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MODELING OF THE RIVER SYSTEM OF GOLIAMA KAMCHIA

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Abstract: *The present study is based on an integrated approach for assessing the conditions and the relations between environmental factors that determine the extent of flooding danger in the researched area. Meteorological and hydrological factors come first, as well as geo-morphological factors, landscape factors and the management of flood risks. For the purposes of the study a wide range of statistical, cartographic, geodesic, remote and inquiry methods, and field observations are used.*

Key words: *GIS, ESRI MAIK 11, ETK, ДГМ, ДGPSM, ГММП, РГО, ERDAS, Swinglet CAM*

1. General information about River Kamchia

Kamchia River's former name was Ticha. Its water catchment area has the following coordinates: B1 = 42 ° 45 ', L1 = 26 ° 20' and B2 = 43 ° 25 ', L2 = 27 ° 55'. The river and its tributaries flow in the eastern part of Stara Planina. Their position is shown on the hydrographic pattern on (Fig. 1).

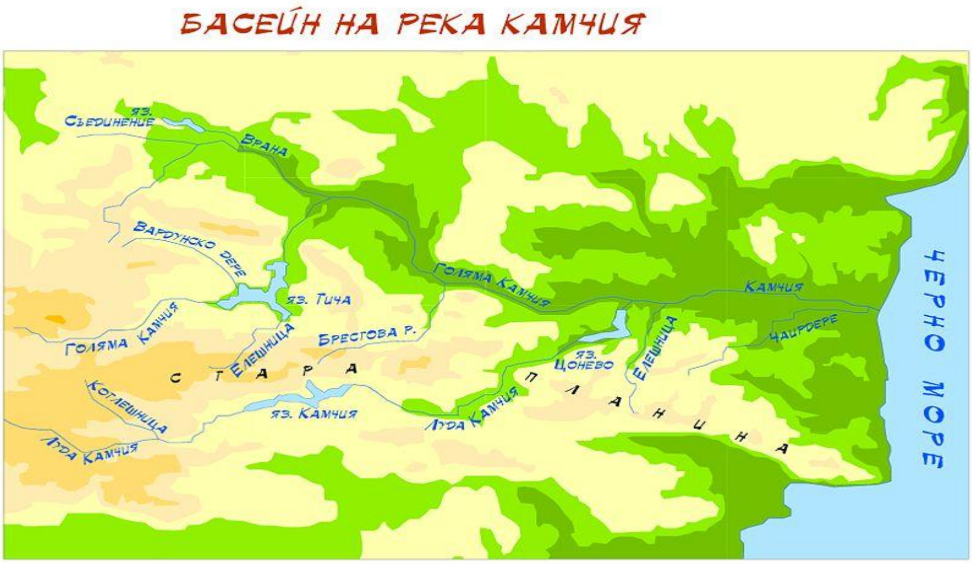

Fig. 1 river system of goliama kamchia

River Kamchia is formed by the rivers Goliama Kamchia (Big Kamchia) and Luda Kamchia (Overflowing Kamchia); Goliama Kamchia is conditionally accepted as its starting point. The total water catchment area of the basin is 5358 km2. River Kamchia begins from Lisa Mountain. The coordinates of its source are C = 42 ° 59'40 "and L = 26 ° 16'40" in height H = 710 m. The river flows northeast, towards the town of Shumen to the village of Khan Krum. At this location, the river makes a big turn to the south, and from the town of Smiadovo it flows eastwards, keeping that direction until its flow into the Black Sea. The coordinates of its mouth are B= 43 ° 01'30 "and L = 27 ° 53 '30". River Kamchia is 245 km long, with an average slope of 2.9°. Despite the many tributaries (27 in all) the density of its river system is too low – 0.7 km/km^2. The largest tributary of Kamchia is Luda Kamchia – its length is 201 km and its catchment area is 1612 km^2, with an average gradient of the river 5.3°. The second largest tributary is Vrana River – having length of 68 km and catchment area of 938 km^2. The average slope for all feeders is between 3.7° to Kerizbunar River (a tributary of River Vrana (the name means 'crow')), and 4.1° to Black River, a tributary of River Kamchia. The average altitude of the river basin of Kamchia is H = 327 m.

2. Overview of the modeling

A river system can be modeled using the following methods [5],[10],[11]:

- Hydrological modeling;
- Hydraulic modeling;
- Geo-information modeling.

Hydrological modeling is applied in river basins where rainfall has to be conducted into runoff of water discharges at special river posts.

Hydrological processes are quite complex, as rain or snow do not go directly into the riverbed, and follow a conceptually different path, passing through various transformations until reaching the outflow of the pool [9],[11].

There are different ways of modeling these processes of water transfer from rain to a runoff of rivers: hydrological models can be generalized (where a pool is considered as one whole), or distributed (the pool is shredded into small connected segments (1ha), in which the modeling of processes is held, and then combined with the others).

