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THE PROBABILITY OF FLOODING WAVE OCCURRENCE AND THE VULNERABILITY OF THE KOSOVO TERRITORY SETTLEMENTS

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Abstract: The work displays the presumed laws of flooding waves which would occur if the 1976 situation when the great floods in Kosovo happened reoccurred again. On a 1:300000 multilayer map of Kosovo and Metohia, there are areas which would have been flooded in case of a maximum flooding wave, and what is also shown is the areas which were covered in water as the average was measured, including the areas used as projects of minimal flooding wave value. There is a layer showing the points with regular flood defense, including the places where protection needs to establish. The map includes the ratio of 1:300000, whilst the areas are calculated with the help of processing their dynamic static's, as well as using the formulae Gumbel Distribution and Weibull Formula. The data have been calculated with their maximum value, including the average and the minimum of flooding period embracing the time of 40 years.

Key words: the multilayer digital map, Kosovo and Metohia flood areas, Gumbel Distribution, Weibull Formula

Introduction

Today, flood modeling is very important when some hydrological features of the river are shown, especially when the potential flooding wave is considered. Such a modeling allows better defense of unwanted flood consequences. In order to make a model properly, we used Geographic Information System (GIS) applications. Geomorphologic cartography has become a field of interest again, especially when we consider new algorithms which allow modeling of topographic data, or transition from the classic 2D maps to 3D maps. (Dobre et al., 2011). When we consider analytical data on the hydrological maps, we use transition from the 2D to 3D maps, too (Peterson, 2006). Differences in portraying geomorphic maps in a GIS require use of the standard methodologies for creating databases and generating symbols. Especially, because of the problems encountered in redefining cartographic language and combining and

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visualizing information require a more precise representation of landforms (Dobre et al., 2011).

We digitalized theme map, in this case it is the river network of Kosovo. All rivers are connected into a single river network (Plana, 1991; Markovic et al., 2003). Only the most dangerous ones, considering the floods have been modeled upon the data showing river flood consequences. (Table 1). (Figure 1). The software used for digitalizing the 1: 300000 Kosovo map is GeoMedia Professional. Similar methods in the GIS tools have been used, layers are selected by geological, geomorphological, and land-use data, including the spatial distribution of past and present landslide events. (Leoni and Barchiesi, 2008).

The theme map is particularly useful when elements of the same phenomenon are shown. On this map is connected hydrological river network through layers, that is the river, the river system and the flood area of the river network (Mcmaster, 1989; Cromley and Campbell,1992; Robinson at al.,1995; Ormeling, 2006;Yamazaki et al., 2009). In order to show the hydrological elements more real, we used the generalization based on the following elements: classification, simplification, exaggeration. (Töpfer and Pilliwizer, 1966; Tyner, 2010; Douglas and Peucher, 2010).

Finally, in order to get the model of flood areas, we use the I 3D elevation model (proceedings of the 13th international cartographic conference, 1987), the geologically vectorized surface, the statistic methods expressed by Weibull formula and Gumbel distribution, (the processing of river deluge flow, including the statistic methods of flood area dimension processing) (Huggeti,2007).

Methods

We used analogue and digital or GIS methods. Other methods are 3D elevation model of terrain of Kosovo and geological background, statistic methods, and the mathematical processing of a flooding wave distribution. With help of software Global Mapper and GeoMedia Professional 6.1 we created multilayer digital map, with the main layer that shows the flood wave.

With help of software Global Mapper and GeoMedia Professional 6.1 we created multilayer digital map, with the main layer that shows the flood wave. Using this software, you can build complex queries with space data and attribute data in different formats and extensions. The software is able to make a phase digitizing and vector data with the geometry. Where it is very important to later determine the level of flood waves. Rivers themselves with the help of 3D grid model.

A Computer Supported Generalisation

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 the creation of geo information infrastructure, spatial data infrastructure. Spatial data infrastructure should contain sources, data base and meta data, and a network of data and users in the end (Kraak, Ormelling, 1996).

