# THESIS OF PHD DISSERTATION

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# THE WATER HABITATS AND THEIR HISTORICAL CHANGES FROM A WATER LEGISLATION ASPECT, AT THE SZIGETKÖZ SECTION OF THE DANUBE

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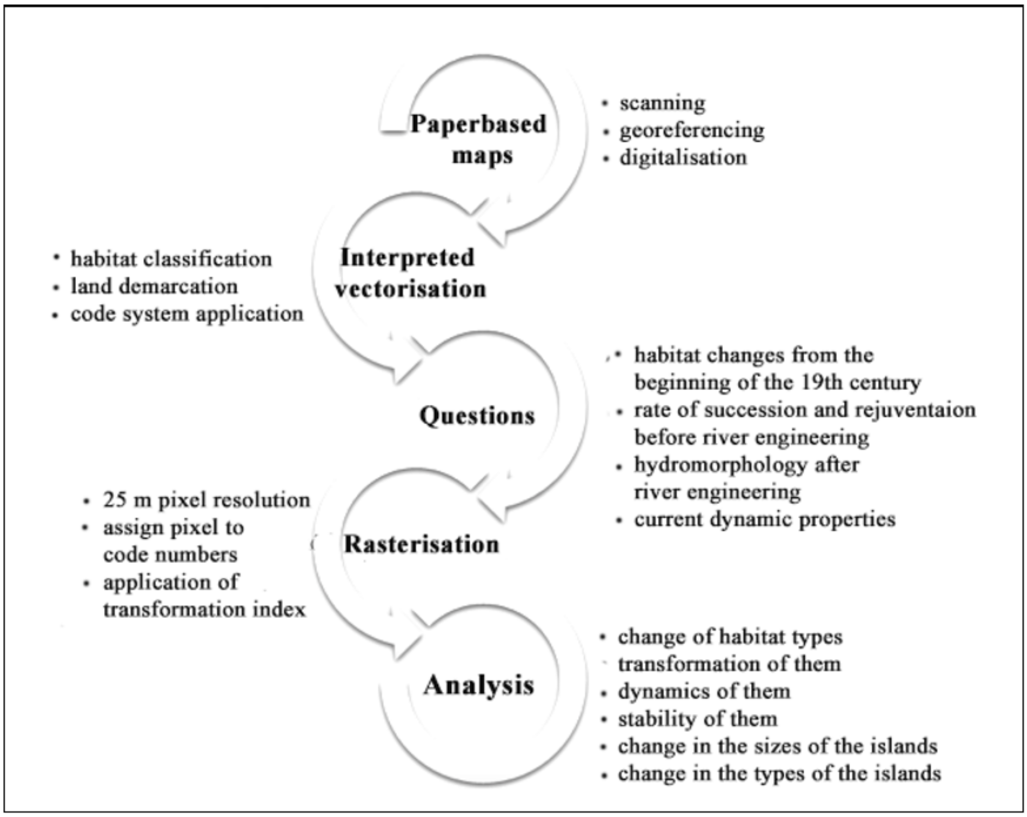
# 1 PREVIOUS RESEARCH AND AIMS

Using and changing the Danube is a thousand year old process, called river engineering, which had a remarkable effect on the river system. The knowledge about the usage of the water and the landscape, imply an important background on the analysis of the long term changes in the structural and functional way. At the Hungarian section of the Danube we cannot find any natural river section, which would be able to show a reference. That is why it is inevitable to analyse the dynamics of the historical river landscape system. Comparing the statuses of the different historical maps, we can admit that before river channelisation, there were ramarkable territorial changes in the river landscape, which had a huge effect on the situation of the people who lived next to the river. It can be easily proved from arguments about legal issues of land properties. River engineering apparently had been offering a solution for the economical and social challenges, because it led the processes to a more statical way. The aims of the dissertation about the Szigetköz were the following:

- recognise the historical dynamics of the river system before and after channelisation and after building of the slovakian reservoir system.
- determine the time- phase which caused irreversible changes
- examine the sustainability of the actual ecological status
- unify the analisation of the dynamics of the historical aquatic habitat system
- based on the results, show the missing parts of the legal regulation and its role on the actual ecological processes.

