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Review

Comparison of an analogue and computer supported line generalisation following the concrete example of the Sitnica River system

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Cartography is a science which most presents changes over ever increasing modern computer technologies. A computer supported generalisation of water flow sets its goal on the effects and achievements of modern cartography science, also showing the results and the levels of basic manual generalisation, comparing them with the effects of a digital computer supported generalisation. Every newly made map which represents the territory given sets the goal of comparing the data, showing the newly created ones in the best and most efficient way. As far as the very river flow is concerned, it is the very degree of generalisation that matters as it affects the quality of the map itself. Generalisation is only one of the methods which can be used for that purpose as the results can be applied to different forms of digital maps. Following the concrete example of the Sitnica River system, using the GeoMedia 6.1 software, by means of GeoMedia 6.1 professional programme, the whole Sitnica River system is presented through vectors on the grounds of topographic maps in proportion of 1:25000, 1:50000, 1:300000. Analyzing the apperance of drainage system of Sitnica, which is shown in both analog and digital, we notice that digital image presents all small meanders as straight lines, in both scales 1:100000 and 1:300000. They are all presented with lines of same thickness and it is impossible to distinguish the importance of watercourse, which river is rich in water or differentiate tributaries from main stream. We will have the results of an analogue and a digital generalisation compared so that only the map which has been properly generalised can be considered to be a map in its real sense.

Key words: Analogue generalisation, computer supported generalisation, river network, geographical information system (GIS), Sitnica River, technology, GeoMedia 6.1.

INTRODUCTION

Functions and rules of presenting waterflow generalisation using an analogue generalisation

Land waters include water flows, lakes, swamps etc. All the objects given belong to physical and geographical elements of every map contents. These are water flows that are by all means most important elements on maps, presented in a waterway hypsometric line- a water line. The water flows which are presented on particular map surfaces joined by river systems represent the river network of a particular territory. Because of their value, they play an important role on maps giving an even more natural look to the landscape being presented on a map. This way, the geographical validity of the contents and the plasticity of the topography are increased, as the waters shown in the map are an inseparable part of the

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unit presented on the map. Part of topography plastically shown as a mutually developing unit creates the basis of a hypsometric line network, the network of a line of water lines and water division lines, which makes possible for the complete interpretation and genesis of topographic forms. All the factors contribute to a better orientation of the position of objects themselves, map contents, and the very aesthetics of maps are also improved when the generalisation process is properly performed. Water flow presentation on a map is performed through generalisation process graphically expressing a river system and a river network, determined along with the length and width of the water flow. This is an analogue approach. A cartographic presentation of water flow must contain two basic data which are considered to be the primary ones (Douglas and Peucker, 1973), and these are the length and width of a water flow. Thereby, a cartographic presentation of water flows undergoes the process of generalisation, which is essential for regular map making (Saliscev, 1947). Generalisation leaves space to regular expressions on maps, which has an effect upon river network development, including the development of water flow length and width. The most important factor in creating a good cartographic generalisation is by all means objective reality which itself is based upon the objective discovery of the environment. A map is a comparatively reduced generalized graphic image presented within a determined space. Therefore, generalisation is one of the most important methods in cartography (Sretenovic, 1961). Generalisation is essentially important, as the geographical unit of 1 km^2 is shown as 1 mm^2 of map area P^2=1:1000000. The form of a graphic sign showing an object or a phenomenon is radically different on a map whose diameter does not exceed 0.4 mm, so that sizes of a smaller scale must be expressed through the point of the same diameter. As shown, they will collide on the map if two objects are shown by the diameter of 0.4 mm especially on the maps of the following proportion (Table 1).

With regular generalisation, there are three basic elements that have to be known:

1. Generalisation elements.
2. Features of map objects, phenomena and their mutual relations.
3. A graphic presentation method.

The size of the very generalisation concerning the objects and phenomena of map contents is shown through the degree of generalisation which shows the size presented in relation to the natural one in proportion 1.00 or 100%. The objects and the phenomena in question are in geo space permanently on a dialectical move, so that the sizes and their mutual relations are at a constant phase of change. Under these circumstances, it is impossible to have constant values of generalisation degree; therefore, the formula of the potential defining of this relation is expressed as (Robinson, 1995)

Table 1. Presentation of the object size 0.4 mm on the maps of certain proportion.

Proportion	R distance in nature L (m)
1:25000	10
1:50000	20
1:100000	40
1:500000	200
1:1000000	400
1:5000000	2000

$$G \approx D \times C \qquad (1)$$

G= Generalisation degree.
D= Dialectic spatial movement.
C= Map elements constant.

With cartographic processing, it is the method of natural characteristics and phenomena comparison that is adopted compared with the values of their expression indications on the very maps. With a cartographic analysis, it is essential to show along with the proper indications, the basic features of map elements natural development (Wang and Muller, 1993).

Flow length is characterised by different meandering, primarily composed of hypsometrically meandering curves, valley curves and hydrographical meandering – a river flow swerving in a valley, most frequently as meanders. Every river meandering is constituted by river valley curves (hypsometric meandering). Flow meandering is based upon different shapes when it comes to the map being generalised. There is an entire set of meanders spotted in flows depending upon the physical traits of the very river. Complex meanders have a successively general direction just as ever more general meandering, which culminates with the central lines which represent fewer grafted curves (Figure 1).

Those factors that operate with typical generalisation are called typical factors. There are factors which will conditionally determine the shape and size of rivers on maps and since determining the very generalisation structure, they seem inevitable.

