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HUMAN IMPACT ON TOPOGRAPHY AND LANDSCAPE PATTERN IN THE UPPER TISZA REGION, NE-HUNGARY

ABSTRACT: KERÉNYI A. & SZABÓ G., *Human impact on topography and landscape pattern in the Upper Tisza region, NE-Hungary*. (IT ISSN 1724-4757, 2007).

Anthropogenic landforms affect ecological patterns in the landscape. This investigation concerns three parts of the Upper Tisza region, where the most significant landforms are flood-control embankments and the country roads running on their crowns. Analysis of space images, topographic maps and field observations show that these embankments exert a beneficial influence on the ecological pattern in two ways. Their grassed slopes provide an uninterrupted green corridor along the river. Also, the undergrowth of the afforested areas behind the embankments provides habitats for numerous plant species and also acts as a partial ecological corridor. Although the country roads running along embankments may also act as ecological barriers, since road density and traffic volumes are small, far below the national average, the effect is moderate.

KEY WORDS: River channelization, Embankments, Ecological corridors and barriers, Remote sensing, Tisza River (Hungary).

INTRODUCTION

Before 1850, floods from the Tisza affected a greater area than any other Hungarian river. However, from 1850, the Tisza River was subjected to one of the largest river channelisation programmes ever conducted in Europe, according to the plans of Pál Vásárhelyi. Its floods were constrained by the widespread construction of embankments (Gábris & *alii*, 2002; Nagy & Schweitzer, 2002). The programme caused major change in both environment and land use on the floodplain. The new flood-control embankments created new topographic habitats and caused major ecological change in the formerly flood-prone area. New arable fields and settlements appeared while existing settlements expanded into the newly flood protected area replacing former water meadows and scrub. In the 20th century, road construction involved further earthworks. This paper focuses on the new landforms along the Upper Tisza and the impacts of the transformation of the ecological pattern.

STUDY AREAS

These investigations concern three sections of the Upper Tisza (fig. 1): the Tisza river floodplain at Lónya; the Tisza river floodplain at Gulács; and the SW Bodrogköz and the Morotva köz floodplains at Rakamaz. These landscapes have been created by the Tisza River in concert with the Tapoly, Ondava and Laborc rivers at Rakamaz.

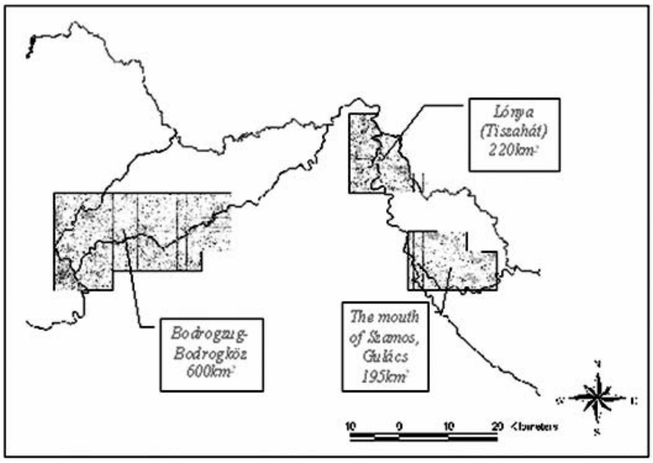

FIG. 1 - Location of the study areas along the Upper Tisza river (NE-Hungary). The Rakamaz (Bodrogzug-Bodrogköz) floodplain (600 km^2), the Szamos confluence area at Gulács) (195 km^2), the Lónya (Tiszahát) floodplain (220 km^2).

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These areas have elevations of 95-110 m above sea level and include both active and presently inundation-free floodplains. Locally, some higher relative relief is found (e.g. the sandy area enclosed by Viss-Zalkod-Kenézlő; backswamps enclosed by natural levees and some sand dunes in the Bodrogzug) but there is little other topographic differentiation. Horizontal diversity is more significant, especially in the Bodrogzug and in the Morotvaköz at Rakamaz where there are, oxbow lakes and abandoned river channels (fig. 2). Surficial geology is dominated by Late Holocene floodplain clays and silts, wetland clays and marshland-mull sediments. These are underlain by Pleistocene sandy loess and, in the Bereg Plain, by fluvial gravels.

