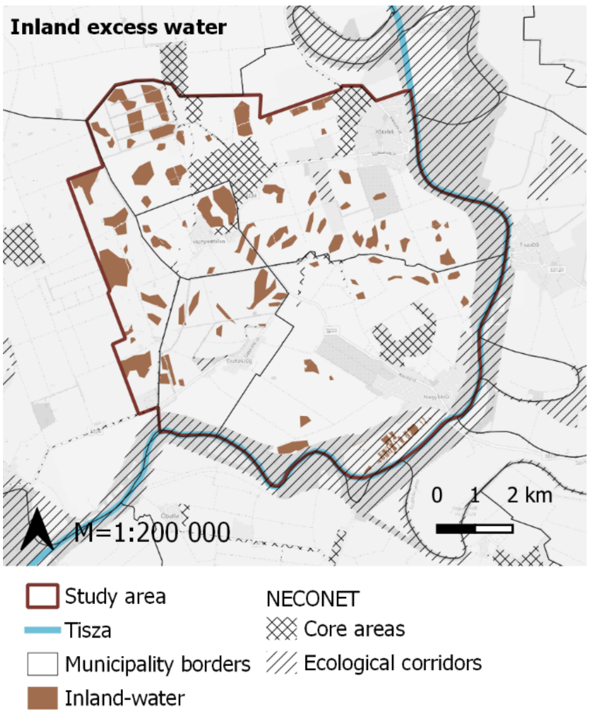


Fig.8 Water management related indicators
Inland excess water

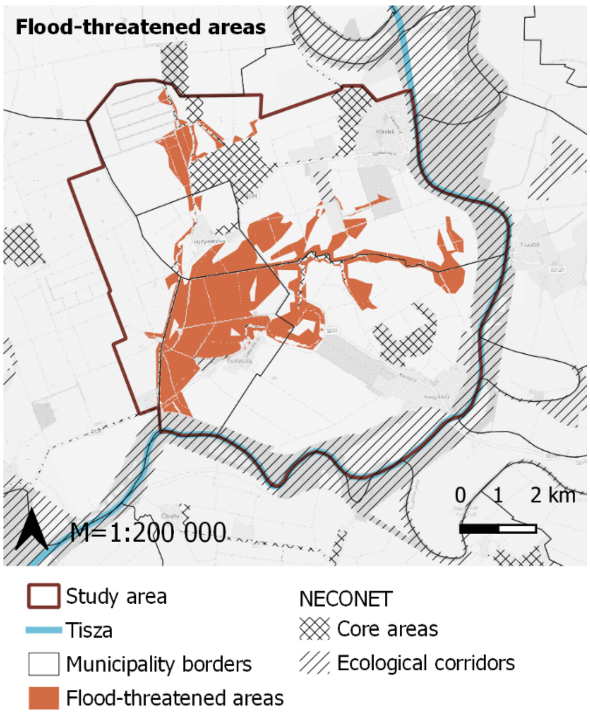


Fig.9 Water management related indicators
Flood-threatened areas

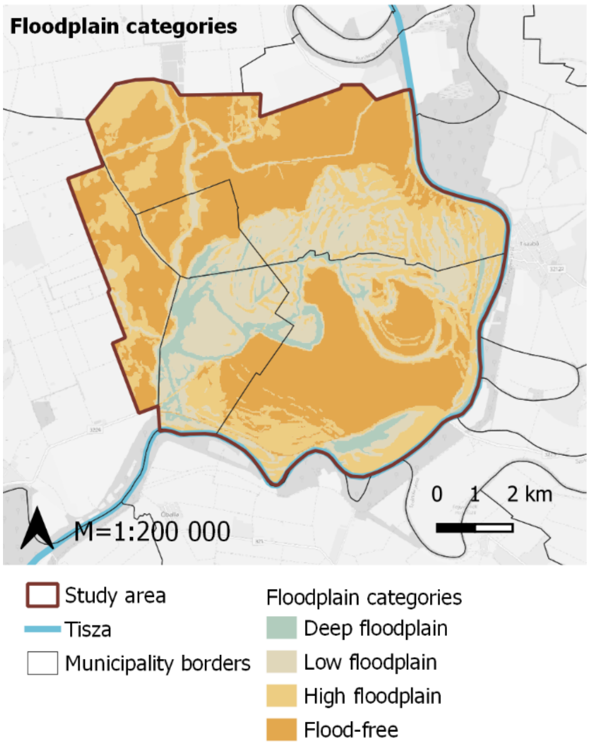


Fig.10 Water management related indicators
Floodplain categories

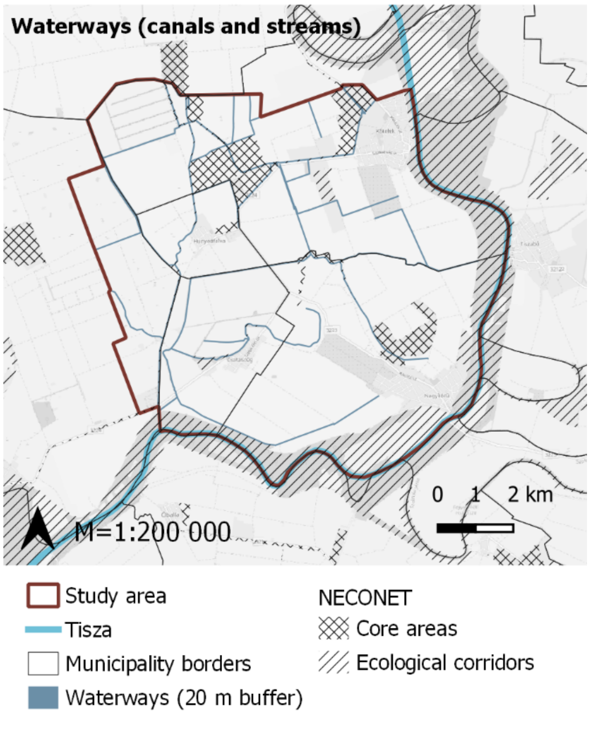


Fig.11 Water management related indicators
Waterways

Concluding the water management based indicators we found that the water flow of the study area is largely defined by topography, as expected. The channels can help with draining inland excess water and serve as water retention spaces during the dryer months when these water supplies can be utilized. The same function of canals can be achieved with storing flood-water. While we couldn't find any relationship between the distribution of canals and floodplains, canals are present in every threatened area and could serve as a solution with storing – and when necessary – using the access water that is available in flooding periods.

Summarized results

After stating that the canals of the study region can have a water-retaining and storing function, we identified those elements and areas where EN development can take place to maintain biodiversity and increase connectivity. We define key patches and canal sections where both objectives are feasible and also urgent, if we want to avoid another extreme summer in agriculture. Our final results of the assessment can be seen on Figure 12.

The Dobai-main channel and its surrounding area showed an outstanding potential for water retention purposes. This area is currently not valuable from an ecological point of view – it is an intensively used agricultural land. Only the narrow water surface – which is already part of EN – is a suitable habitat for biodiversity in its current form. Regarding this area, which used to be a lake, our suggestion is that landuse should be rethought and gradually, from the channel outside should be used differently. Wetlands and alluvial forests can take the place of arable lands on the deep floodplains while low floodplain areas are suitable for orchards, mowing and grazing. Farming should not be an option on the deep and shallow floodplains. We suggest that the canal and its close environment can be part of the NECONET as an ecological corridor, while the potential floodplain areas could serve as buffer zones, protecting the existing NECONET cores and proposed corridors.

Thinking in smaller steps, any canal that links the already existing grasslands (mainly in an east-west direction where the least-cost path analyses found an important link for indicator species) could serve as an ecological corridor. The Dob num. 19 channel next to Kőtelek is already part of the NECONET but other canals in the northern side could serve as a similar link between meadows. The three main waterways on the southern part of the area could link the new habitats to the forests along the river.

