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Hydrographic changes of the Strėva Basin in the 20th century. Part 1. Water streams

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Hydrographical changes of the Strėva catchment had been analysed since the end of the 19th century up to the 9th decade of the 20th century. The aim of this article is to show the anthropogenic impact on the hydrographical network of the Strėva catchment. The main objectives of this work were to determine changes of the catchment area, of the watercourse length of the water bodies' areas, and of the watercourse sinuosity. The main research materials were topographical maps compiled at the end of the 19th century, early in the 20th century and at the end of the 20th century. The methods of geographic information systems (GIS) as well as *ArcView 3.2a, ArcGis 9.1* software were applied. The main results of the research showed the anthropogenic impact on the hydrographical network of the Strėva catchment.

Key words: rivers length, basin area, hydrographic river network

INTRODUCTION

Rivers and their basins are shifting in terms of time. The hydrographic river network in Lithuania has changed as a result of land reclamation, road building and other engineering works (Fig. 1). The length of smaller rivers, their channels and basin area have undergone most marked changes (Gailiušis ir kt., 2001).

The Strėva River basin is one of the most interesting in Lithuania from the scientific point of view. In the last century, the basin of this river has been strongly affected by human activity. Landscape transformations were entailed by deforestation and the resulting intensification of erosion processes. An intensive transformation of the hydrographic network changed the country in the second half of the 20th century. Appearance of automated agricultural machinery expanded the area of farm lands and conditioned soil changes.

The present article was designed as an analysis of changes of hydrographic network in the Strėva River basin. The following tasks had to be fulfilled:

1. Determination of changes of the Strėva River basin area in the 20th century.
2. Evaluation of changes of the stream length in the 20th century.
3. Determination of the ratio of anthropogenically affected and natural streams in the basin.

GEOGRAPHICAL SURVEY OF THE STRĖVA BASIN

The Strėva River basin belongs to the Lithuania-largest Nemunas River basin. It is a first-order Nemunas tributary which is 73.6 km long and has a basin area of 758.9 km^2 (Kilkus, 1998). The Strėva River has 23 tributaries, the largest being Spengla 11.5 km, Margis 13.1 km, Dabinta 14.8 km, Lijonas 10.6 km, and Limšius 17.7 km.

The present landscape of the basin is rather variable. Morainic plains stretch in the northern and central parts of the basin. In the north, a local sandur plain wedges into the basin. The Strėva River valley extends as a narrow strip from north-west to south-west. The remaining south-eastern and south-western parts of the basin are occupied by a hilly morainic upland.

The lithological cover of the Strėva basin is variable. The central part is composed of glacial tills and sandy loams. Clayey horizons are exposed in the hilly slopes of the river. In the south and south-east, lakes are surrounded by inequigranular sand and sand with gravel. The northern part of the basin has no lithological dominant; the greater part of it is covered by inequigranular sands. The valley of Strėva River is composed of fine-grained sand and aleurite. Lake banks, hollows and stream banks are filled with peat beds.

The soil cover of the Strėva basin is composed of sod-podzol soils. In the central part they are medium podzolized and in the remaining part of the basin weakly podzolized. Sod-podzol

gleyey soils occur only in the northernmost part of the basin (Lietuvos …, 1980).

Forests in the Strėva basin occupy 223.3 km^2 or 29.5% of the total area (DB50LT, 2003). Pine forests extend in the northern and southern parts, spruce forests in the central, and mixed coniferous–deciduous forests in the south-eastern parts of the basin. Today, the Strėva River valley is least forested.

A SURVEY OF USED MAPS AND INFORMATION SOURCES

The plane-table instrumental survey of the territory of Lithuania was started in 1881. The scale of the survey was 1 : 21 000. According to instructions, it not only had to meet the military requirements, but also had to serve the interests of economy and science (Samas, 1997). The survey map was compiled in the transverse cylindrical Gaus–Krüger's cartographic projection. It was used for field constructions and geological and road research (Krikščiūnas, 1928). The horizontals were 4.26 m long. For survey map, each plane-table (a board of solid material – aluminium, veneer or cardboard – with a special paper pasted for drawing) had to have no less than 2–3 triangulations and about 10 other geometrical points (Samas, 1997). The maps were of especially good quality. During World War I, the German Army photographically magnified these maps to a scale of 1 : 25000. They have been preserved at this scale. Topographic works for the Strėva River basin survey were started in 1898 (Krikščiūnas, 1928).