# 2 MATERIALS AND METHODS

The study focuses on the changes on the anabranching channel of the Old-Danube (rkm: 1831-1808). The research was based on military, cadastral surveys, hydrographical maps and aerial photographs with their basic data information.




*1. picture. habitat classification and the process of the analysis (own edition)*

I have collected forty historical maps, which had information on the study area and I have chosen ten of them to analyse the hydromorphological changes. The maps were made in: 1820, 1825, 1838, 1872, 1908, 1946, 1955, 1986, 2004, 2013.

## 2.1 Habitat classification

The habitat classification was based on the data of the georeferenced and digitized maps. The segregation of the diverse water bodies - which are typical in the lowland rivers - was mainly based on the 'functional sets' concept (Amoros et al. 1987). The basic types of the functional figures - which are composing the ridge of the concept - were written by Roux et al. (1982) by the integrade continuum of ecological succession. The definitions were used in the Austrian section of the Danube river (Hohensinner, 2005), followed with some modifications, which was suitable for separate the aquatic habitats and the drier habitat types connected to them.

*1. table. The definitions and code numbers of aquatic and drier habitat (Edition of the author Amoros et. al, Roux et al, Hohensinner et al, and Guti et al.)*

<table>
<tr><th colspan="3">Definitions of habitats</th></tr>
<tr><th>Habitat type</th><th>Code</th><th>Definition</th></tr>
<tr><td>Eupotamon-A</td><td>15</td><td>Main channel arm</td></tr>
<tr><td>Eupotamon-B</td><td>14</td><td>Side arms</td></tr>
<tr><td>Parapotamon-A</td><td>13</td><td>Highly dynamic backwaters: abandoned braided channels blocked by bare gravel/sand deposits</td></tr>
<tr><td>Parapotamon-B</td><td>12</td><td>Less dynamic backwaters: abandoned braided channels blocked by vegetated deposits</td></tr>
<tr><td>Pleisopotamon</td><td>11</td><td>Permanent water body/oxbow, close to the main channel, highly influenced by river discharge</td></tr>
<tr><td>Paleopotamon</td><td>10</td><td>Temporary water body/oxbow, not so close to the main channel, less influenced by river discharge</td></tr>
<tr><td rowspan="6">Area below bankfull</td><td>9</td><td>Island with swamp/aqueous area</td></tr>
<tr><td>7</td><td>Gravel, sandy island, usually close to the thalweg-line</td></tr>
<tr><td>6</td><td>Grassy island</td></tr>
<tr><td>5</td><td>Bushy island</td></tr>
<tr><td>4</td><td>Woody island</td></tr>
<tr><td>3</td><td>Other floodplain area, usually coalescenced with the bank zone</td></tr>
<tr><td rowspan="2">Elevated floodplain areas</td><td>2</td><td>Higher floodplain terrain, separated by dam system</td></tr>
<tr><td>1</td><td>Settlement</td></tr>
<tr><td>Bypass channel</td><td>8</td><td>Artificial water body, created for the hydroelectric power plant in Bős.</td></tr>
</table>

## 2.2 Transformation index

I have assigned code numbers to each habitat types. If the code number is high, than it is more suitable for transforming into a fresh, running water habitat type. The transform of the code numbers showed a two-way alteration process;

- succession: it occurs, when the code number of the earlier map is higher (for example, code: 15), than the code number of the later map.
- rejuvenation: it occurs, when the code number of the later map is higher, than the code number of the earlier map.

I have used the transformation index of Hohensinner et al. to quantify the habitat changes. For evaluating the habitat changes, the TI index is based on a matrix, showing the quality of transformation between habitats.

$$TI_{period} = \sum_{x,\ y=1}^{n} d_{x,\ y} \ / \sum_{x,\ y=1}^{n} A_{x,\ y}$$

$$n = \text{ number of habitat types}$$

where the individual weighted distance $d_{x,\,y}$ for each differently developed habitat share is:

$$d_{x,\ y} = A_{x,\ y}\ (\mathrm{y} - \mathrm{x})$$

$A_{x,\ y}$= habitat share in % of the active zone area (AZ)

y= y – position of the later habitat share

x= x – position of the earlier habitat share

Positiv values of TI showed the dominance of habitat rejuvenation, negative values of TI showed the dominance of habitat succession. In order to be more precise in the comparison of the data of different time periods, I have distributed the value of $TI_{period}$ with the number of the years.

