Journal scientific and applied research, vol. 8, 2015
Association Scientific and Applied Research
International Journal

Original Contribution ISSN 1314-6289

PRELIMINARY STUDIES ON THE EXPERIMENTAL RESEARCH OF THE EFFECTIVENESS OF THE USE OF GEO-INFORMATION MODELS IN THE AREA OF THE RIVER GOLIAMA KAMCHIA

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ABSTRACT: *Preliminary studies were necessary to ensure that the experimental research to demonstrate the effectiveness of the technology and the geo-information model were carried out in North-Eastern Bulgaria, along the river Goliama Kamchia.*
KEY WORLDS*: geo-information model, GIS*

General

Preliminary studies were necessary to ensure the experimental studies demonstrating the effectiveness of the technology and geoinformation model. They were made in northeastern Bulgaria, along the river . Goliama Kamchia. [1,2]

Methodical approach

This study was conducted on the basis of an integrated approach to assess the conditions and the relationships between the environmental factors that determine the danger extent of flooding in the researched area. First are the meteorological and hydrological factors, 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.

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.

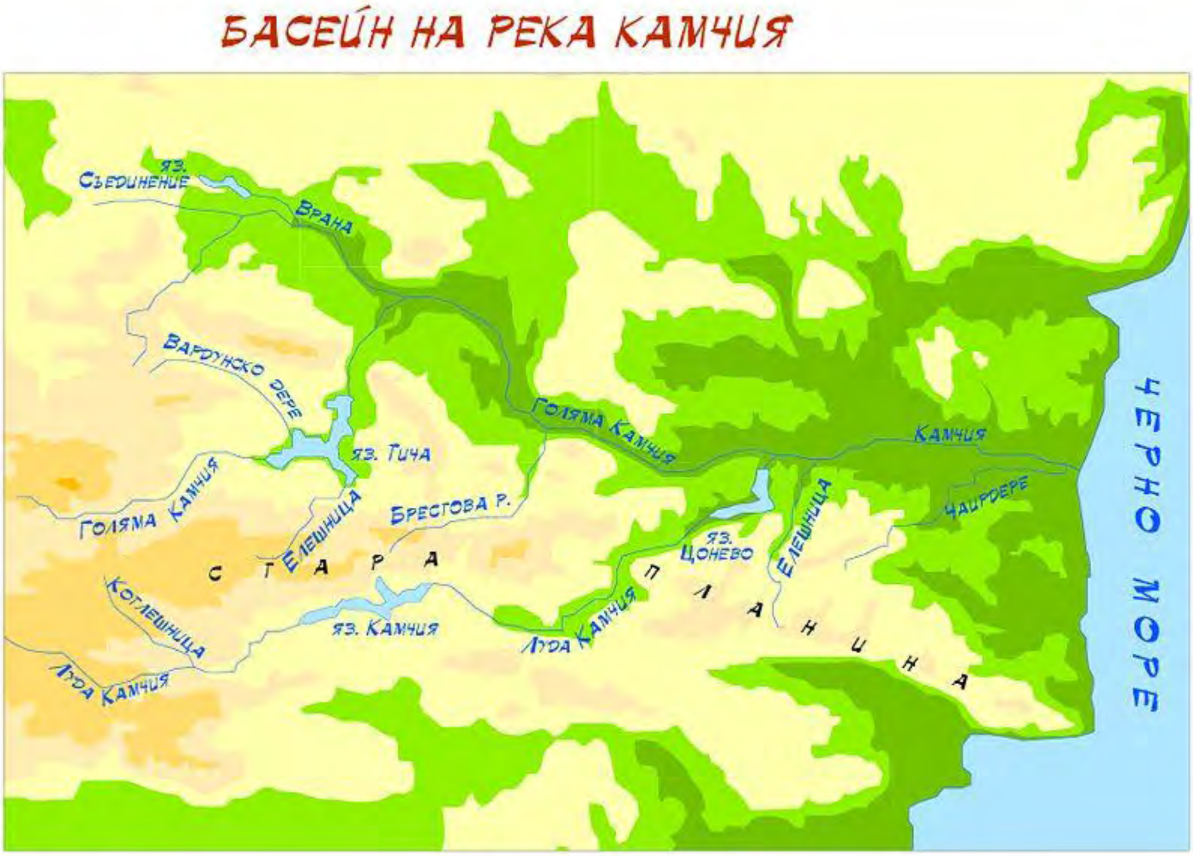

Fig. 1

River 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.