Another precise large-scale survey of the Strėva basin territory appeared in independent Lithuania. In 1925, the Department of Military Topography compiled Lithuanian maps of the Middle Nemunas environs at a scale 1 : 25 000 based on an original field survey. They were tricolour: green forests, blue water bodies and black contours and isohypses. Isohypses were spaced 4 metres. Later (1934), the spaces were changed to 5 m. Every tenth isohypse was drawn as a considerably thicker line, every fifth as a long dotted line, half-and-half isohypses (spaced 2.5 m) as a short dotted line and quadrant isohypses (spaced 1.25 m) as a very short dotted line (Samas, 1997). The total number of pages of these maps was 92. They were issued from 1925 until 1940. The Strėva River basin was mapped in about 1930. The topographic maps were based on a new triangulation grid and on the old preserved tsarist triangulation grid of the 3rd and 4th order. The works lasted until 1940.

The last most precise survey of Lithuania's territory was compiled in 1966–1987. The chosen scale was 1 : 10 000. The survey map was compiled by the Supreme Board of Geodesy and Cartography. The maps were of limited access. The pages of some territories were classified. The maps were based on aerophotography. The complete set of the maps of 1963 was printed in five colours. The run of the maps was not indicated as all cartographic material of those times was classified (until 1999).

METHODS

Shifts of the hydrographic network in the Strėva basin were investigated by comparative analysis of maps.

The first step included a comparison of three large-scale maps of different years. The maps were compiled based on instrumental surveys at a similar scale. Each of the maps has its plane error. This means that the point plotted in the map not necessarily corresponds with the same point in a territory: the error of the map at a scale 1 : 10 000 equals to 4–5 m, at a scale 1 : 21 000 to 10–11 m and at a scale 1 : 25 000 to 8–10 m (Žikulinas ir kt., 2005). Though the derived mean errors were different, they did not exceed the error limit which makes 5% of the map scale. Therefore, we can assume that the information contained in the map is correct. These errors correspond with the x and y axes (Berliant, 1986).

The second step included digitization of the maps, and their scales were unified. This was done with the aid of ArcGis 9.1 software of the ESRI Company.

The third step included drawing and digitization of the Strėva River basin at different times. The water streams of the basin were also digitized. For this purpose, ArcView 3.2 software of the ESRI company was used.

All the digitized hydrographic objects and basins, analysed by statistical methods, comprised the fourth step of investigation. The size of basins and stream lengths were derived. These operations were performed by accessory XTools of ArcView 3.2 (ESRI Company).

DATA ANALYSIS

For derived values of the stream lengths and basin areas, comparative data tables were made. Table 1 shows shifts of the Strėva River in different time frames. In the map of 1898 at a scale 1 : 21 000, the Strėva basin area is 757.9 km^2. This territory can be treated as a relatively natural river basin. In the map of 1930 at a scale 1 : 25 000, the territory of the basin remained the same, whereas in the map of 1980 at a scale 1 : 10 000, the basin area reduced by 0.7%. The basin reduced due to formation of the Kauno Marios water reservoir. Some of the water bypassing the Strėva River directly discharges into the Kauno Marios.

Table 1. **Shifts of Strėva River basin in the 20th century**
1 lentelė. **Strėvos upės baseino kaita XX a.**

Year of publication of the map Žemėlapio išleidimo metai	Scale of the map Žemėlapio mastelis	Basin area, km^2 Baseino plotas km^2	Shifts of the basin area, % Baseino ploto kaita %
1898	1 : 21 000	757.9	0
1930	1 : 25 000	757.9	0
1980	1 : 10 000	752.7	– 0.7

Water streams of the Strėva basin have undergone greater changes (Table 2). From 1898 until 1980, the length of water streams increased by a few tens to a few hundred percent. In the map of 1898, the length of natural streams was 310 and the length of newly formed or anthropogenically transformed streams increased by 36.7%. In the map of 1930, the length of streams increased by 37% and in 1980 by 127.5%, i. e. 2.5 times versus 1898.

As a result, the ratio between the natural and anthropogenically trnsformed channels in the Strėva basin has changed (Table 3). In 1898, the small streams of the Strėva basin were already affected by human activity: in estates, gutters were dug,

Table 2. **Shifts of the length of water streams in the Strėva basin in the 20th century**
2 lentelė. **Strėvos upės baseino vandens tėkmių ilgių pokyčiai XX a.**

Year of publication of the map Žemėlapio išleidimo metai	Scale of the map Žemėlapio mastelis	Length of water streams, km² Vandens tėkmių ilgis km²	Increase of the length of water streams, % Vandens tėkmių ilgių padidėjimas %
1898*	1 : 21 000	310.0	0
1898	1 : 21 000	423.7	36.7
1930	1 : 25 000	542.7	75.0
1980	1 : 10 000	705.2	127.5

* Natural water streams.