GeoMedia Professional Software

The advantage of the GeoMedia 6.1 software is its capability to characterize and integrate the vector and raster data. Also, it can create phase digitalization and vector data with the very help of geometric transformation. The other important tools and algorithms is the possibilities to create 3D data and input to the map. In this case all data is inputted like x,y,z area integral, for three common rivers (Beli Drim, Ibar, Sitinica). We determined the length difference, which comes as a result of computer supported generalisation on the same element display (rivers) on topographical maps (TM300). Also, we digitalized geological map of Kosovo in ratio 1:300000. For making map we used GIS software Geomedia Professional 6.1. For first stage of making map we used 2D modeller of program to gain main hydrological and watershed map. In later stages we used 3D Geomedia modul to make flood waves from 30m DEM and present them in 3D view. Further, we combine 2D and 3D view of maps to make final map "Floodplain areas of Kosovo* presented on hydrological multilayer map with maximum flood waves". 3D GeoMedia.

The basic Hydrological Characteristics of the Sitnica river

The Sitnica river (L=110 km F=2.861 km2) is the largest Ibar tributary, occupying the central place and is the largest river of Kosovo Polje. The Sitnica river network, take 26% of the Kosovo and Metohija territory or 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. R. Plana (Plana, 1991) thinks that the spring leg should be viewed as the river Topila, and D. Labus 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. River is very dangerous in the place of area: entrance of River Lab to Sitnica, settlement Dobri Dub, and mouth of river Sitinica to Ibar. (Figure 2).

The basic Hydrological Characteristics of the Ibar river

The Ibar, is a river that flows through eastern Montenegro, Serbia and Kosovo, with a total length of 276 km. It belongs to the Black Sea drainage basin. Its own drainage area is 8,059 km2, average discharge at the mouth 60 m^3/s. It is not navigable. The Ibar originates from six springs on the Hajla mountain in eastern Montenegro. Near by Kosovska Mitrovica and also across Raska the river is very dangerous, and potential of floods is existing. (Figure 2).

The basic Hydrological Characteristics of the Beli Drim river

The length of Beli Drim River is 175 km, 156 in Serbia and 19 in Albania, and it is the largest river in Kosovo and Metohija. Beli Drim River originates in the southern slopes of Rusolije Mountain, about 10 km north from town of Pec and flows through the semi-karst region of Metohija. The hydrological characteristic of rives is average discharge 56m^3/s, length 175 km, area of basin 4964 km^2. (Plana, 1991). The White Drim is very dangerous in next area of watercourse near by settlement Djonaj. And on this place is a very high possibility for floods. (Figure 2).

Results

The standard deviation formula is:

$$S = \sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{N}(X_i^2 - \overline{X})^2} \qquad (1)$$

$$S = \sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{N}(X_i^2 - \overline{X})^2} \qquad (2)$$

Where $\sum X_i^2$ is the sum of numbers

$\bar{X}^2$ is a squared arithmetic averag, variation formula is $S^2 = \sigma^2$.

Gumbel distribution formula is

$$y = -\ln(-\ln P') = -\ln(-\ln(1-P)) = -\ln\left(-\ln\left(1-\frac{1}{T}\right)\right) \qquad (3)$$

Weibull formula is $T = \dfrac{n+1}{m}, P = \dfrac{m}{n+1}$ (4)

Q_p runoff peak, P probability of exceedance, P' probability of non-exceedance, T recurrence interval, y is reduced variate from annual period with maximum series for a hypothetical stream (Ghahramani,2000). After determining of flood years, then processing the data by using GeoMedia Professional 6.1 flooded areas are identified as follows: Connect to an existing warehouse from which data is to be exported.

Select Warehouse > Export to > AutoCAD. Specify the feature to export in the Features to export field on the Export to AutoCAD dialog box. The dialog box items enabled or disabled vary depending on whether you selection. Or export a linear or an area feature or select a compound or text feature. In the Output file name field, if an output file name is other than the default is required, select or type the name of a file to contain the exported data. Select the appropriate Output file mode option. Note The Output file mode options are enabled only if the output file name is an existing file. Select the appropriate Output file type option. Optional: Check the Export attributes check box; then select the appropriate attribute option. If you select As database linkages, click Linkage Details; then set the appropriate values on the Linkage Details dialog box. In the Layer name drop-down list, if a layer name is other than the default (selected feature name) is required, select or type the name of a layer to contain the exported data. If you select By attribute from the Layer name drop-down list, select the appropriate existing attribute from the Attribute name drop-down list. Set the appropriate layer visibility options. If a line type other than the default CONTINUOUS is required, select or type an.AutoCAD line type file name (lin), in the Line type file name field. Select the Line type name from the drop-down list. If you are exporting text features, if a text style is other than the default STANDARD is required, select or type an AutoCAD text style name in the Texi style name field. Specify the text properties as appropriate. Optional for point or compound feature: Check the Export point as block reference check box; then type or select the appropriate Block drawing file name. Select the Block name; then type the Block scale. Optional: Check the Export options / 3D coordinates check box. Click Apply to export the data. Continue the export process until complete; then click Close to dismiss the Export to AutoCAD dialog box. Thus, in GeoMedia Professional 6.1 software get flood waves with coordinates.