1. Flow size - length and width;
2. Flow development characteristics, the shape and number of flow meandering curves.

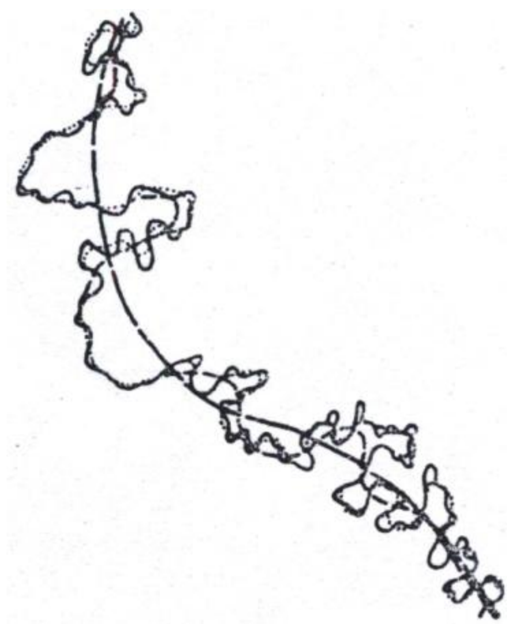
Without knowing physical and geographic characteristics of the river, it is impossible to embark on the process of generalisation (Салишчев, 1976).

A general overview of the data from Table 2 and the degree line of the very generalisation leads to the following laws.

1. The more developed the flow, the higher the degree of the generalisation appearing in proper map proportion.

Table 2. The degree of generalization about the length of the river flows on the maps, which are represented in different proportions, with special reference to the River Sitnica.

Rivers	Development of the flow		Degree of the generalization		
	Coefficient	%	1:500000	1:2500000	1:5000000
Danube	1.64	39.2	0.997	0.96	0.94
Sava	1.72	41.8	0.93	0.84	0.80
V.Morava	2.10	52.2	0.84	0.65	0.59
Tisa	1.34	25.6	0.98	0.92	0.90
Ibar	1.86	46.02	0.75	0.60	0.53
Sitnica	2.00	49.75	0.80	0.71	0.61



1:50000

Figure 1. The actual and the general directions of the river flow of the certain size of the curve meandering for part of the river. On the map 1:50000 (VGI) curve meandering for the river Kolubara is given.

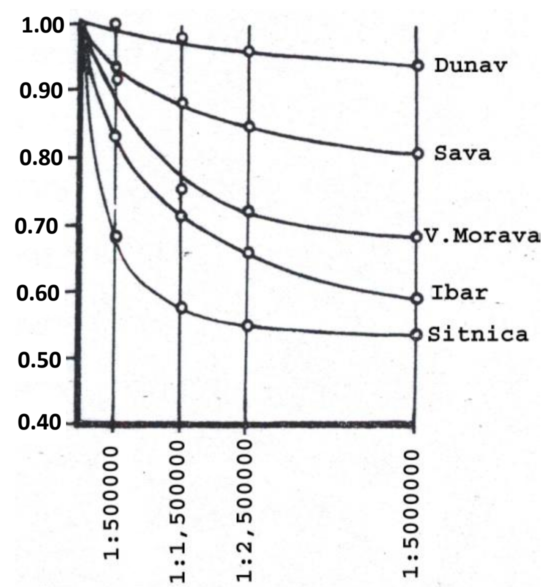


Figure 2. The degree of generalization curves of length flows of major rivers in Serbia compared to rivers in Kosovo and Metohia on the smaller proportion maps in the range 1:50,000 to 1:5,000,000. (TK 500 VGI, TK 50 1:50,000-1:5,000,000. (TK 500 ВГИ, TK 50 VGI, cross sections of the rivers Danube, Sava, Velika Morava, Ibar, Sitnica 1:4,000).

This is a general regularity. On some maps, when applying heterogeneous or process generalisation, there is a slight deviation from a general regularity as while eliminating curves, one must account for accentuating flow development characteristics, including the size and shape of the curves on maps. With flow hydrographical meandering, the very shapes of the meanders should be observed, as with more visible hypsometric differences, the development of the curves is even more perceptible (Figure 2).

Apart from the varying development (meandering) of the flow, it is a characteristic of development (meandering) that affects the whole flow image (size, shape, the number of curves). The development of the flow, with the change of meandering and different sizes, shapes and the total number of flow curves (Figure 3), presents a basic water flow shift which is river related.

The general regularity is such that, with a decreased proportion, a generalisation degree increases yet comparatively falls, which means that the biggest generalisation, that is water flow length reduction in bigger proportions when compared with smaller ones relatively decreases. As an absolute and a relative value, the maximum of generalisation value on smaller scale maps is accounted for. Thereby, in proportions 1:50000 to the proportion 1:500000 of the Velika Morava River, the proportion of 0.52 to 0.84 has on average decreased by 3/5. Yet with the map proportions of 1:2500000 and 1:50000000 the flow has decreased by only 0.04, while the generalisation degree has insignificantly risen from 0.52 to v 0.53. Conditioned by vsuch v conclusions, the

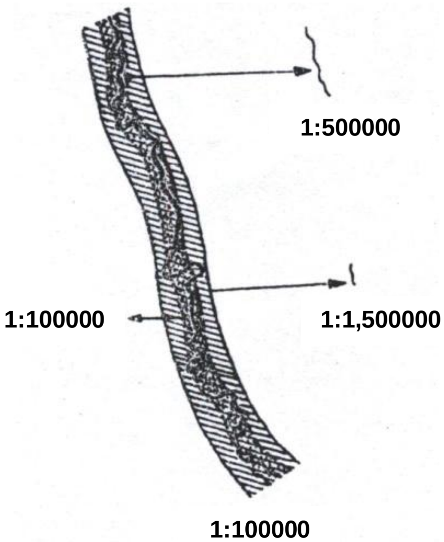


Figure 3. Some general regularities of the analog generalization of the flow in different proportions.

