ACCURACY OF DETERMINATION OF THE RUNNING OF THE SHORE LINE ON ORTHOPHOTOMAP

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Abstract

The ways of determining the course of the coastline of natural watercourses are regulated by the Water Law Act. Pursuant to the Act, lands covered with inland waters flowing within the coastline are owned by the State Treasury. The coastline of natural watercourses is the boundary of the property defining the extent of property rights, which is why its correct indication is so important. The accuracy of measuring situational details that identify the course of the shoreline in the field is regulated by the Regulation on technical standards. This accuracy varies depending on the method for determining the course of the shoreline. As part of this work, the course of the coastline of natural watercourses with regulated and unregulated channels flowing through the Świętokrzyskie and Małopolskie Voivodeships in Poland was analyzed to investigate whether the cartometric measurement of the shoreline performed on an orthophotomap can replace the measurement of situational details in the field.

Key words: shore line, bank edge, land registry

Introduction

The ways of determining the course of the coastline of natural watercourses are regulated by the Water Law Act (ACT, 2017). Pursuant to the Act, lands covered with inland waters flowing within the coastline are owned by the State Treasury. The coastline of natural watercourses is the boundary of the property defining the extent of property rights, which is why its correct indication is so important. Nevertheless, in practice, the implementation of the procedure for determining the course of the shoreline faces numerous problems (KWARTNIK – PRUC, 2014).

The ways to determine the course of the shoreline are defined in art. 220 of the Water Law Act. For watercourses with regulated channels, the shoreline runs along a line connecting the outer edges of the building's banks. For watercourses with unregulated channels, the shoreline may run: a clear edge of the bank, a line of permanent grass growth or an average water level from at least the last 10 years.

The accuracy of measuring situational details that identify the course of the shoreline in the field is regulated by the Regulation on technical standards (KOWALSKI, 2012). Pursuant to the regulation (REGULATION, 2011), the channels of regulated flows are included in the the first group of accuracy of the situational details. The accuracy of their measurement is 0.10 m in relation to the nearest points of the geodetic control network. The measurement accuracy of the shoreline of watercourses with unregulated channels varies depending on the method of determining them. According to the Regulation (REGULATION, 2011), the measurement accuracy of the shoreline of the watercourses, where the clear edge of the shore is considered to be the upper edge of the slope is 0.30 m (as the situational details of the second group of accuracy). The boundary of permanent grass growth is the situational detail of third group, whose measurement accuracy is 0.50 m compared to the nearest points of the geodetic control network.

Along the rivers with unregulated channels, difficult terrain conditions often hinder field work, therefore, as part of this work, the accuracy of defining the shoreline on the orthophotomap was analyzed to determine if a cartometric measurement performed on an orthophotomap can replace field measurement.

Determining the course of the boundaries on the orthophotomap was allowed in § 37.2 of the Regulation on the Lands and Buildings Registry (REGULATION, 2001).

The use of methods the determining the shoreline using image processing techniques has already been studied (MCBETH, 1956, DOLAN et al., 1980, ANDERS, BYRNES, 1991, FISHER, OVERTON, 1994). Recently these methods are becoming more and more popular in the world (BOAK, TURNER, 2005, BOUCHAHMA, YAN, 2012).

Subject of research

The subject of the research were natural watercourses with regulated and unregulated channels, so that the analysis would cover all methods of determining the course of the shoreline defined in the Water Law Act. The research was carried out in Poland in the Świętokrzyskie and Małopolskie voivodships. The analyzed watercourse on the regulated riverbed was the Vistula river flowing through the city of Cracow located in Małopolskie voivodeship, whereas the watercourse of the unregulated riverbank subjected to analysis was the Drzewiczka river flowing through the Końskie county in Świętokrzyskie province (Fig. 1).

Fig. 1. Object of research.
Source: Own study.