## 2.3 The river habitat dynamics from a legislation aspect

The sedimentation of the river habitats, and the disappearance of them, can be in context with the deficiencies of the regularisation. In our case the sedimentation, the silt and the appearance of reed vegetation on the shoreline, ergo those ecological processes, which are related to the aridification of aquatic habitats processes can be summarised with one word in the Hungarian legal system: increment, more precisely: increment of the riparian zone.

When we speak about succession, we can use “increment” as a synonime from the juristical aspect. The increment of the riparian zones cannot reach a rapid result in changing of the river habitat system, meanwhile it can cause significant changes with longer time periods.

Nowadays there are no special rules in the native water legislation system, which focuses on the property changes caused by the increment. It is feasible that the mock of the stability - after river engineering – wanted to be sustained by the lack of regularisation related to the dynamics of the river system, which can cause property changes. It can be a cause why there is no accurate borderline for islands and floodplain areas to define the changes of the increment in the riparian zones.

# 3 RESULTS

## 3.1 Changes in river morphology in the different river branches

Before river engineering the morphology of the three river branches were in continuous change. The originally anabranching river section (bodaki branch) became an anastomosing riverbranch type and vice versa, the originally anastomosing river section (ásványi branch) and the anastomosing and meandering river section became a braided river channel. After river channelisation the morphology of the different river sections became stabile as a straightened, slightly meandering riverbed.

## 3.2 The territorial changes of river habitats

Before river engineering the most dominant habitat-type was the eupotamon-A, but this changed after channelisation. The eupotamon-A habitats were relayed by the eupotamon-B habitats and after the closuring of the sidebar system the significant proportion of the eupotamon-B habitats became parapotamon-B type. Their rejuvenation happened after the built up water replacement system, mainly in the ásvány riverbranch. There was a less significant but similar change at the bagomér branch system also.

## 3.3 Territorial changes of the islands

At the initial channelisation era there were bare, grassy, bushy and forestry islands in the area. The islands had stronger vegetation coverage from the thalweg line outward to the shoreline. The proportion of the bare and grassy islands were extremely decreased, while the proportion of the soggy islands increased after river engineering. After the diversion of the Danube there were only forestry islands in the floodplain area.

## 3.4 Transformation of the aquatic habitats: rejuvenation, succession

In the initial channelisation era one rejuvenation (1820-1825) and two succesion (1825-1838, 1838-1872) occured considering the dynamics of the aquatic habitats. Contrary to the expected outcome, there was also a rejuvenation after channelisation, when the maps were showing remarkable inland water formations. After the built up of the bypass canal the terrestrial processes were strenghtened without any rejuvenation processes.

## 3.5 The stability of aquatic habitats before and after channelisation

Before channelisation only the 3,71% of the aquatic habitats remained stable, while after channelisation the 6,11% of the aquatic habitats remained fixed.

## 3.6 Connecting points to law regulation system, possible suggestions

To determine the necessity of legislation, it is need to be estimated, if there is a relevant pretension to control - by law - the siltation processes at the riparian zones. The relevancy of the question can be established by the processes of the climate change, especially the dry up of the water bodies with sedimentation processes of them.

I have suggested to alternate the definition of the shoreline with a more precise definition as the following: the borderline of the riverbank and the shoreline, which is defined by the secondary flow. The values of the secondary flows can change from year to year, and it would cause a huge disadvantage for the authorities. To avoid this disadvantage I have determined a five-seven year long time period to reconsider the borders of riparian zones.

### 3.7 New scientific results. Theses

1. **thesis** Possible rejuvenation of habitats

**I have attested that the aquatic habitat changes of the river were mainly revealing succession.** Two time periods were exceptional: 1820-1825 and 1908-1946. Both periods were represented local, not too intensive interventions**. I have determined, that beside smaller interventions it is possible for the aquatic habitats to rejuvenate**, while beside intensive anthropogenic interventions the result is succession.