Table 3. **Structural changes of water streams in the Strėva River basin in the 20th century**
3 lentelė. **Strėvos upės baseino vandens tėkmių struktūriniai pokyčiai XX a.**

Year of the publication of the map Žemėlapio išleidimo metai	Scale of the map Žemėlapio mastelis	Length of anthropogenically affected or newly formed water streams, km Antropogeniškai pakeistų ar naujai suformuotų vandens tėkmių ilgiai km	Length of anthropogenically affected or newly formed water streams, % Antropogeniškai pakeistų ar naujai suformuotų vandens tėkmių ilgiai %	Length of naturally surviving or newly formed water streams, km Natūraliai išlikusių ar naujai atsiradusių vandens tėkmių ilgiai km	Length of naturally surviving or newly formed water streams, % Natūraliai išlikusių ar naujai atsiradusių vandens tėkmių ilgiai %
1898 (Fig. 2)	1 : 21 000	113.7	26.8	310	73.2
1930 (Fig. 3)	1 : 25 000	235.2	43.3	307.6	56.7
1980 (Fig. 4)	1 : 10 000	486.8	69.0	218.4	31

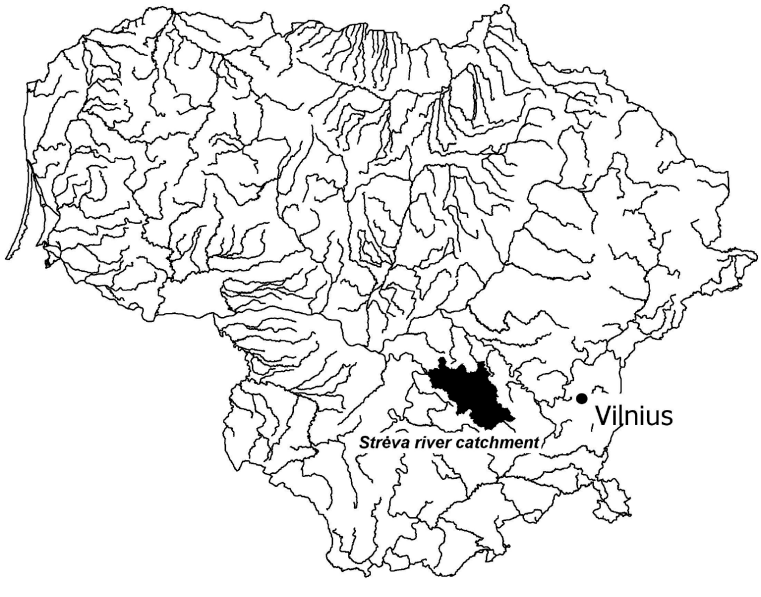

Fig. 1. Strėva river basin
1 pav. Strėvos upės baseinas

bogs meliorated and ponds formed. As a result, at the end of the 19th century, 26.8% of water streams were transformed or newly formed. Even greater changes of the hydrographic network were recorded in the map of 1930 at a scale 1 : 25 000. They were entailed by dispersion of individual homesteads over a large territory. The areas of waterlogged lands and bogs reduced. Road building also produced a great impact. The water streams increased by 43.3%. The most marked transformations of the hydrographic network of the Strėva basin occurred in the time span from 1955 to 1990. Not only the number of new streams increased, but also the length of natural channels reduced; in 1980, the natural streams accounted only for 31% of the total number of streams. In 1990, the percentage of natural streams in the Strėva basin was even smaller than in 1980. This was predetermined by intensive melioration which took place before 1990.