Relief of Kamchia's valley

River Kamchia's valley covers the entire Eastern Balkan Mountain foothills in this part and a wedge of the Danube plain , the tip of which touches the isolated height Arkotin.

Afforestation of Kamchia's valley

River Kamchia has well - forested catchment area. The forest occupies 2600 km², or 49 % of its entire area. Almost half of this area is occupied by low-stemmed forests that have the highest prevalence. The other half of 2,600 km² is forested with oak and beech forests. The last two species occupy the highest parts of the Eastern Balkan Mountains, as the beech forests in comparison to the oak are less numerous and form separate large stains in them. Kotel and Varbishka mountain are occupied mainly by beech forests, while coming eastwards to Karnobat and Tichanska mountain is occupied mainly by oak forest. Also oak forests predominate in the southern half of the Preslav Mountain. Ash and elm forests are typical for the 3-kilometer strip along the right bank of the river from the merger of the two rivers Kamchia to the mouth, that area is known as Longosa. Best forested is the southern catchment area - along Luda Kamchia. The forests in the upper reaches of the river occupy 79% of the area, while flows into Big Kamchia are about 66%. In the watershed, bordering the valley of t Goliama Kamchia, there are beech and oak forests. Low-stemmed forests cover the lower parts of the valley. The influx of Kamchia – river Vrana is the least planted - only 23%. Here the forests are entirely low-stemmed, scattered along in separate small groups. Larger areas and continuous forests occupy Preslav Mountain and southwest of the town Shumen. The upper flow of the river Big Kamchia is with 56% forested area, as downstream the forest territories significantly reduce. Thus, in the village Bial Briag the forests are only 37% of the entire area. This significant reduction of the afforestation is due to the weak wooded tributary of the river Vrana. Oak and beech forests occupy the southeastern branch of the Preslav Mountain and northern slopes of the mountain Karnobat. After the merger of Goliama Kamchia the afforestation characterizes by the following: the left (north) side of the valley is coloured with low-stemmed forests, the right coastline (Longoza) is covered with dense ash and elm forests, while the right (southern part of the catchment area) is characterized by its large oak and beech forests stretching between Longosa, Staro Oryahovo, watershed with river Dvoynitsa and. Balabandere - a tributary of Luda Kamchia.