As part of the work, the course of the Vistula river shoreline was analyzed at a length of 1.5 km by the shore on the regulated channel (Fig.2). The shoreline of the Drzewiczka river runs through fragments with a clear edge of the shore, which can be clearly identified in the area as the upper edge of the slope and a line of permanent grass growth (Fig. 2).

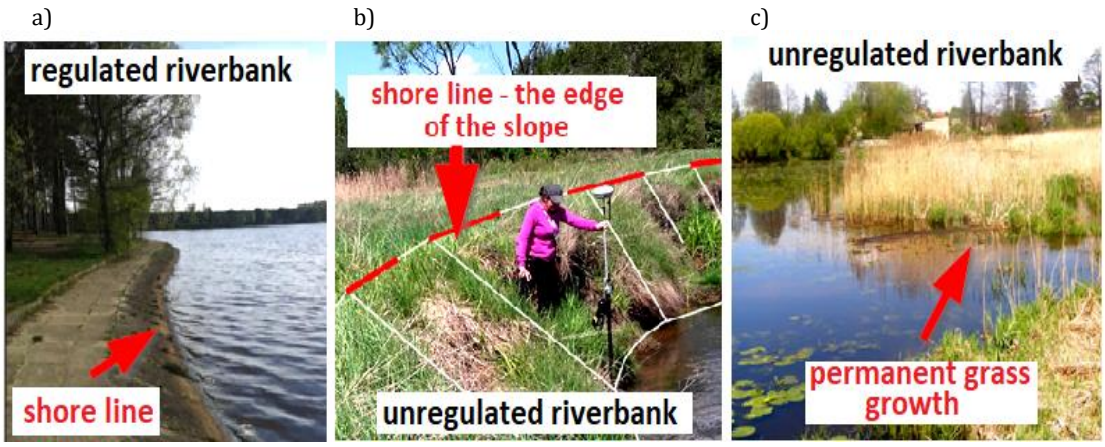

Fig. 2. Course of the shoreline in the area (a) regulated riverbank (b) the edge of the slope (c) unregulated riverbank.
Source: Own study.

Research methodology

To determine the accuracy with which one can determine the course of the river's shoreline on the orthophotomap, spatial analyzes of GIS were carried out using Esri's commercial ArcGIS software and the Canny algorithm (MĄCZYŃSKA, 2017) which is used to detect edges on the image made in the Matlab program.

a) Comparison of the course of the shoreline on the orthophotomap and cadastral map

In the first stage of the work, the course of the water border revealed in the Land and Buildings Registry documentation was compared with a shoreline visible on the orthophotomap. Analyzing the visual course of the shoreline with a small magnification of the map drawing for the Vistula River, no major differences were noticed, whereas for the Drzewiczka river numerous discrepancies were found (Fig.3).