development quotient rapidly decreases in larger proportions; as in smaller ones, this happens gradually. If the map is of smaller proportion, the generalisation degree is higher. With generalisation process and smaller map proportions, the flow is shortened. All the curves can be predicted, especially with an increasing line width when more details will be eliminated. However, a comparatively larger flow deviation from the generalised course of meandering is allowed. These are only flows or some straight line flows which are not made shorter, keeping the previous direction, with an increased width. Meandering flows with many curves are affected by a higher generalisation degree. These have more striking details of their own development which are especially important with generalisation. Generalisation outposts transition from the straight part of meandering course, the neighbouring point between the lines, extreme curve meandering, the source, and the confluence. With flow generalisation, one must particularly aim at the outpost giving a clearer geometrical position, as they serve as a basis to the geometric correctness of placing the other parts and flow details. Every flow line is featured by a particular number of such outposts. The smaller their number is, the less likely it is that there will be some deviation from their natural development, as the line comes closer to a straight line (Beljin, 2001). Depending on the proportion, the function and the special purpose of the map, the characteristic meandering of the flow, including the depiction of line width on the map, one should strive for a meandering flow look that retains, in its basic features, natural flow development. One must elaborate on some meandering features which could not be taken into consideration if map proportion were solely to be taken as the grounds of the very generalisation. Small untypical curves with the diameter of 0.4 to 0.5 mm in map proportion are omitted while generalising. In order to express certain typical curves, which could not be expressed in a proportion given, we increase their width and the curve radius on the very map, in a way in which geographic correctness and validity are diminished. In the process, the closest proximity of generalised flow meandering line parts is within the scope of 0.2 to 2 mm, depending upon the generalisation degree- the smaller the degree the closer; the higher the degree the wider.

Water flows on maps of medium and smaller scaled maps are usually represented by a single line, as on such maps, the body's width is considerably increased. In order to express the direction of the flow and its natural magnification, the line gradually becomes thicker from the spring to the confluence, and as a general rule the mainstream line is thicker than the tributary line. These are the general principles of generalisation while creating maps of different proportions and purposes. During the generalisation of flow width on maps, it is essential that the quotients of width increase on the map should be known. There are general postulates on maps which need to be dealt with accordingly when the width quotient is in question.

1. The width of flow lines on a map along the river direction from the spring to the confluence, including the lines of a particular map flow, get a various increasing value if the river branches off.
2. Downstream the main flow, the increasing quotient decreases. This depends on the very flow width in relation to a map proportion as if the flow is naturally wider, the increasing quotient is lower. Near the confluence, the flow width is shown more realistically.

It is impossible to retain the same quotient value from the spring to the confluence as the river on the map would be too wide near the confluence. One such example is a school wall map of 1:1000000. The line width of the Sava River is thus 8 mm, if it would to become proportionally wider, retaining the same quotient value. Then the line width would be 9.2 mm or the width would be multiplied by 11.5. But the width on the wall map is 2.7 mm, or the river is approximately 3.5 times wider. In this case, generalisation has been deliberately reduced, as the flow has been visibly shown and at the same time the feature of natural expansion has been emphasised with the direction fulfilled, as the map burden is relatively small. The wider the river, the lower the increasing quotient of flow width, including the very difference among the quotients of the basin profiles given. Narrowing flows have a higher increasing quotient and a lower expanding quotient. The Velika Morava River is one such example which on a map of 1:500000 proportion (The Velika Morava plan 1:25000) and which has the narrowest part of 7.1 mm and the widest of 1.3 mm. The Danube near Belgrade is 1.1 mm and in Djerdap is 2.5 mm. This is an exception from the general rule of generalisation where

Table 3. Hydrological characteristics of the River Sitnica and analog generalization presented on the maps of certain proportions.

Proportion	Natural width of the River Sitnica		% flow length with a width in the proportion for the River Sitnica	
	0.1 mm	0.5 mm	0.1 mm	0.5 mm
1:50,000	47	41	2.5	12.5
1:20,0000	20	-	1	1
1:50,0000	-	-	1	1

the quotient always decreases downstream. The expanded flow line on the map downstream from the direction of the tributary confluence is narrower than the sum of the mainstream line between the upstream direction and the tributary. The natural expansion of the downstream flow is not always proportional to the width of the upstream and the tributary, nor is the quotient itself proportional but it decreases (McMaster, 1989).

The proportional flow expansion: $\frac{a+b}{a}$ (2)

The disproportional flow expansion: $\frac{c}{a}$ (3)

The disproportion of natural expansion: $\frac{c}{a+b}$ (4)

a) Confluence tributary upstream.
b) River near confluence.
c) Confluence tributary downstream.

The most regular formula determining an average flow width when it comes to a river which should be placed on smaller proportion maps is:

$$\frac{F}{L} \quad (5)$$

F- Particular flow part area cover
L - Particular flow part length

The conclusion states that the expansion quotient downstream is lower than the upstream expansion quotient, so that the downstream width is presented more realistically. This has an effect on the map as a natural quality of downstream part expansion from the tributary confluence (Ljesevic and Zivkovic, 2001). With longer flows whose flow width gradually increases to the confluence where it is impossible to express the width of the flow by the thickness of the line, the increasing quotient becomes considerably increased. Also, it is necessary that the flow direction, including the value and the importance to other flows, should be emphasised by the thickness of the line (Table 3). The thickness of the line in a relatively smaller proportion is more disproportional. A natural flow expansion from the spring to the confluence can be put in per mille with the following formula (Peterca, 1974).

$$B \downarrow ‰ = \frac{Bu - Bi}{L} = \frac{\Delta B}{L} \quad (6)$$

ΔB - Flow width near spring and confluence.
L - Particular flow part width (Bertin, 1983).