Usually, practical hydrology makes use of generalized models. Thus is the approach in the present experiment.

Hydrological modeling allows for tracking the movement of the high wave along the river current, by setting also the elevation of the water surface. Individual items can be 1D (one-dimensional) or 2D (two-dimensional) planes.

The following table shows the watershed of River Kamchia. The river is modeled in two parts: from Ticha Dam – near the village of Cherny Vrah (Black Peak), Shumen District, and from the village of Cherny Vrah to the Black Sea (Varna). After completing the modeling of each part, the two models are merged and validated as a general model. The length is measured in kilometers.

Tabl. 1First part of Goliama Kamchia River

Name – hydrodynamic model	CRS	Length
Kamchia	50	40 km
Vrana	1	68 km
Poroyna	1	19 km
Brestova	1	15 km
Total	53	142 km

Tabl.2 Second part of Goliama Kamchia River

Name – hydrodynamic model	CRS	Length
Kamchia	50	63 km
Luda Kamchia	1	5 km
Eleshnitsa	1	5 km
Total	51	73 km

A) Creating a hydrological model

Hydrological model could be created by using the specialized program of ESRI MAIK 11[13],[14].

Each hydrological model in the system is defined on a conceptual level first, by splitting the river basin into sub-basins. The models are constructed from GIS of the river basin and its sub-basins. Their definition (i.e. the first calculation of parameters) before calibration is based on various features provided by GIS: surface and shape of the basin, vegetation, soil characteristics, geological information, incline, slope, etc.

The calibration of a hydrological model consists of specifying the parameters that form each model. For the present model, data of past observations have been used. At the start of the model, with real recorded data input into the system (rain, snow, temperature, excessive intake of water, etc.) and at the end comparing them to the observed water quantities, the various parameters are optimized to minimize the differences between the results at the end and the observed data in several measured periods characterized by high waves.

B) Creation of a hydraulic model

Hydraulic models are created using the exact details of the gutters, the ratio of total runoff, storage mechanisms on floodplains, as well as major facilities such as bridges, dams, dikes, terraces, and drained swamps. Detailed topography is required – of the areas endangered of flooding, to the intersection of the slope, to the terraces or to the hills – to form and shape the hydraulic system.

Hydraulic modeling is based on points that are connected in a topology network. For the connected points in the main channel and the nearest left and right side of the flood plain.

For points in the flood plain associated with the topographic structures such as dams, roads, railways, whose borders of water retention are defined. In addition, floods can be modeled through equations using water overflowing quantities.

Since a detailed topographical description is used, the water level is the main variable controlling the modeling of currents in the spill. Thus, the topographic information must be accurate enough, so that the model is effective in its forecast. Accuracy of ± 10 cm of the topographic structure as a whole is desirable for these models.

Depending on the topographical variations of the riverbed and fortifications, the distance between the cross sections can vary from 2-3 kilometers to 500 meters.

When the area of the spill and the slope of the riverbed are in planes (as is the case with the lower river current of Kamchia), the hydraulic models are very sensitive to errors in the topography. This means that variations in the water level (which may be the result of a not so good topographic survey) between real data and simulation data will spread downstream and upstream, which will generally lead to a bad result.

The main disadvantage of the hydraulic models is in the quality of geo-information used for designing topology.

The creation of a hydraulic model contains the following steps:

- Gathering and processing information for cross-sectional and topographic data.
- Assessment of the terrain in which water discharges, and of the ground on which water retains, in the cross sections and spills.
- Collection and processing of measurements for the level and the quantity of water flow of hydrological stations situated on the tributaries of the rivers from the first order.
- Collection of data for the constructed river structures and ways of managing them.

Building of the model by recording data on:

- The borders of the rivers and their tributaries with relevant significance;
- The cross sections;
- The side and border flow;

Calibration and validation of the hydraulic model through testing it with data from the past, leads to minimization of model deviations (as compared to the ones reported by the stations) in water levels and quantities.

One should have in mind that the calibration and validation of the model can be started only when all necessary information is collected, analyzed and processed; the steps before checking the model do not depend on each other and can be executed separately.

C. Creation of Geo-information models [1-3],[7]

As the hydrological and hydraulic models show, a central role in their building takes the credibility of the geo-information model.

1. Geo-information model, created using the method of digitalization of topographic maps

For the development of a geo-information model using the method of digitizing topographic information from topographic maps, the following materials are collected and analyzed:

- Topographic maps at a scale of 1:25000;
- Large-scale topographic maps (ETC) at scale 1:5000;
- Cadastral maps in digital form;
- Coordinate lists, catalogs and registers of geodesic points SGN, DGPSM, GNLI, BER etc..