METHODS

LANDSAT satellite images from 1992 and 2001, scale 1:10,000, were used to identify the distribution of man-made landforms and also elements of the ecological pattern on topographic maps (tab. 1).

TABLE 1 - Major characteristics of the satellite images applied

Instrument	Sensor	Resolution	Available channels	Date
LANDSAT-5	Thematic Mapper	30x30m	1,2,3,4,5	1992.07.30
LANDSAT-5	Thematic Mapper	30x30m	1,2,3,4,5,6,7	2001.08.08

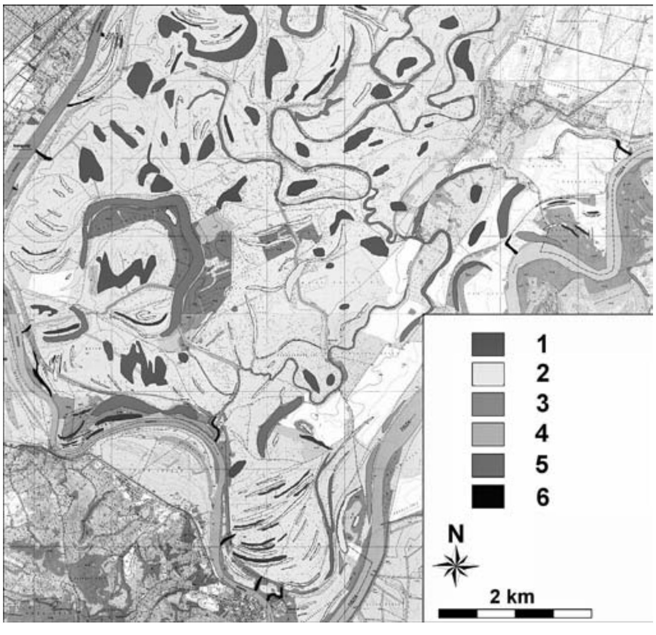

FIG. 2 - Landforms of the SW Bodrogköz (In: Szabó & *alii*, 2004). 1: fluvial ridge, 2: swale, 3: abandoned cut-offs, 4: present natural levee, 5: backswamps, 6: (remnants of) one-time flood-plain ditches.

For interpretation, first, composites were created from the images applying three-three sensor belts, then variations suitable for land-use analysis were selected: 432 (RGB), 532 (RGB) and 453 (RGB), then data bases were derived from the images depicting vegetation. Normalised vegetation (NDVI) indices established by PCA (primary component analysis) and Tasselled Cap statistic methods were employed. Their common property is that they include data gained through the combination and mathematical transformation of several bands from the satellite images.

Detailed interpretation, ground-truthing, and the classification of borderline cases were accomplished by field observation. Typical sites were photo-documented. Simultaneously, 55 point-coordinates, accurate to 8 m, were established by means of a global positioning system (GPS). Many of these coordinates defined study areas, while others were used as control points. Field survey permitted the accurate determination of the vertical dimensions of these forms and also helped establish the inter-relationships between the artificial landforms and the ecological pattern - whether negative (ecological barriers) or positive (green corridors). Finally, land-use maps were prepared that showed the man-made landforms and the present-day ecological pattern.

RESULTS

In the course of the second half of the 19th century, the Tisza was channelized and 114 meanders were cut, so reducing its length from 1419 to 996 km. This formed numerous oxbow lakes, as near Jánd village in the Gulács area (fig. 3).