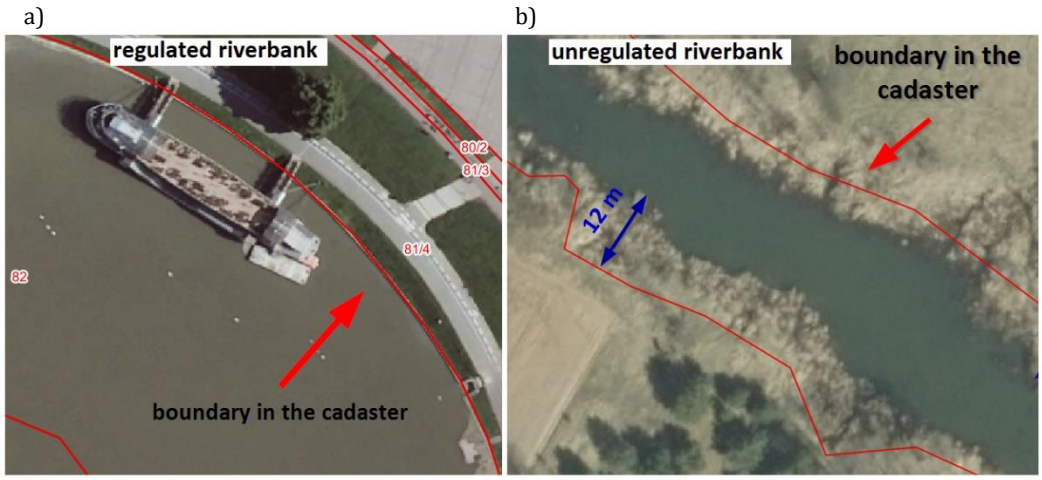

Fig. 3. Comparison of the course of the shoreline on an orthophotomap and a cadastral map (a) regulated riverbank (b) unregulated riverbank.
Source: Own study.

b) Cartometric measurement of the shore line on the orthophotomap and cadastral map

In the next stage of the work, a cartometric measurement of the coastline of watercourses on the orthophotomap was made. In order to eliminate the subjective factor during the vectorization, the Canny algorithm which is used for automatic edge detection, was used. Edge detection was carried out in the Matlab program (Figure 4). Then the cadastral map raster was also vectorized.

a)

b)

Fig. 4. Determination of the course of the shoreline using the Canny detection algorithm: (a) regulated riverbank (b) unregulated riverbank.
Source: Own study.

c) Calculation of the percentage compliance of the surface of land covered with water on an orthophotomap and a cadastral map

In order to determine to what extent the surface of the land under the waters on the orthophotomap within the boundaries determined using the Canny algorithm coincides with the surface determined on the basis of the vector of the cadastral map using the ArcGIS program, the appropriate surface was determined. Then, using the spatial analysis of GIS, the product of intersecting surfaces was determined. In the next stage, the percentage share of the product of intersecting surfaces to the area determined on the basis of the cadastral map from the formula (1) was calculated:

$$\%_A = \frac{A_{intersect}}{A_{cadaster}} * 100\% \quad (1)$$

where:

$\%_A$ – compliance of the land surface under the waters on the orthophotomap and cadastral map,
$A_{intersect}$ - field of the product of intersecting surfaces,
$A_{cadaster}$ – field of the land occupied under the waters on the cadastral map.

d) Execution of spatial buffers for the border of a watercourse shown on an orthophotomap and a cadastral map

In order to determine the conformity of the actual course of the shoreline determined on the basis of an orthophotomap with the boundary of the watercourse disclosed in the Land and Building Registry documentation, spatial buffers were established. The diameter of the buffer for the border indicated in the

cadastre was adopted at the level of 0.30 m according to with the required accuracy of the border points disclosed in the Land and Buildings Registry (§ 82. 3 of the Regulation on Land and Building Registry). Diameters for particular methods of determining the course of the shoreline were calculated according to the formula (2):

$$D_B = \sqrt{D_{Pom}^2 + D_{Orto}^2} \quad (2)$$

where:

D_{Pom} – measurement accuracy of the terrain detail,
D_{Orto} – the size of the field pixel on the orthophotomap,
D_B – calculated diameter of the spatial buffer.

The results of the calculated buffers are shown in Table 1.

Table 1. Calculated diameter of the buffer for particular methods of determining the course of the shoreline.

The method of determining the course of the shoreline The Water Law Act	Type of the area detail	Accuracy of the terrain detail measurement D_{Pom} [m]	The size of the orthophotomap field pixel D_{Orto} [m]	Calculated diameter of the spatial buffer D_B [m] according to the formula (2)
Regulated channel	I group	0,10	0,25	**0,27**
Unregulated channel/ clear edge of the bank (escarpment)	II group	0,30	0,25	**0,39**
Unregulated shore / line permanent of grass growth	III group	0,50	0,25	**0,56**

Source: Own study.

Spatial buffers were made on the basis of the calculated diameters. Examples of buffers are presented in Figure 5.