ETK in scale 1:5000 of the Nomenclature line-wide river Kamchia (84), as well as topographic maps in scale 1:25000 (25), are scanned. The scanned images are in raster format, with JPEG extension. In an MKAD medium, the raster images are geo-referenced in coordinate system year 1970 K-7. A series of related ETK throughout the valley is obtained. In an MKAD medium, a transformation of the image coordinate system of the 1970 K-7 in the coordinate system UTM - WGS 84 Zone 35N is performed. Based on the resulting image, vectorization is performed. A “relief” layer is created first, and then main, additional, and auxiliary horizontals are vectorized in base section 5 m (1 m). The vectorization is held in an AutoCAD medium map. Data for the metrics and semantics are saved in files with DXF and DWG extensions, by creating also files for ESRI medium with SHP extension. The objects (the horizontals) in the “relief” layer are obtained discretely using the graphics primitive POLYLINE. Data for objects are stored in object-oriented relational table of the layer (the topic). The correctness of the data in the table is checked and, if necessary, corrections are made. In an ESRI medium - ArcGIS (ArcView) theme “relief” is added. The coordinate list of points from SGN, GNLI, DGPSM, BER are introduced, in the form of TXT or DBF format tables, which enriches the information about the landscape. The result theme is of points. To obtain a model of the surface of the research area, based on the information from linear and point themes “relief”, an irregular network of triangles (TIN) is created. Based on the created TIN model, a GRID model and a raster DTM models are made [4],[15].

Following the “relief” theme, a “hydrography” theme is created. Goliama Kamchia River is vectorized, part of the larger tributaries - Vrana River and Luda Kamchia River, Ticha Dam, Tsonevo Dam, and part of the Black Sea. The vectorization is done in an AutoCAD medium map. Data for the metrics and semantics are saved in files with DXF and DWG extension, by creating files for an ESRI medium – with SHP extension. Objects in the “hydrographic” layer (rivers, dams, the sea) are discreetly obtained by using graphical primitives POLYLINE. Then Polyline is edited and presented as a polygon.

Exporting "hydrographic" layer from AutoCAD map in ESRI - ArcGIS (ArcView) is performed as a polygon theme with the SHP file. Consecutive topics are created, such as: "roads", "vegetation", and "settlements". With the last topic, "settlements", data from the cadastral maps is used, in CAD and ZEM formats. All files are converted into coordinate system UTM – WGS84 – zone 35N in advance.

All topics are supplemented with attribute information and stored in the database as "Kamchia" Project. The developed model is shown in (Figure 2).

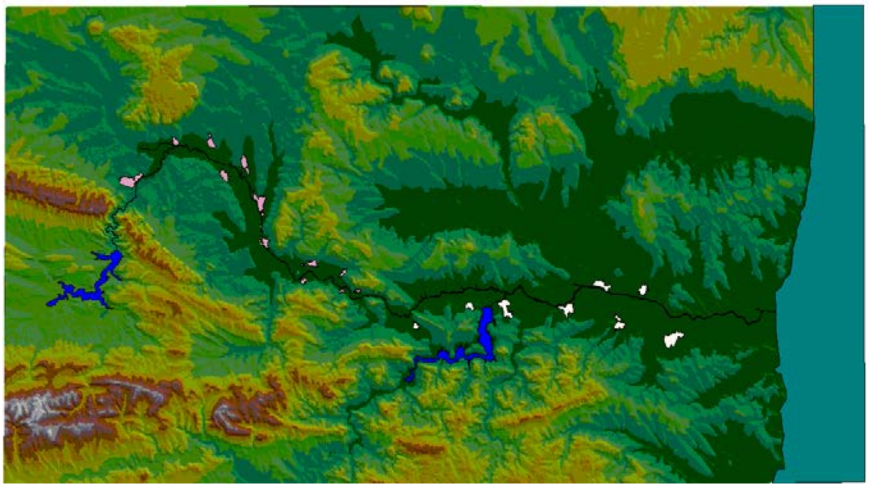

Fig. 2 The developed TIN model

2. Geo-information model established by photogrammetric methods

A). *Introduction of raster data* - of ortorectificated aerial photographs, is realized by the following technology: Scan of the source materials with precision photogrammetric scanner ULTRA SCAN 5000; Creation of project in ERDAS; Defining the sensor model; Determination of control (anchor) points and their measurement with GPS or reporting from topographic maps, Automatic generation of interconnection points; Block alignment (including aero-triangulation); Ortorectification; Quality Control; Alignment of brightness (and color) of the images; Creating of mosaics (pooling of individual grid lines and aerial photographs of map sheets); Entering metadata.