A COMPUTER SUPPORTED GENERALISATION

The geographical information system (GIS) belongs to the group of information systems which is applicable to geographical data supported by the computer tools which serve for mapping an analysis of real system events in the very base. Computer supported cartography has gradually developed into digital cartography whose basic aim is the data processing and visualisation of space which has to be supported by computer technology and technique. Digital technology has emphasised map importance as a crucial information medium because it is most important that map users themselves understand the function of the very map. Particular cartographers have shared different opinions concerning the relationship between the GIS and cartography. For Kraak and Ormeling (1996), cartography is a subsystem of the GIS which only serves for data visualisation (Topfer and Pilliwizer, 1996). While in Taylor's (1991) opinion, modern cartographic visualisation presents the profound application of visual elaboration in real time, embracing digital cartography and computer graphics, GIS technology nowadays represents a modern technological environment for solving management problems in space. Geo information is a phenomenon directly or indirectly linked with a particular location on Earth, so in this way digital cartography becomes important. Digitally appearing information is a result of systematic data (collection, analysis, summary, ordering in a logical unit). Data types within the GIS can be spatial and non-spatial. Spatial data describe a particular position directly and indirectly, depending on the type of digital data. By placing maps and other spatial information in a digital format with later abstracting on the global network, users are allowed previously to show, find and update maps on-line. The GIS is used in every field which use maps as data. Today's GIS is composed of four interactive components: the input subsystem, which converts maps and other spatial data in a digital form; the storing and data recalling subsystem; the analysis subsystem; and the output subsystem for map, chart, and data base making. The analogue map used to be the only way of showing spatial data. The phenomenon of the GIS has improved the possibility of the organisation, storage and the management of spatial data which are now digitalised. Information technology development boosts the terms of organisation and management of spatial data, as well as the creation of geo information infrastructure, and spatial data infrastructure. Spatial data infrastructure should contain sources, data base and meta data, and a network of data and users in the end (Coleman and McLaughlin, 1997).

SOFTWARE GEOMEDIA 6.1 PROFFESIONAL IN USE OF COMPUTER SUPPORTED GENERALISATION FOLLOWING THE EXAMPLE OF THE SITNICA RIVER

Software GeoMedia 6.1 professional was manufactured by the corporation Intergraph, as an overview tool for analysing geo spatial data. This package offers a guarantee of geographic data from different sources, in different formats and with different projects with all these in the same environment. By using this software, complex queries with spatial and attributive data of different sources may be performed, inducing numerous bases with highly sophisticated data. Geo media has the possibility of printing these images on a single sheet of paper, and in such a way, it is possible to arrange maps in different proportions presenting them in different formats of printing paper. The concrete advantage is that GeoMedia 6.1 is capable of characterising and integrating vector and raster data (Harrie and Weibel, 2007).

The software is also capable of creating phase digitalisation and vector data with the very help of geometric transformation. The other tools are supported and generated into the very data base.

HYDROLOGICAL CHARACTERISTICS OF THE SITNICA RIVER

The Sitnica River (L=110 km, F=2.861 km^2) is the largest Ibar tributary, occupying the central place and is the largest river of Kosovo Polje. It runs through the bottom of the Kosovo valley, collecting the waters coming down from the edge taking them to the Ibar River. The Sitnica River network has been formed in an area of 2.861 km^2, taking 26% of the Kosovo and Metohija territory or taking 35% of the total Ibar flow area. The Sitnica waters only participate in the Ibar flow with 22.6%, which indicates a low value of the Sitnica River and its tributaries. Our experts, who deal with the hydrological exploration of rivers, show some disagreement on the Sitnica spring. It is believed that the Topila River and the north Nerodimka leg should be taken for the Sitnica River legs. Plana (1991) thinks that the spring leg should be viewed as the River Topila, and Labus (1974) thinks that the Sitnica emerges at the village of Robovac from two streams, Sazlija (its right tributary) and Stimljanka (its left tributary). However, it is the left tributary Stimljanka that should be viewed as the Sitnica spring. All the water flows leading to the village of Rabovac comprise the upper stream of the Sitnica River. These are small rivers of little water quantity and a slight fall. They are often affected by drought in the summer.

THE VECTOR DRAINAGE SYSTEM OF THE SITNICA

By means of GeoMedia 6.1 professional programme, the whole Sitnica River system is presented through vectors on the grounds of topographic maps in proportion of 1:25000, 1:50000, 1:300000. In Table 4 the data of an analogue and a computer supported generalisation are compared. The degree of the very generalisation indicates the advantages and flaws of both generalisations.

Computer assisted generalisation has certain similarities comparing analog and automatic generalisation such as: identity, general methods of generalisation, general principles of generalisation, and special principles of water course generalisation. The only defect which manifested is a presence of stratified database within ASCII code. Then all attributes change so that the software could detect them with a help of some general algorithm like colors, with ASCII code), for example: what is the main watercourse and on what base the lines (their sizes) can be presented, so that the map is properly generalised. Digital cartographic generalisation is very active and fast when it comes to data processing, but it is fully possible if the person who is doing it well is aware of all cartographic rules and regulations. Software GeoMedia 6.1 is used for digitizing of topographic map with scale 1:25000. All map papers with rivers which belong to Sitnica River system are treated in same way. Segmental line generalisation was done on maps, and processed later with OriPro 8.1 software (Mackaness and Edwards, 2002). The processing of all generalisation factors showed some deviations when it comes to generalisation algorithm. It follows that if the scale is large, error of generalisation will be smaller (Brunner, 1997). There are some deviations from Table 5 in Sitnica drainage system. Some marked rivers have certain generalisation errors that could make serious problems during the use of map (Guo and Ren, 2003). Therefore some comparative methods were used to show that the best solution is to use both analog and

Table 4. Map scales - 1:25000, 1:50000, 1:300000; A-analog, D-digital.