Discussion

Professional tools successfully created the floods of three rivers in Kosovo and Metohia for a period of 40 years, with help of Gumbel Distribution and Waibyll Formula. Maybe, some other software can better show flood area and flood wave. But, the combination of all of them presents the best results. Also if we know the precisely hydrological data from the hydrological stations and the result can be better. The future papers and works must be concept on this way. Multiyear maps are important to present a potential flood of the territory of Kosovo and Metohija. The difference between these cards and traditional cards that were static form, the dynamics. GIS tool provides great mobility, so along with data that could be downloaded could put a database that is fed data from the meteorological station mobile. These stations would be set up along the river course from source to mouth, so to obtain not only multiyear it is a real digital map of flood areas.

Conclusion

The method used in this work is presented by statistic data processing, the mathematical distribution river flow data distribution, including the function of river deluge areas (Corné,2003) in Kosovo prone to flooding in three periods 1955-1975, 1976-1996, 1997-2010 (Republic hydro meteorological service of Serbia) All the areas of all the three periods are presented on a 1:300000 map, later, with a help of statistically mathematical processing, the points at which flood protection needs to be established are determined (Shulei andYufen,2004). When all the statistical and mathematical analyses are finished, the given values are presented digitally and processed in the form of a vector of the newly made hydrological map of Kosovo in 1:300000 ratio. The map legend with geology is included too. The 3D Kosovo river elevation model presents an important point showing the direction of water lines, as well as the drainage position of Kosovo rivers, so it is shown too. GIS tools with mathematical and statistical calculations make it possible to map of Kosovo and Metohija display graphics along with the distribution of flooded areas for a certain period. So it can be seen from floods for a long time.

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Appendix

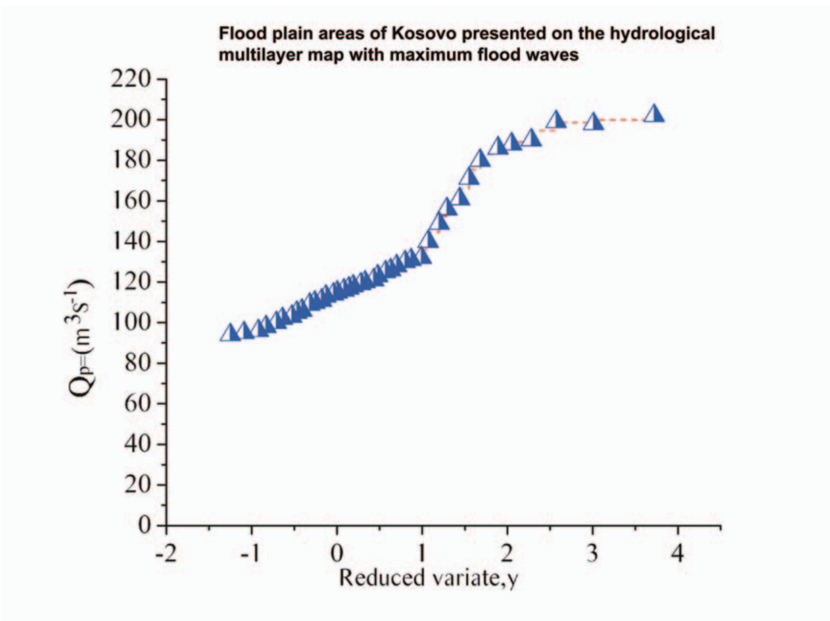

Figure 1. The runoff peak Q_p versur reduced variate y for period 1970 2010 of main rivers on Kosovo

Table 1. The runoff peak Q_p, order number in m, probability of exeedence P, probability of non- exeedence P', recurrence interval T, and reduced variate y from a 40-year annual maximum series on Kosovo.