B). *Input of data for the relief by photogrammetric method* includes: Creating a project in ERDAS; Defining the sensor model; Determination of control (anchor) points and their measurement with GPS or reporting from topographic maps; Automatic generation of interconnection points; Block alignment (including aero-triangulation); Extracting digital elevation model of the relief; Editing the digital elevation model of the relief; Quality control; Import of raster data for the terrain in geo-base data;

In the accomplishment of the photogrammetric methods, data from aerial photographs in the period 2000 - 2011 are used, by courtesy of the company Geodetect Bulgaria and CI. (Fig. 3)

Company Geodetect provided an UAV - Swinglet CAM of the Swiss company SeneseFly, for the experimental research of the section of the village Khan Krum near the village Salmanovo. Swinglet CAM is an innovative mini airplane. Swinglet CAM has a 12-megapixel camera with a focus length of 24 mm. When flying at an altitude of 50 m, the pixel size of the pitch is 2 cm. The altitude can reach up to 1500 m, which corresponds to 60 cm pixel size.

Despite the small area (about 15 km), data from the measurements and their processing show that this modern method is economical and the precision achieved is within the standard photogrammetric method - (0.3 - 0.5 m) in both horizontal and vertical position.

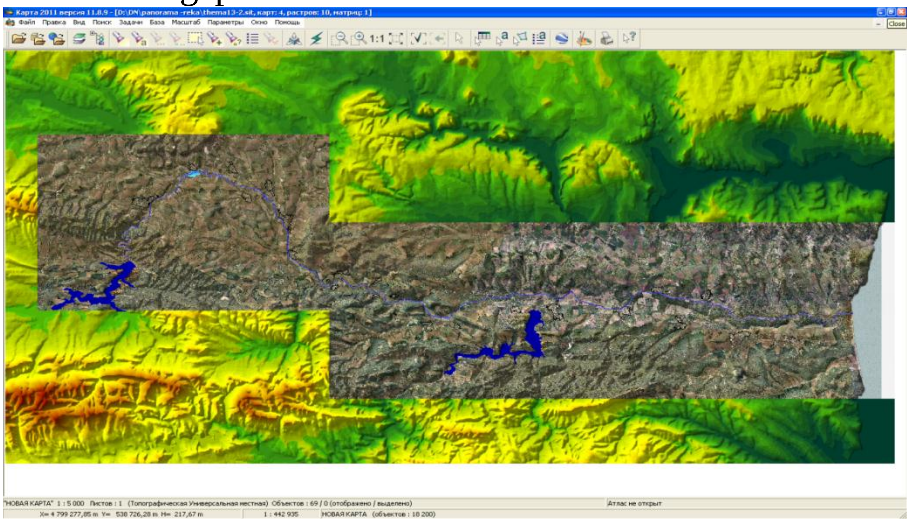

Fig. 3 the photogrammetric methods

The models created by these two methods were tested (validated) in previously developed concept and methodology. This is done through geodesic surveying of the terrain, which is considered a standard. Due to the large size of the studied area and the limited resources available, impressive part of the whole territory is tested. The obtained results are positive and the models' reliability is proven, which allows for their implementation into practice.

Some minor omissions and inaccuracies in modeling are detected in the process of validation, and after analyzing the discrepancies between model and reality, the model parameters are adjusted and changed.

Comparative analysis of the models is performed, using methodology specially created for the purpose. In the evaluation of the geo-information models by using the two methods, accuracy and reliability are accepted as main criteria. The data are shown in Figure 4 [6].

The accuracy of the geo- information model, created by using the digitizing of topographic maps, is m_{ETK}=+/-3.66

m, while with the model, established by photogrammetric method, it is $m_{АФС}$=+/-0.51 m.

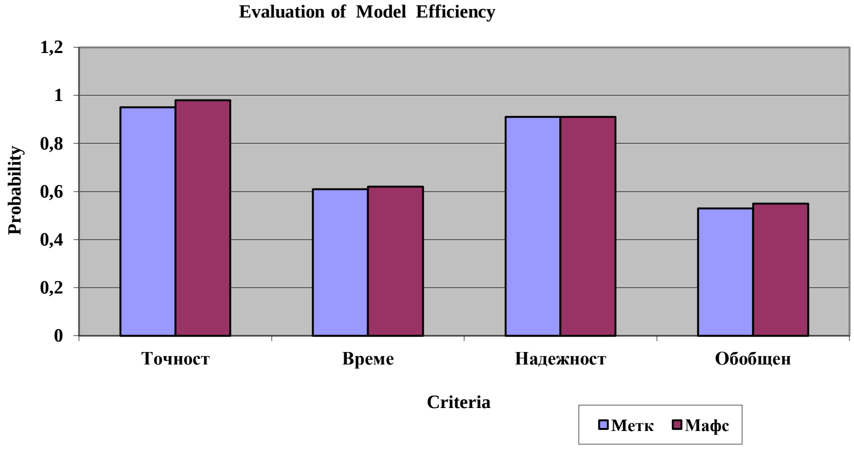

Fig. 4 the evaluation of the geo-information models by using the two methods

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