Name of River	Tributary to	Left Bank Tributary (L) Right Bank Tributary (R)	Rank	Length 1:50000 A (km)	Length 1:300000 D (km)	Length 1:50000 D (km)	Length 1:25000 D (km)	Generalisation algorithm errors for map scales 1:25000, 1:50000 and 1:300000
Drenica	Sitnica	L	I	41	42.9	39.2	42.1	
Nameless	Drenica	L	II	10	12.0	9.4	11.9	*
Klisura	"	L	II	6	6.2	5.7	5.8	
Nameless	"	L	II	5	5.4	5.3	6.1	*
Nameless	"	L	II	10	10.5	10.2	10.1	
Nameless	"	L	II	5	5.9	5.8	5.2	
Vrbica	"	L	II	25	24.7	24.6	24.1	*
Klisura	Vrbica	R	III	5	4.9	4.5	4.3	*
Nameless	"	R	III	5	5.4	5.2	5.1	
Ljug i Kršit	"	R	III	7	7.7	6.8	6.9	
Bog dalj	"	R	III	8	8.3	7.9	8.0	
Nameless	"	R	III	8	8.4	8.3	8.2	
Nameless	Drenica	R	II	2	2.5	2.4	2.3	
Nameless	"	R	II	5	5.6	5.4	5.2	
Nameless	"	R	II	10	10.8	10.6	10.5	
Nameless	"	R	II	6	7.4	7.2	6.9	
Gladni potok	"	L	II	10	10.8	9.7	9.5	*
Nameless	"	L	II	4	4.8	3.8	3.9	
Brosovačka	Sitnica	L	I	12	11.8	11.9	12.1	*
Nameless	Brosovačka	R	II	5	5.5	4.9	4.8	
Nameless	"	R	II	5	5.4	5.8	5.3	
Nameless	"	R	II	5	6.3	5.9	5.8	
Nameless	Sitnica	L	I	5	6.0	5.7	5.4	
Nameless	"	L	I	5	5.6	5.3	5.2	
Trstena	"	R	I	19	18.8	18.7	18.9	
Prodanče	"	R	I	9	9.2	9.1	9.0	
Nameless	Sitnica	R	I	9	10.0	9.5	9.2	
Smrekovnica	"	R	I	12	11.8	11.9	11.6	
Barska reka	"	R	I	15	16.7	16.6	16.4	
Vodovođa	"	L	I	10	11.8	10.9	10.7	
Grika	Vodovođa	L	II	8	8.8	8.6	8.4	
Magurska reka	Sitnica	L	I	9	9.4	9.4	9.1	
Žegovka	"	R	I	22	23.0	22.5	22.3	
Janjevka	"	R	I	16	17.8	16.9	16.5	
Oklapska	Janjevka	L	II	10	10.8	10.7	10.5	
Gračanka	Sitnica	R	I	17	17.8	16.6	16.9	
Labljanska	Gračanka	L	II	10	11.1	10.6	10.3	
Mramorska	"	R	II	5	5.5	5.9	5.2	
Androvačka	"	L	II	5	5.4	5.3	5.2	
Prištevka	Sitnica	R	I	20	20.8	19.8	19.9	
Nameless	Prištevka	L	II	5	5.8	5.6	5.4	
Smrdan	"	L	II	5	5.8	5.5	5.3	
Kojilovačka	"	L	II	2	2.7	1.7	1.8	
Crni potok	"	L	II	1	1.8	1.6	1.4	
Baljevička	"	R	II	2	3.5	3.4	2.9	
Šljivaštica	"	R	II	1	1.8	1.6	1.9	
Lab	Sitnica	R	I	57	58.5	58.2	59.1	*
Brnjička	Lab	L	II	15	16.1	15.9	15.8	
Nameless	"	L	II	5	5.6	5.2	4.9	

Table 4. Contd.

Kaluđerica	"	L	II	5	5.9	5.6	5.2	
Batlava	"	L	II	20	20.1	20.0	20.2	
Trnavica	Batlava	L	III	8	8.9	8.6	8.4	
Šarbanska	Trnavica	L	IV	6	6.7	6.8	6.4	
Perovića	"	R	IV	6	7.0	7.1	6.9	
Sponca	Batlava	L	III	4	4.9	4.8	4.4	
Balabanska	"	L	III	9	10.8	10.4	10.2	
Kolićka	Balabanska	L	IV	2	2.3	2.5	2.2	
Pljeništa	"	R	IV	4	5.5	4.7	4.6	
Kačikolska	"	L	IV	6	6.8	6.5	6.3	
Brainska	Batlava	L	III	6	6.9	6.7	6.2	
Koljatička	"	R	III	6	6.6	6.5	6.2	
Turučička	"	R	III	10	11.9	10.9	10.8	
Nosovci	Turučička	L	IV	3	3.8	3.6	3.4	
Rakinička	"	L	IV	4	4.7	4.5	4.4	
Dražnja	"	R	IV	2	2.9	2.7	2.4	
Dubnička	Lab	L	II	24	24.9	22.7	22.9	
Mirovački potok	Dubnička	L	III	3	3.9	3.5	3.3	
Lauška	"	R	III	3	4.0	3.6	3.4	
Pakaštička	Lab	R	II	4	4.9	4.8	4.8	*
Nazurski potok	"	R	II	6	7.0	6.5	6.3	
Bradaška	"	R	II	14	14.8	14.6	14.4	
Nameless	"	R	II	15	15.6	14.7	14.8	
Kačandolska	"	R	II	30	31.2	29.6	29.1	*
Lešnica	Kačandolska	L	III	7	7.8	7.7	7.6	
Bajgora	"	L	III	2	2.6	2.6	2.5	
Stara	"	R	III	4	4.9	4.7	4.4	
Kovačica	"	R	III	4	4.8	4.7	4.5	
Nameless	Lab	R	II	2	2.8	2.7	2.2	
Nameless	Lab	R	II	2	2.9	2.6	2.4	
Nameless	"	R	II	2	2.3	2.2	2.1	
Koskovik	"	R	II	6	6.8	6.6	6.5	
Đelbište	"	R	II	10	10.9	10.5	10.5	
Dubnica	Sitnica	R	I	13	13.4	13.3	12.8	
Crvena	"	R	I	15	16.9	15.5	15.9	*
Sudimljanska	"	R	I	10	10.8	10.7	10.6	
Repski potok	Lab	L	III	2	2.5	2.4	2.3	
Slatina	"	L	III	10	10.9	10.8	10.5	
Murgulska	"	R	III	17	17.8	17.6	17.5	
Jezerski potok	Murgulska	R	IV	3	3.9	3.8	3.4	
Žitinjska	"	R	IV	6	8.9	7.3	7.2	
Siljevička	Lab	R	III	10	12.7	11.6	11.2	

digital methods in correlation, because there is no software which can fully replace human decisioning during generalisation process (Table 6 and 7) (Szyperski and Murer, 2002).