Changes in landuse on the lower part of the area and using the canals as water retaining elements will prevent inland-water, will raise groundwater-level (because water can flow according to the landscapes natural attributes) and provide climate control and irrigation water where needed during the drier summer months, supporting local biodiversity. All this contributes to better conditions for farming on the remaining fields and helps with managing our water resources.

On flood-free agricultural fields (which still make up almost half of the area) change in landuse is not necessary but recommended. Establishing ecotones and having sites that are extensively farmed can help in maintaining biodiversity.

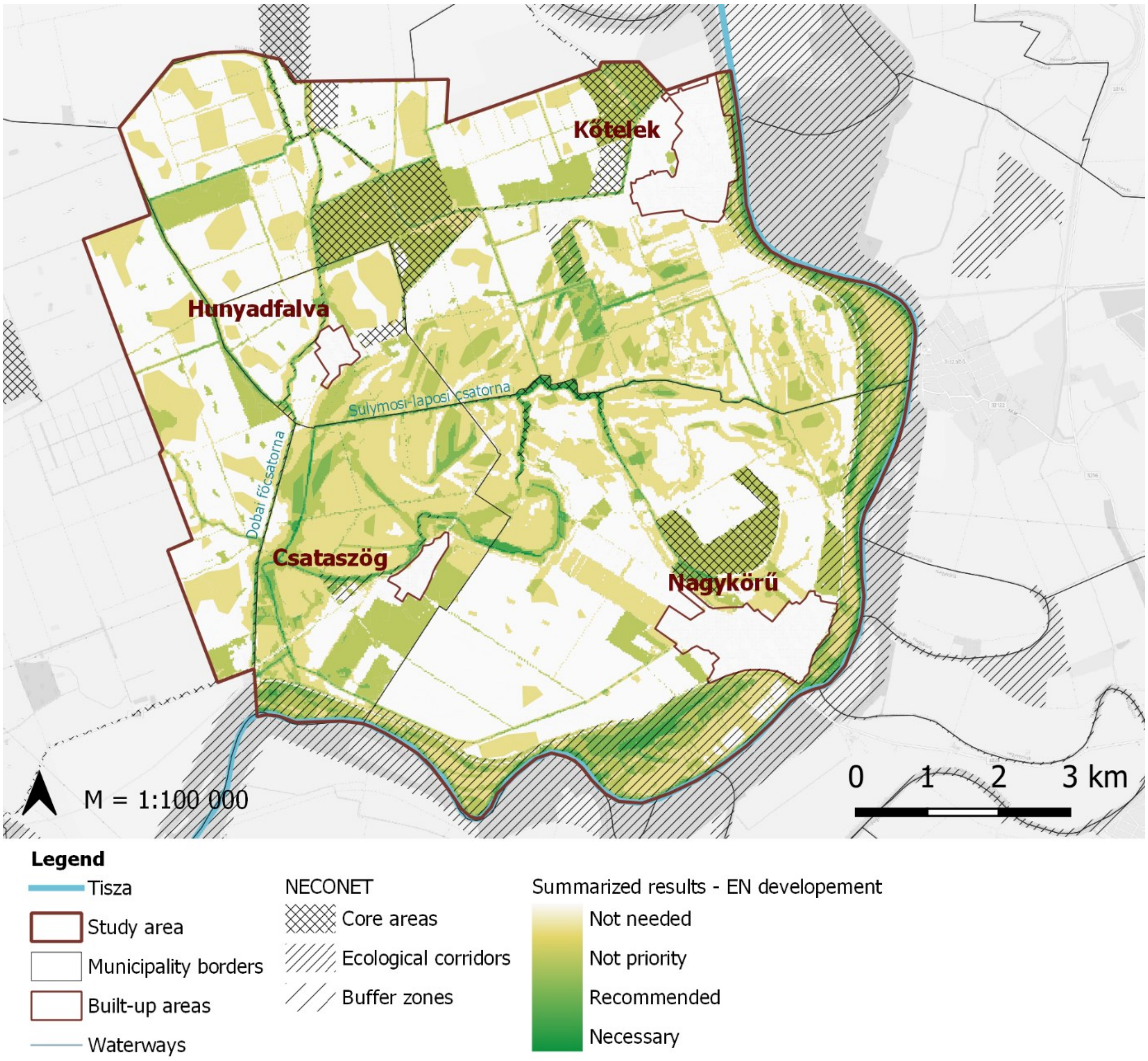


Fig.12 Synthetized results of step 2 and 3

DISCUSSION

Our methodology is based on an integrated approach, linking the concept of EN with sustainable landuse and water management in order to provide suitable conditions for farming while also maintaining biodiversity via the improvement of connectivity and preservation of habitats.

If we want to get a more nuanced picture of the agricultural attributes of the area some other data could be used in the future, like types of crops, production methods, quantity of crop yields, irrigation data. Unfortunately, this kind of database is not available currently, but with the help of local farmers who are motivated to solve the problem of drought could be provided in the future.

Regarding the waterways, the 20 m buffer zone on both sides of the waterbed, double the width of the ecological corridors along the canals, proved to be big enough in size for modelling purposes and leave enough space for water retention and maintaining biodiversity. During the restoration process these canals can be transformed to have other functions as well: serving as a biodiversity sanctuary between intensive farmlands and providing space for water retention during flood-season or heavy rainfalls. However, most of the canals, as we stated above, are in degraded condition, or polluted and should be restored to function properly again. This strongly depends on two factors: the assigned water management authorities and also the local farmers who could utilize these waterways but would have to give up some area (10-15 meters along canals) from their field for the creation of ecotones. While every stakeholder would benefit from the effects of restoration, resources and willingness are often limited for such projects.

Although canals can also function as landscape-barriers for some species, it is negligible compared to the connectivity benefits. Furthermore, green infrascture development and water retaining interventions would also moderate these negative effects.