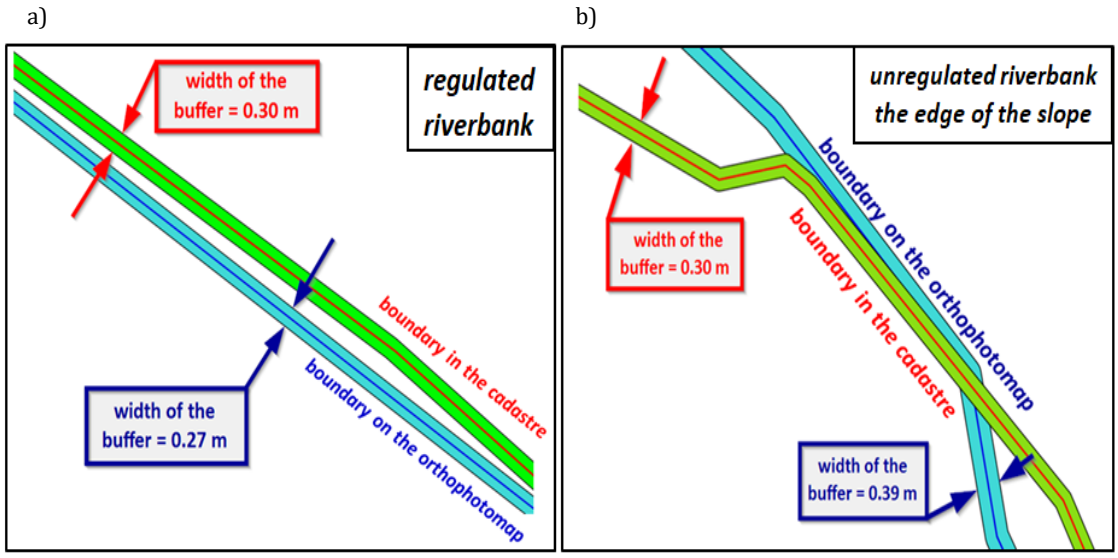

Fig. 5. Examples of spatial buffers (a) regulated riverbank (b) unregulated riverbank.
Source: Own study.

e) Determining the product of buffer boundaries of the watercourse and determining the estimated accuracy

In the next stage of work using the ArcGIS program, the products of the intersecting surfaces of the spatial buffers formed were determined (Fig. 6).

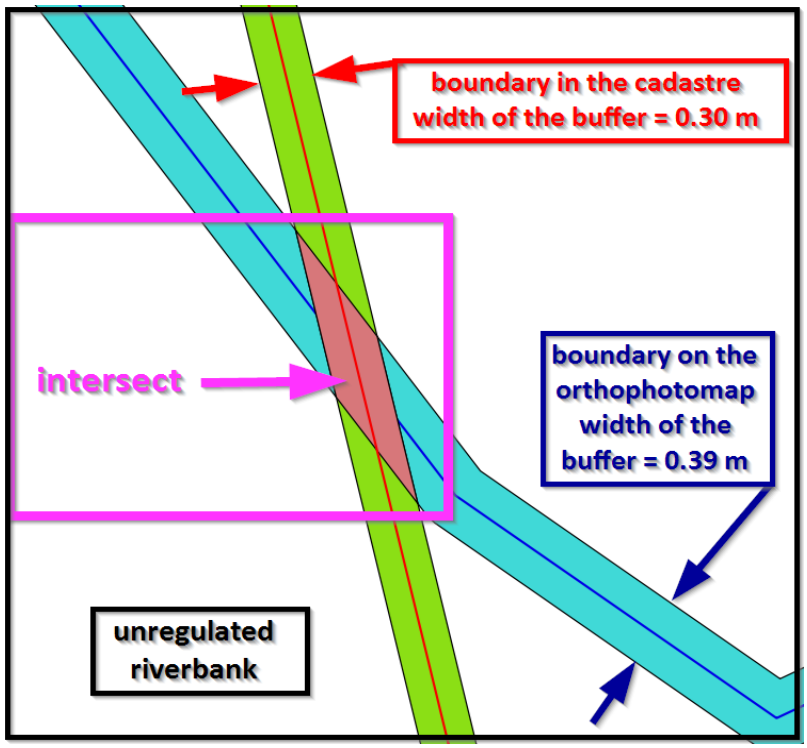

Fig. 6. Product determination of intersecting surfaces of formed spatial buffers.
Source: Own study.