CONCLUSION

Sitnica has well developed drainage system in its upper part of the watercourse. Labs basin, Sitnicas right-bank tributary, is especially well developed. Most of tributaries of higher ranks belong to Drenica and Lab. A drainage pattern of Sitnica River is of rectangular drainage pattern where tributaries make shape bends entering the mainstream at high angles. Sitnica is a right bank tributary of Ibar, which length is 110 km and basin size of 3040 km^2.

Analyzing the apperance of drainage system of Sitnica, which is shown in both analog and digital, we notice that

Table 5. Coefficient of watercourse development.

Name of river	River length, L (km)	Shortest distance, L_k (km)	Coefficient of watercourse development, L/L_k
Sitnica	110	59	1.86

Table 6. Coefficient of watercourse development at different map scales.

Name of River	Ratio of actual river length and its length after generalisation on map scale 1:500000	Ratio of actual river length and its length after generalisation on map scale 1:1000000	Ratio of actual river length and its length after generalisation on map scale 1:2000000	Coefficient of watercourse development
Sitnica	0.68	0.56	0.53	1.86

Table 7. Degree of watercourse generalisation (ratio of actual river length and its length after generalisation) presented with differences between different map scales.

Name of River	Difference of watercourse generalisation for scale 1:500000	Difference of watercourse generalisation between 1:500000 and 1:1000000	Difference of watercourse generalisation between 1:1000000 and 1:2000000	Difference of watercourse generalisation between 1:500000 and 1:2000000	Overall value of the Degree of watercourse generalisation
Sitnica	0.32	0.12	0.03	0.15	0.47

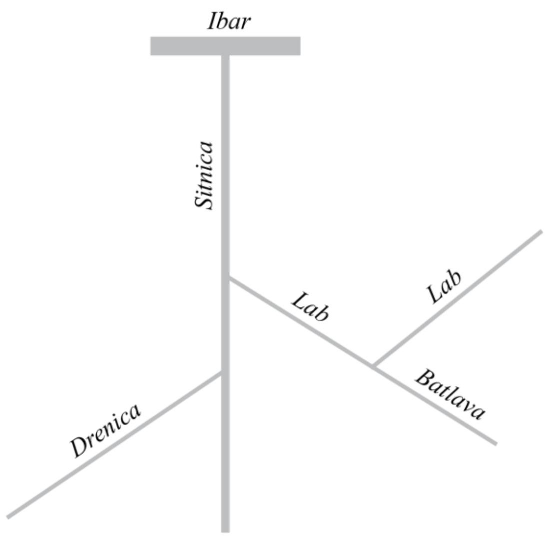


Figure 4. The Sitnica River system.

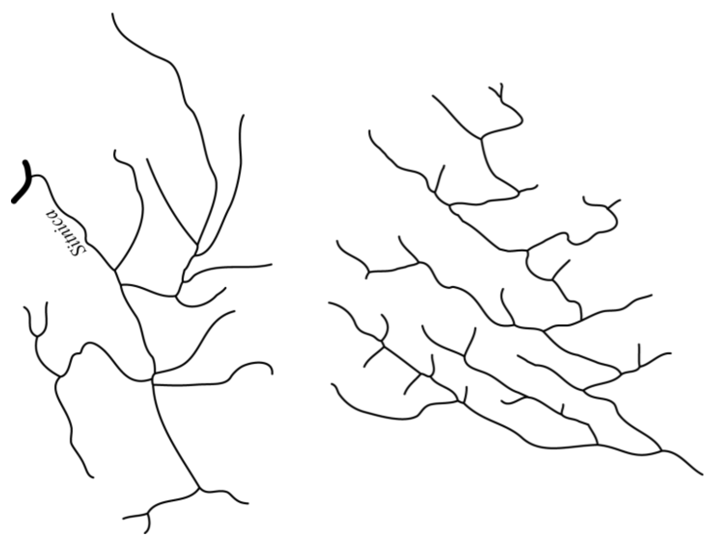


Figure 5. Sitnica network (dendroid type).

digital image presents all small meanders as straight lines (Petere, 2001), in both scales 1:100000 and 1:300000. They are all presented with lines of same thickness and it is impossible to distinguish the importance of watercourse, which river is rich in water or differentiate tributaries from main stream (Tomasevic, 1997).

The conclusion based on analyzing Figures 4 to 10 is that a length difference as a result of digital cartographic generalisation on maps with proportion 1:25000 and 1:50000 are between 0.027 and 0.035%. With a smaller map proportion (1:300000 and smaller) length difference of water course on generalised maps grows, resulting in length bigger than its real length.