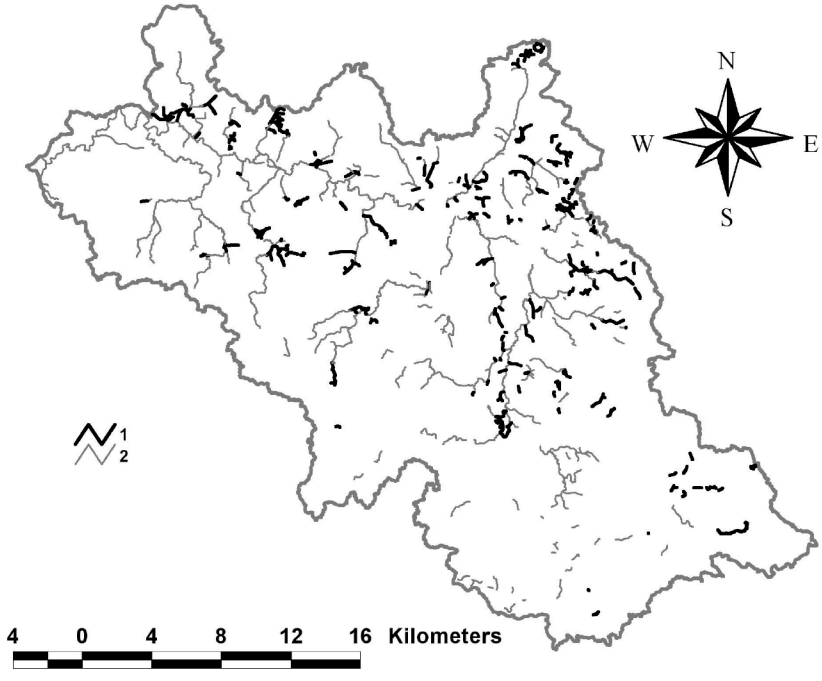

Fig. 2. Structural changes of water streams in the Strėva River basin in the beginning of the 19th century: *1* – antropogenicaly transformed water streams, *2* – natural water streams

2 pav. Strėvos upės baseino vandens tėkmių struktūriniai pokyčiai XIX a. pradžioje: *1* – antropogeniškai pakeistos vandens tėkmės, *2* – natūralios vandens tėkmės

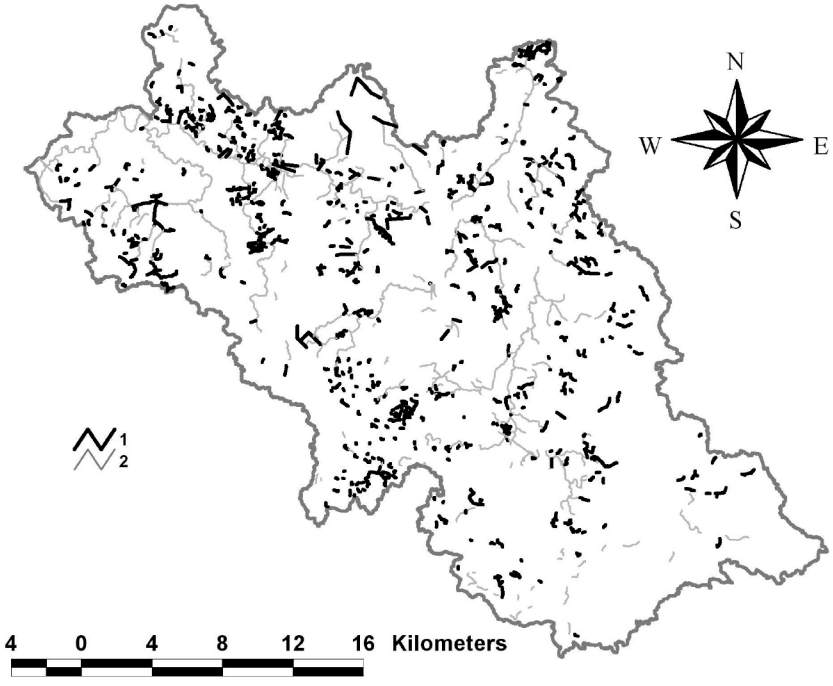

Fig. 3. Structural changes of water streams in the Strėva River basin in the middle of the 20th century: *1* – antropogenicaly transformed water streams, *2* – natural water streams

3 pav. Strėvos upės baseino vandens tėkmių struktūriniai pokyčiai XX a. viduryje: *1* – antropogeniškai pakeistos vandens tėkmės, *2* – natūralios vandens tėkmės