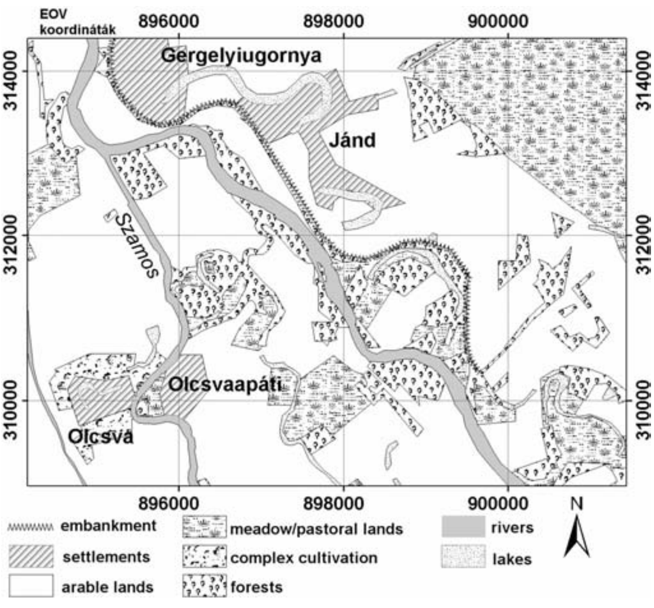

FIG. 3 - Map of the study area at Gulács.

Simultaneously, floodplain constriction through the construction of embankments raised average flood levels by 2 m, which, subsequently, was tackled by increasing the height of embankments. As a result, embankments have become the most significant landform in the floodplain. Naturally, the designers of the embankments adjusted their alignments to the local topographic conditions and, consequently, the embankments do not always follow the river. Fig. 3 shows an embankment running on the right bank of the river, protecting the villages of Jánd and Gergelyiugornya. Its height varies between 2-6 m depending on local relief.

Rising above its surroundings, the embankment has had a – partly direct and partly indirect – but always significant influence on the ecological pattern along the river. Formerly, the natural riparian vegetation was composed of floodplain gallery forest, wet grasslands, pastoral lands and swamps and locally reed-beds. After embankment construction, wetland habitats largely disappeared from protected areas – surviving mainly in oxbow lakes and navvy pits. Arable land became dominant and large areas became occupied by settlements.

Today, the slopes of the embankments are mostly overgrown by self-set herbaceous vegetation. This is important for slope stabilisation and the prevention of erosion (fig. 4) but also from an ecological point of view. Rising above the general level of the plain, they provide better drained and new arrays of habitats, which foster greater biodiversity. The two sides of the embankments provide very different habitats. The active floodplain side is wetter, flood inundations affect it for periods up to a few weeks per year, which contributes to the survival of water resistant plants.

Forest shelter belts have been planted to protect the internal slopes of embankments. Although these are plantations, they play an important ecological role as green corridors. Fig. 3 shows a forest belt running along the embankment and connecting distant green patches.

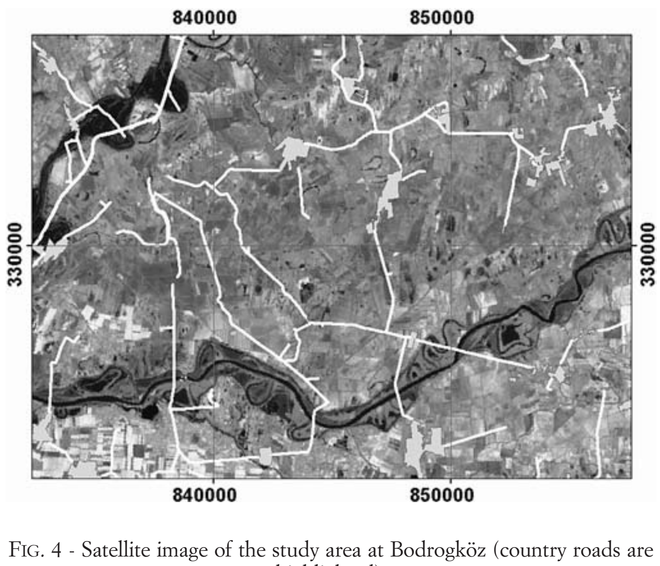

FIG. 4 - Satellite image of the study area at Bodrogköz (country roads are highlighted).

The floodplains, including now flood-free areas, are dissected by pits and ditches formed by excavation for construction or roads, flood embankments and for adobe building materials. These are frequently filled by water as the water table is near the surface. Adobe was an important building material until the second half of the 20^{th} century. In general, there was no building material worth transporting on the Great Hungarian Plain, so adobe was the cheapest solution and most of the old houses are built of adobe.