Landuse changes and “loosing” agricultural fields are often controversial and political issues. Some could argue that it will affect not only the local framers who may lose some of their income but also – if thinking in a larger scale - on the whole country’s food supply and export. Furthermore, current agriculture is strongly dependent on financial support from the government and from the EU which all help to maintain this water-wasting method of farming. This way the use of the land becomes strongly politicized, and local farmers depend on funding received from the authorities, which they can lose if they change the way they currently cultivate their land. All of this causes continuity instead of resiliency in agricultural methods.

We can see the challenges and difficulties in the current agricultural environment of Hungary and know that change will not happen immediately but rather in smaller steps. Nevertheless, it is crucial and inevitable.

Restoration of some of the canals that have the greatest effect on their surroundings, like the Dobai-main channel, just to mention one example, can already have a great impact on the water-management of the area. And if properly timed, in small steps, field by field the correct land use (in terms of landscape characteristics and the water cycle) can be restored, resulting in safe sustainable production on the remaining agricultural land, requiring less irrigation inputs, making agriculture profitable and sustainable.

CONCLUSIONS

In our research we used the EN concept and attributes of the land to define the key ecological areas for water retention and landuse change. We identified some canals that – if restored correctly with their surrounding areas - could have a significant impact on farmlands. Also, the conflicting landuse of the current and potential floodplain causes the fields to dry out, and makes the groundwater-level decrease. These areas are not suitable for farming, as we experienced during our fieldwork. The agricultural field in the middle of the study region, formerly a water surface, needed irrigation to provide suitable conditions for farming, even in the month of September. These anomalies should be resolved with strategic changes in farming, completely changing the way we see the solution of the drought in the Great Hungarian Plain.

As we also experienced during our fieldwork, from the perspective of the local farmers there is a willingness to change, if the required conditions and support is given by the government or other authorities. We hope that in the near future the first steps of change can be materialized and when the next extreme summer comes our suggestions will help to decrease the effect it will have on our agriculture and - also - everyday life.

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