Next, in order to determine the accuracy with which the course of the shoreline on the orthophotomap can be determined, the ratio of the product of intersecting surfaces to the area in the Land and Buildings Registry was calculated according to the formula (3):

$$\%_C = \frac{P_I}{P_{EGIB}} * 100\% \quad (3)$$

where:

$\%_C$ – estimated percentage of compliance,
P_I – field of the product of intersecting surfaces,
P_{EGIB} – area of land occupied under the waters on the cadastral map.

Results

Based on the analyzes made according to the formula (1), the percentage correspondence of the surface of the land under the waters in the edges of the edges defined by the Canny algorithm on the orthophotomap to the area determined according to the record map was estimated. The results were obtained: for regulated banks - 99%, for unregulated banks - 75% (Fig. 7).

In the next stage, the formula (3) marks the accuracy of determining the course of the shoreline on the orthophotomap, taking into account the ways of determining the boundary of the watercourse. Estimated accuracy for watercourses the regulated channel was 27%, while for unregulated banks much less (Fig.8).

Conclusions

On the basis of the performed analyzes, it was clearly stated that for the Drzewiczka river, the course of the shoreline cannot be clearly determined on the basis of an orthophotomap. Accuracy of the watercourse limit for unregulated trays was below 10%. For a watercourse with a regulated channel (analyzed Vistula River) the accuracy is much higher (27%), but definitely too small to be able to use only the orthophotomap while determining the course of the shoreline.