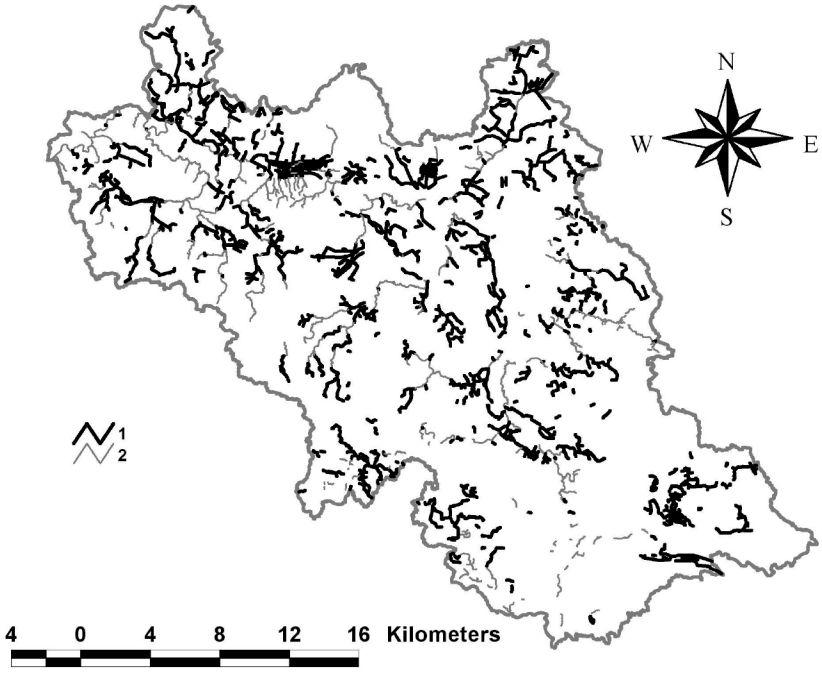

Fig. 4. Structural changes of water streams in the Strėva River basin in the end of the 20th century: *1* – antropogenicaly transformed water streams, *2* – natural water streams

4 pav. Strėvos upės baseino vandens tėkmių struktūriniai pokyčiai XX a. pabaigoje: *1* – antropogeniškai pakeistos vandens tėkmės *2* – natūralios vandens tėkmės

CONCLUSIONS

1. In the 20th century, the Strėva River basin area reduced by 0.7%. This change did not exert a decisive influence on the change of the hydrographic network of the basin.

2. The transformation of the hydrographic network of the Strėva basin was predetermined by the shifts of water streams. Between 1898 and 1980, the total length of water streams increased by 127.5%.

3. The structure of water streams in the Strėva basin cardinally changed in the time span 1955–1990 which was marked by intensive melioration and building of hydrotechnical constructions. Until 1980, only 31% of natural streams had survived in the Strėva basin.

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STRĖVOS BASEINO HIDROGRAFINIAI POKYČIAI XX AMŽIUJE. PIRMA DALIS. VANDENS TĖKMĖS

S a n t r a u k a

Straipsnyje nagrinėjami Strėvos baseino hidrografiniai pokyčiai, vykę nuo XIX a. pabaigos iki XX a. 9-ojo dešimtmečio pradžios. Straipsnio tikslas – atskleisti žmogaus ūkinės veiklos poveikį hidrografiniam tinklui. Tam tikslui buvo suformuluoti šie uždaviniai: 1) baseino ploto kaitos nustatymas, 2.) vandens tėkmių ilgių kaitos nustatymas, 3) vandens tėkmių struktūriniai pokyčiai. Pagrindinė tyrimų medžiaga yra stambaus mastelio topografiniai žemėlapiai, sudaryti XIX a. pabaigoje, XX a. pradžioje ir XX a. pabaigoje. Tyrimai atlikti GIS (geografinės informacinės sistemos) metodais naudojantis ESRI kompanijos *ArcView 3.2a* ir *ArcGis 9,1* programine įranga. Realizavus iškeltus uždavinius buvo nustatytas žmogaus ūkinės veiklos poveikis Strėvos baseino hidrografiniam tinklui.

1. Strėvos upės baseino plotas XX a. sumažėjo 0,7%, bet tai neturėjo lemiamos įtakos baseino hidrografinio tinklo kaitai.

2. Strėvos baseino hidrografinio tinklo transformacijas lėmė vandens tėkmių ilgių kaita. Nuo 1898 iki 1980 metų bendras vandentėkmių ilgis padidėjo 127,5%.

3. Vandens tėkmių struktūra Strėvos baseine iš esmės pasikeitė 1955–1990 metais. Šiuo laikotarpiu vyko intensyvi melioracija ir hidrotechninių įrenginių statyba. Strėvos baseine iki 1980 m. natūralių vandens tėkmių liko tik 31%.