$Q_{p(m^3 s^{-1})}$	m	$P_{(fraction)}$	$P'_{(fraction)}$	$T_{(year)}$	$y_{(reduced-variate)}$	$q_{(specific\ discharge\ l/s/km^2)}$
202	1	0.024	0.976	41.0	3.72	18.55
198	2	0.048	0.952	20.5	3.01	18.18
199	3	0.073	0.927	13.6	2.57	18.27
190	4	0.097	0.903	10.2	2.28	17.45
188	5	0.12	0.98	8.2	3.90	17.26
186	6	0.14	0.86	6.8	1.89	17.08
180	7	0.17	0.83	5.9	1.68	16.53
171	8	0.19	0.81	5.1	1.55	15.70
161	9	0.21	0.79	4.5	1.44	14.78
156	10	0.24	0.76	4.1	1.29	14.32
149	11	0.26	0.74	3.7	1.20	13.68
140	12	0.29	0.71	3.4	1.07	12.85
132	13	0.31	0.69	3.1	0.99	12.12
131	14	0.34	0.66	2.9	0.87	12.03
130	15	0.36	0.64	2.7	0.80	11.94
128	16	0.39	0.61	2.5	0.70	11.75
126	17	0.41	0.59	2.4	0.63	11.57
125	18	0.43	0.57	2.2	0.57	11.48
123	19	0.46	0.54	2.1	0.48	11.29
121	20	0.48	0.52	2.0	0.43	11.11
120	21	0.51	0.49	1.9	0.33	11.02
119	22	0.53	0.47	1.8	0.28	10.93
118	23	0.56	0.44	1.7	0.19	10.83
117	24	0.58	0.42	1.7	0.14	10.74
116	25	0.60	0.40	1.6	0.08	10.65
115	26	0.63	0.37	1.5	0.005	10.56
114	27	0.65	0.35	1.5	-0.04	10.47
113	28	0.68	0.32	1.4	-0.13	10.37
111	29	0.70	0.30	1.4	-0.18	10.19
110	30	0.73	0.27	1.3	-0.26	10.10
109	31	0.75	0.25	1.3	-0.32	10.01
106	32	0.78	0.22	1.2	-0.41	9.73
105	33	0.80	0.20	1.2	-0.47	9.64
103	34	0.82	0.18	1.2	-0.53	9.46
102	35	0.85	0.15	1.1	-0.64	9.36
100	36	0.87	0.13	1.1	-0.71	9.18
98	37	0.90	0.10	1.1	-0.83	9.00
96	38	0.92	0.08	1.0	-0.92	8.81
95	39	0.95	0.05	1.0	-1.09	8.72
94	40	0.97	0.03	1.0	-1.25	8.63

Source of data: Valjarevic at all.

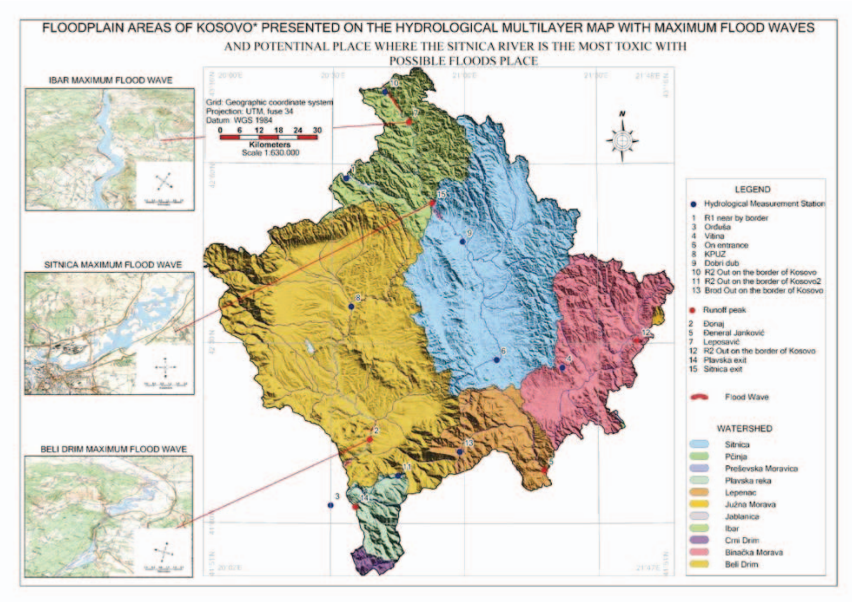

Figure 2. Flood plain areas of Kosovo presented on the hydrological multilayer map with maximum flood waves