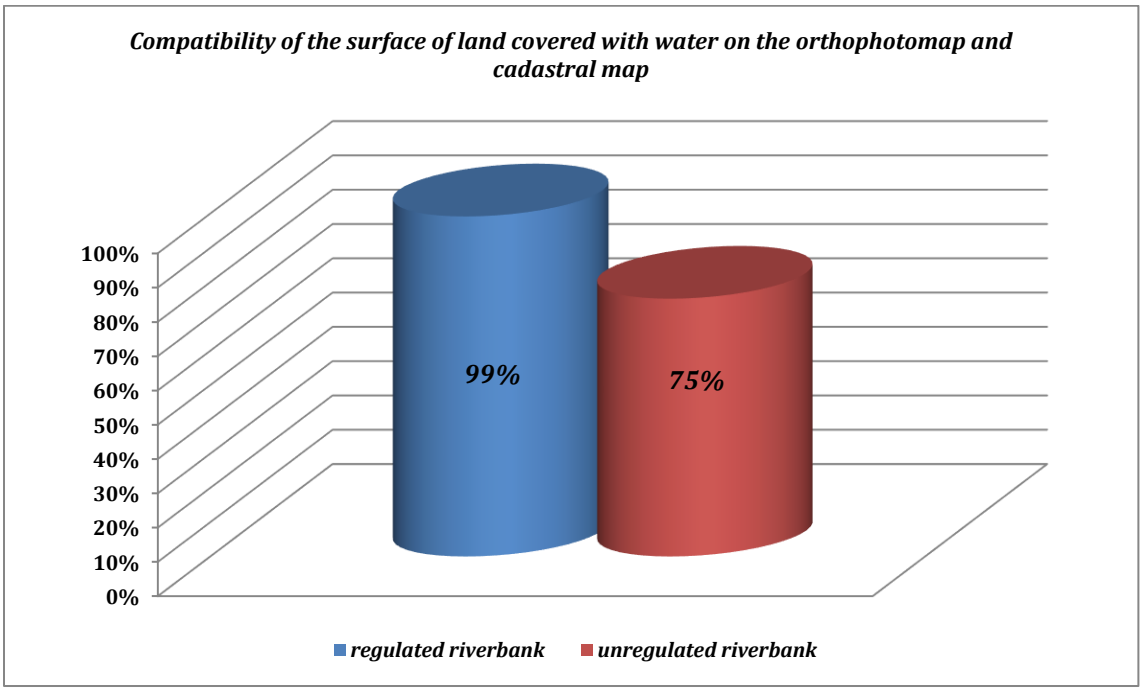

Fig. 7. Compatibility of the surface of land covered with water on the orthophotomap and cadastral map.
Source: Own study.

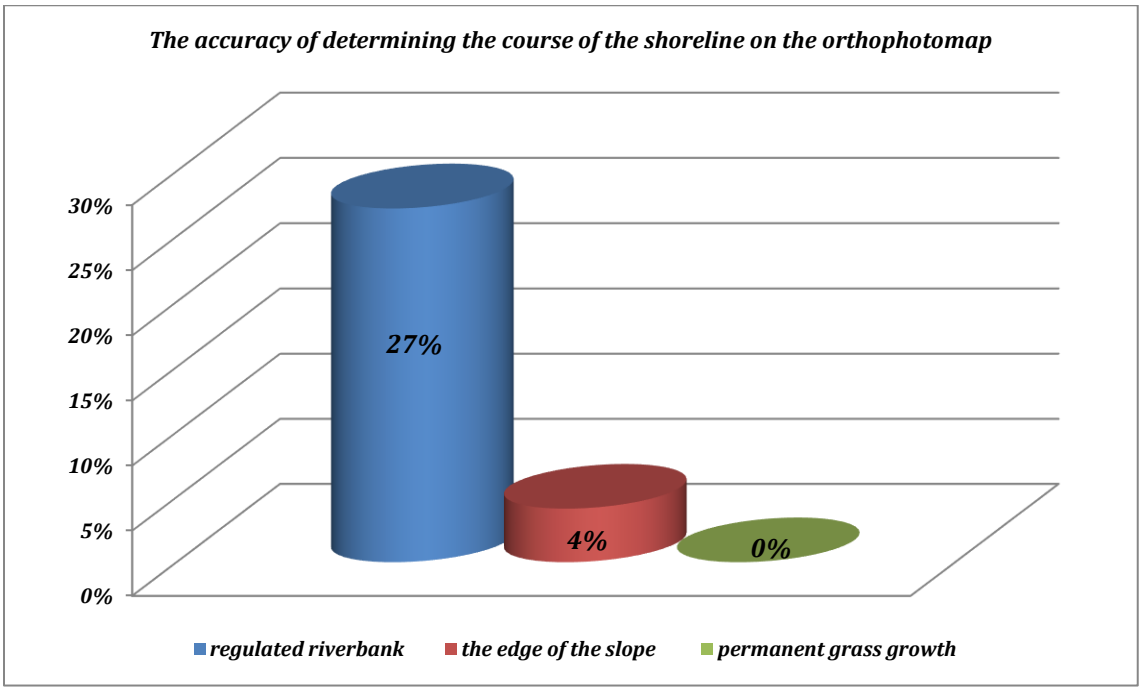

Fig. 8. Accuracy of determining the course of the shoreline on the orthophotomap.
Source: Own study.

A higher percentage of data compliance obtained for regulated channels is caused by the fact that on the orthophotomap it is easier to identify the edge of the buildings edge than the limits of permanent grass growth or the upper edge of the escarpment.

The research has shown that with the help of an orthophotomap, the limit of intersection of the water table with the adjacent soil can be determined (range of the water table). However, this border does not always coincide with the actual shoreline in the area.

Based on the analyzes made, it was noticed that although the course of the shoreline cannot be clearly determined on the basis of the orthophotomap, it can be used to determine the places where, due to the inaccurate data in the Land and Building Registry, steps should be taken to determine the runoff.

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