In traditional map generalisation, decreasing of map proportiong is and will make a watercourse shorter because of simplification and smoothing of lines, and loss of certain amount of meanders. Based on the above we can conclude that automated map generalisation derived

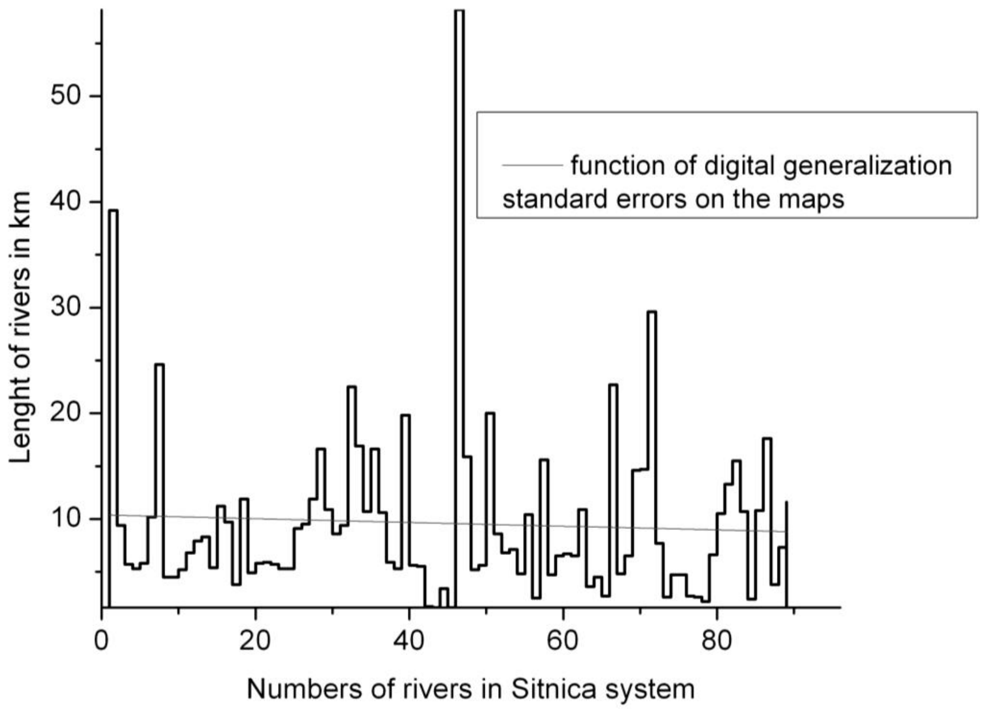


Figure 6. Standard errors on the same maps, on the example of Sitnica River system (analogue generalisation 1:50000).

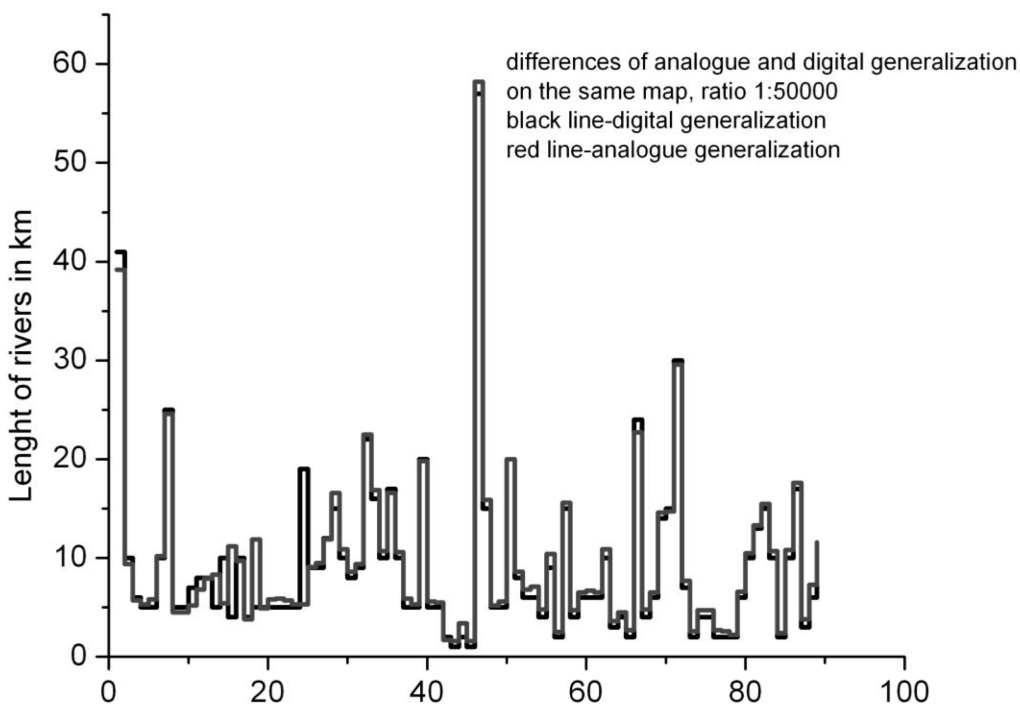


Figure 7. Differences of analogue and digital generalization in scale 1:50000, on the examples of Sitnica river system.

by software GeoMedia 6.1 can be used for large scale maps because the obtained values do not differ a lot and significantly speeds up the process of generalisation. With help of software GeoMedia Professional 6.1, we