2. **thesis** Large-scale transformation of habitats

**Based on my analysis I have adumbrated that in the next eighty years we have to count with the whole transformation of the Szigetköz.** This is supported by the extreme flood events (2002, 2006, 2013), which would be able to refresh the area, if it would not be an artificially regulated floodplain with totally forested islands and floodplain area. The accelerated succession and the extreme floods are pointing to the fact that, with the law of the nature, **a significant habitat transformation will eventuate in this century**. If it will not happen in coordinated circumstances it will endanger the settelements next to the river.

3. **thesis** Introducing the most typical habitats

**I have successfully adopted the habitat analysis** of an austrian **research,** which **is suitable to the follow-up the procession of succession or** rejuvenation based on historical maps. **The habitat dynamic changes were showing the most proper aquatic habitats before and after channelization.** The classification can be adopted in the other anabranching river sections, for example at the Danube delta, Tulcea (Romania), and in the upper section at Brajla (Romania), Silistra (Bulgaria), and at Novi Sad (Bulgaria) and Gemenc (Hungary). The austrian and hungarian classification are both suitable to separate the different habitats of the straightened river sections.

4. **thesis** Different island sizes at the variant river sections

**I have stated that the different hidromorphological properties were influencing the sizes of the islands before channelization.** The bodak-branch with accelerated run-off conditions had bigger (20 ha), while the bagomér branch with slower run-off conditions had smaller (10-15 ha) islands. The mainly anastomosing ásvány-branch had a balancing role with its averagely 15 ha big islands between the maisnly anabranching bodak section and mainly meandering bagomer sidearm system.

5. **thesis** Different habitat proportion at the variant river sections

**I have established that at the different branches of the river the proportion of the aquatic habitats is different.** It can be stated that the parapotamon-A habitat was not significantly presented in our case, that's why it is not necessary to have a distinct definition for that, at the same time at the lower part of the Danube it can be still applicable.

6. **thesis** Clarify the exact time of map making by hidromorphological analysis

The date on the maps are not always showing the exact times of map creation. **With the analisation of hydromorphological dynamics and water habitat dynamics I have defined the probable time of map creation for the second military survey and the hydrographical map of the 1830's**. I have stated that with the help of hidrodynamical analysation we can clarify the time of map creation.

7. **thesis** Defining the legal barriers in case of sustaining the water habitats

**I have pointed to, that there are prior main channel areas, that became to be islands, and after that became to be shorelines. Because of the frontier it is not possible to accomplish legal water management. I have ascertained that nowadays it is not possible to walk on the river shoreline without border violations in case of medium water level. Based on international case law, I have showed the result of the** uncertainities of the boundaries – in our case the inexpedience of it – if it lasts longer between countries.

8. **thesis** Use of transformation index in practice

Based on real queried ownership cards **I have revealed the incompleteness of the field register**, contemporaneously I have revealed that **the transformation index can be capable to develop the field and waterbody register**, because it has a potential to predict the spatial changes both in the ownership and country borders.

# 4 CONCLUSIONS AND SUGGESTIONS

In my doctoral dissertation, I have revealed the chief conclusions for the dynamics and management of water habitats which is concluded below:

- Before channelisation the water habitats were able to rejuvenate, though it has become truly demonstratable, that the transformation processes of riverine system are mainly influenced by succession.
- The maps of the investigated period are not showing the natural processes of the river but the near-natural and human-modified processes.
- The river regulation, the blockage of the sidearm system and the construction of the hydrolelectric power system of Bős resulted the freezing of the fluvial system, and the lack of dynamics of it, which was influenced by social and economical inetrest.
- The actual legal status does not allow the rehabilitation aspirations of wetlands. The conclusion is supported by the lack of the precise boundaries of watery system.
- The actual legal regulations are not suitable for an overall landscape rehabilitation, which can demonstrate the near-natural water habitat dynamics. Beside that the border situation of the Danube and the not defined function of the Old-Danube arm are make it necessary to find a new conception for the for the region.
- For a long term and successful landscape rehabilitation we need to reconstruct the dynamical conditions and not for a statical landscape rehabilitation.