Road construction required almost as much material removal as building flood embankments in the area. Fig. 4 shows road network in the largest study area (Bodrogköz), where the largest amount of earth – almost 5 million m^3 – was moved for road construction. However, almost 1 million m^3 of earth was moved in even the smallest study area.

Most paved access roads follow the embankments on the flood-free side. However, the slopes of road embankments serve the same green corridor functions as the flood-control embankments. We have measured the length of each of the country roads running on embankments in the study areas from the satellite images and calculated road density by study area (tab. 2).

TABLE 2 - Extent of the study areas and the data of the country roads

Number	Name of study area	Road length (km)	Road density (km/km^2)	Filled material (m^3)	Area (km^2)
1.	Bodrogköz-Rakamaz	222.1	0.37	4,997,250	600
2.	Vicinity of Lónya	41.4	0.19	931,500	220
3.	Vicinity of Gulács	52.6	0.27	1,183,500	195
	Total	316.1	average: 0.31	7,112,250	1015

Average road density for the three study areas (0.3 km/km^2) remains significantly below the national average (1.13 km/km^2). This may be socially disadvantageous but it has a favourable ecological aspect. The ecological function of the road network has two opposing attributes. First, embankment slope may function as green corridors, although this function is limited as the plants are regularly mown and the vegetation disturbed. Second, the tarmac road surface with regular car traffic present an ecological barrier for many animal species and so impair the operation of an ecological network (Spellerberg, 2002). Research proves that the barrier effect of the roads can be very significant (Forman, 1995; Forman & Godron, 1986). However, this ecological barrier effect may be smaller in this location than elsewhere in the country. The Lónya area is least dissected and here the effects of the roads are minimal. The road density of Rakamaz, the most dissected study area is 0.37 km/km^2 – but even this is small compared to the national average.

Locally, roads run across the still-active floodplain. Today, most of the area between the Tisza flood embankments is cultivated – so access roads are required. Such a road can be observed in figure 3, found between the embankment and the Tisza channel west of the village of Jánd (fig. 3 along the embankment). This road follows an embankment rising only 0.5-1.0 metres, just enough above the floodplain is enough to keep it dry and open during smaller floods. However, the road creates another green corridor between itself and the forest belt. The forest belt, even though it consists of planted poplar varieties, is of high ecological value because of its well developed undergrowth. The foliage, the herbaceous vegetation and the forest floor together offer cover for many species, especially insects and worms.

Table 3 shows the data of the levees of the study area. It can be observed that the average levee density is lower than the road density. In the more extended Bodrogköz-Rakamaz study area the roads form a network, while levees run parallel to the river. In this study area less earth was used for building the levees than building the roads and that can be explained by the total length of the roads: it is more than twice the length of the levees. The situation is reversed, however, in the other two study areas. This is explained by that the levees were built higher than the roads on the prevented side and the length of the roads differ only slightly from the length of the levees. It can be stated for all three study areas that the ecological barrier effect for the local biosphere presented by the levees is less than that presented by the national roads. Levees are built by natural material and only the vehicles of the water agencies use them.

An unusual anthropogenic geomorphological element in the Bodrogköz-Rakamaz area is the remnant of a thousand-year old earthwork at Szabolcs, which, rising 10 m above the floodplain as a dam is the highest elevation in the region. This whole ediifice, including the herbaceous vegetation of earthwork slopes, is under protection.

CONCLUSION

The analysis of space images, topographic maps and field measurements in three sections of the Upper Tisza valley confirm that, ecologically, the most significant anthropogenic landforms are the flood-control embankments created after 1850 and the country roads that run along their crowns. Although the road network may act an ecological barrier, low density and low traffic volumes, mean that this impact is relatively minor. Instead, these embankments enhance the ecological pattern, because their grassed slopes provide an uninterrupted green corridor along the river while the undergrowth of the afforested area on the flood-protected side of the embankments provides habitats for numerous species and also acts as an ecological corridor. Some of the navvy pits created during the extraction of several million cubic metres of material for road and embankment constructions are now flooded and provide new, valuable wetland habitats.

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