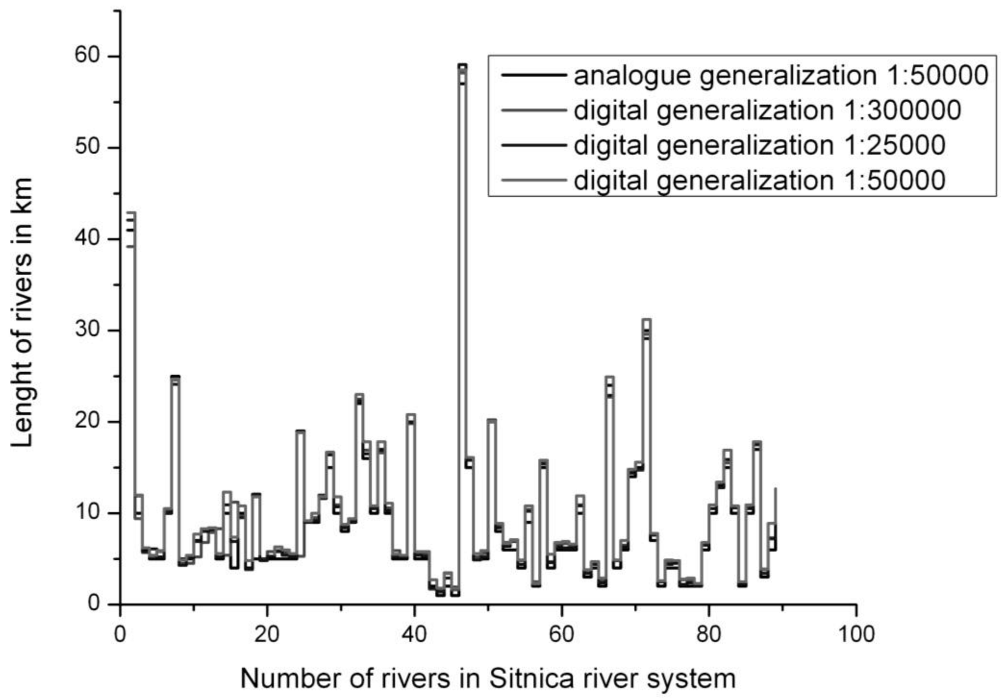


Figure 8. All four types of generalizations on the example of river systems Sitnica, scale of map (1:25000, 1:50000, 1:300000).

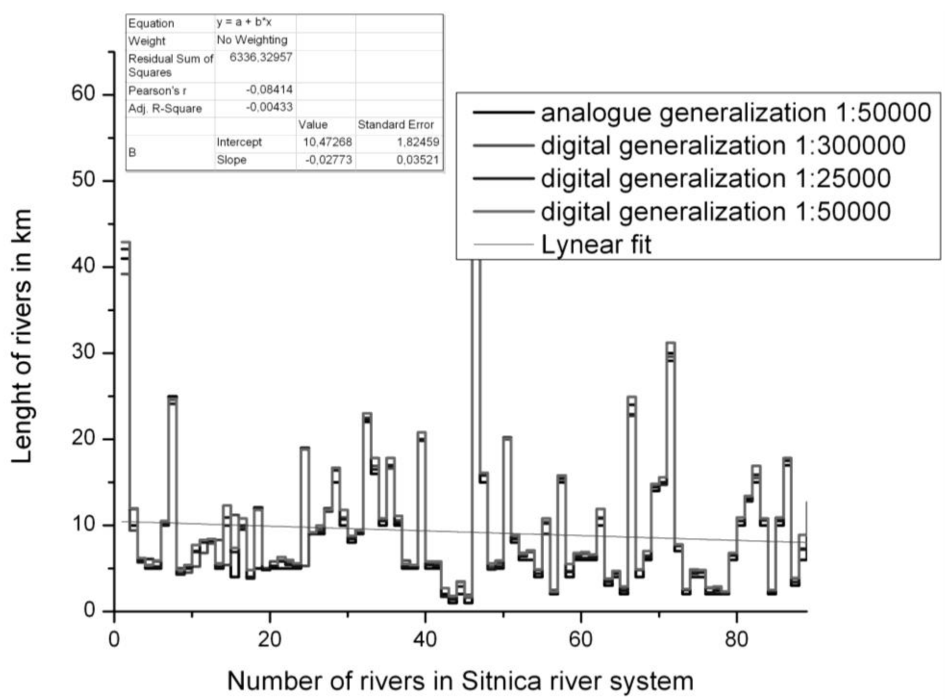


Figure 9. Standard error for three scale of generalization, on the examples of Sitnica river system.(1:25000, 1:50000, 1:300000).

compared two ways of generalization, analogue and automated or digital supported. (SÈbastien and Lorenza, 2010). The most common problems is defined with errors on the maps. We especially tried to cropped all data from analogue to digital maps, and digitalized all river networks from the maps.

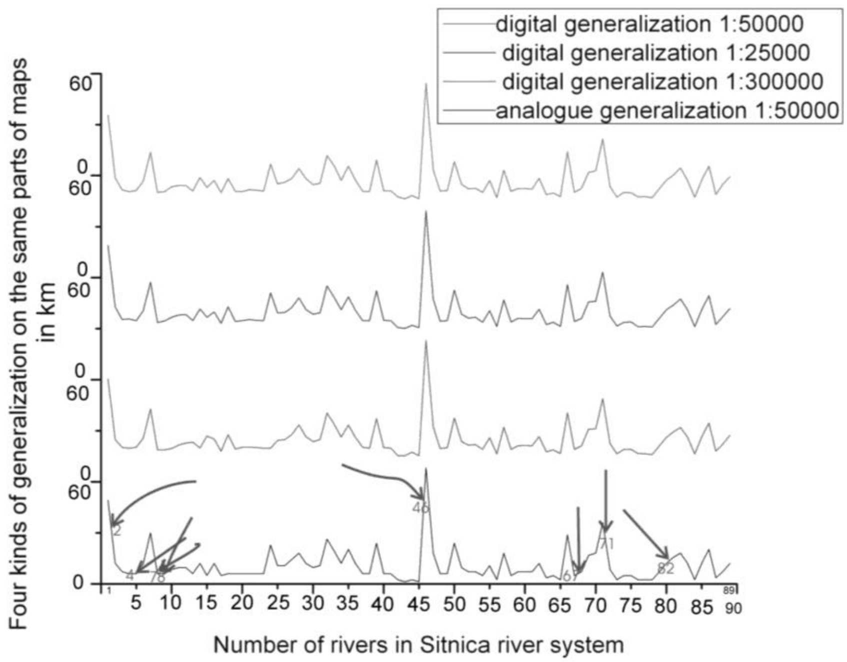


Figure 10. The biggest mistake of generalization in all of three scale, the numbers indicate the number of river.

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