# 5 PUBLICATIONS RELATED TO THE TOPIC

**Journal articles, with impact factor**

Farkas-Iványi K, Guti G.(2014): The Effect of Hydromorphological Changes on Habitat Composition of the Szigetköz Floodplain, In: *Acta Zoologica Bulgarica S7*: 117-121. pp. IF: 0,532

FARKAS-IVÁNYI K. & TRÁJER A. (2015): The influence of the river regulations on the aquatic habitats in river Danube, at the Bodak Branch-System, Hungary and Slovakia, In: *Carpathian Journal of Earth and Environmental Sciences,* 10 (3) pp. 235-245 IF: 0,730

**Other worthy article**

TRÁJER A, FARKAS IVÁNYI K, PADISÁK J (2015): Area-based historical modeling of the effects of the river bank regulation on the potential abundance of eleven mosquito species in the River Danube between Hungary and Slovakia, In: *Advances in Oceanography and Limnology* 6:(1/2) p. 45-56.

FARKAS-IVÁNYI K. (2016): Vízgazdálkodás és a hozzá kapcsolódó területi viszonyok hazai és nemzetközi szabályozása. Pázmány Péter Katólikus Egyetem, Jog és Államtudományi Kar, Közigazgatási Jogi Tanszék, Budapest, p. 4-44

**Conferences supplements**

<u>Full paper</u>

IVÁNYI K, KÁSA I. & GUTI G. (2012): Historical review of river engineering in the Hungarian section of the Danube, In: Berczik Árpád, Dinka Mária, Kiss Anita (szerk.) *Living Danube: 39th IAD Conference: Proceedings*. Konferencia helye, ideje: Szentendre, Magyarország, 2012.08.21-2012.08.24. Vácrátót; Göd: MTA ÖK Duna-kutató Intézet, 2012. p. 279-283.

FARKAS-IVÁNYI K. & GUTI G. (2013): A szigetközi Duna-szakasz folyódinamikája természetes és antropogén viszonyok között. In: *Koncz István, Nagy Edit (szerk.) Tudományos Próbapálya: PEME VI. Ph.D. konferencia*. Konferencia helye, ideje: Budapest, Magyarország, 2013.03.12 Budapest: Professzorok az Európai Magyarországért Egyesület, p. 617-619.

Hungarian abstracts

IVÁNYI K. & GUTI G. (2012): A szigetközi Duna szakasz folyódinamikai változásainak áttekintése történeti térképek alapján In: Bíró Péter, Reskóné Nagy Mária, Kiss Keve Tihamér (szerk.) „VIZEINK SOKFÉLESÉGE KIEMELT ÉRTÉK": LIV. Hidrobiológus Napok. Konferencia helye, ideje: Tihany, Magyarország, 2012.10.03-2012.10.05. Tihany: MTA Balatoni Limnológiai Kutatóintézet, p. 36.

International abstracts

FARKAS-IVÁNYI K, MÉSZÁROS J, PÁSZTOR L. (2016): Spatio-temporal assessment of aqueous habitat dynamics at the Danube river floodplain based on historical topographic maps and remote sensing data GEOPHYSICAL RESEARCH ABSTRACTS 18: Paper 5503. EGU General Assembly 2016. Bécs, Ausztria: 2016.04.17 -2016.04.22. (European Geosciences Union)

PÁSZTOR L, FODOR N, FARKAS-IVÁNYI K, SZABÓ J, BAKACSI ZS, KOÓS S. (2016): Mapping specific soil functions based on digital soil property maps GEOPHYSICAL RESEARCH ABSTRACTS 18: Paper EGU2016-5745. p. 1. EGU General Assembly Conference. Bécs; Horn, Ausztria: 2016.04.17

**Part of a book**

FARKAS-IVÁNYI KINGA (2014) Vándorló szigeteink, a Szigetköz múltja, jelene... és jövője In: Csemez Attila (szerk.) Időszerű tájrendezési feladatok. Budapest: BCE Tájépítészeti Kar, 2014. p. 87-96. (Tájakadémia; 4.) (ISBN:978-963-503-576-2)