Valley and bed of river Kamchia

River Goliama Kamchia originates from Lisa Mountains. The springs are small and river is formed by 2-3 spruits. The spring area is planted with beautiful deciduous forests, and this region near the village Ticha is known as Tuzluka. The river's longitudinal incline to the mouth of its tributary Cherna is $22,3^0$, while the transversal profile of the valley in the upstream is narrow with high and steep slopes. River Goliama Kamchia, from its springs to the village Ticha, flows in an easterly direction, and after entering Gerlovo, it adopts northeastern direction, and remains the same to the dam Ticha. After the village Ticha the nature of the valley is amended. Its transversal profile resembles a trough, as the valley follows the strongly curved meanders of the river. The inclination of the slopes does not exceed 30°. They are planted with deciduous forests (hornbeam, beech) and farmland 30-40%. The longitudinal incline of the river falls sharply to 4%. The width of the river is 5-6 m, the depth - up to 0,80 m. The bottom of the riverbed is uneven, rocky, and sandy in some places with separate boulders. The height of the coast reaches up to 2 m. Typical for this area is that the river makes frequent rapids and thresholds. After the village Filaretovo river Kamchia enters the famous hilly area called Gerlovo. The nature of the valley is amended as the transversal profile from a troughlike takes the shape of a trapezoid. The slopes of the valley in the longitudinal direction are separate hills, which is typical for Gerlovo. Their inclination is less than 40°, but they are lower 50-60 m. The afforestation significantly reduces at the expense of the working spaces which reach up to 80%. The river makes strong curved meanders in the straight section of the valley. Water meadows appear here with width of 40-50 m. The watercourse is still variable. Its width varies from 15-100 m, but in many areas narrows to 6-8 m. The water depth varies from 0,30 - 0,50 m. By approaching Ticha dam the slopes of the valley are higher and steeper. In this part of Gerlovo a widening and narrowing of the valley is noted. The river continues to make strongly curved meanders. Through the village Staroselets the valley narrows to 100 m, then a widening of 300-400 m follows. The incline of the slopes is kept around 40 °, as the longitudinal profil of the valley becomes again a trough. Near dam Ticha the watermeadows' width reaches up to 300 m, and that of the river is 6 m with a depth of 0,50 m. The banks are steep and overgrown with willow. Under dam Ticha, river Kamchia enters the Preslav narrow. The transversal profile of the valley here is narrow with steep and high slopes planted with low-stemmed forests, mainly oak and hornbeam. The longitudinal incline the river is $2,1^0$. The valley floor is entirely occupied by the riverbed, forming rapids in places. The banks are steep, high up to 1 m, overgrown with willows in places merge with the almost vertical rocky slope of the valley. After leaving Preslav narrow, river Kamchia enters in a wide trapezoidal valley. The slopes become low and deforested, and the valley's floor becomes wide up to 1,5 km. The inclination of the slopes is preserved and the longitudinal slope of the river falls to 0.70 in this region. In some places the riverbed reaches up to 300 m in width, but typically ranges between 20-40 m with an average depth of 1,5 m. After the village of Kalnovo, the river stays constant with width of 7-8 m and depth of 2 - 2,5 m. The banks are loamy, friable, high 1-1,5 m, planted with willow. In this area the river makes a strong curved meanders. The entire bottom of the valley is flooded. In the village of Novo Yankovo the valley narrows to 100-150 m, as its transversal profile becomes again a troughlike. The nature of the riverbed and the river does not change. Below village of Cherni Vrah the river makes average curved meanders. Its depth increases up to 2,5-3,0 m. The bottom is sandy and loamy. After passing the narrow near the village of Komunari, river Kamchia enters in wide valleys (1,7 km) with trapezoidal transversal profile. The slopes of the valley are low, sloping and remain so almost to the mouth. The width of the valley reaches 3 km, and that of the river - up to 20-30 m. In this section the river makes only one rapid. Its longitudinal incline is $0,5^0$. From the village of Grozdovo, Kamchia enters in Longoza - old ash and elm forests which continue as broad strips of 600-700 m to the mouth. The river flows through the forest much spilled, forming multiple azmatsi.

Weather reasons of flooding

Heavy rains are the main cause of floods. They are in the form of rain falling on wet soil, which runs off or is in the form of snow, which in some cases can melt rapidly due to exceptional warming.

In all cases heavy precipitations are associated with the formation and development of Mediterranean cyclones in the Balkans.

Broadly speaking, in the basin of the river Kamchia there are four types of floods: [Zyapkov, 1988: 6]

• Winter floods (from December to mid-February).

They are most often caused by one or several Mediterranean cyclones which spread to the east of the Mediterranean, across the Balkans. Such situations, where the main driving force is the dynamics of the atmosphere, cause intense, repetitive rain throughout the basin and turn into a huge and prolonged flooding in the middle and lower reaches of the river Kamchia.

• Floods in late winter and early spring.

Their origin is the same as the above but with sudden warming of the air, mainly related to a large polar front waves causing meridional circulation. They are often worsened by the effects of the snowmelt due to a rapid warming over the earth's surface covered with a relatively thick fresh snow at low altitude. River Goliama Kamchia and the lower reaches of the river Luda Kamchia have rainfall of 125-150 mm.

• Flooding in the spring and early summer (and later in the summer if it is rainy).

This is the convective precipitation along the cold fronts of slowly moving cyclones (in the east), again fueled by soil moisture. This type of rainfall affects the upper streams of the river Kamchia and can be the cause of large flash floods in these areas. Here the convection is the main driving force in the formation of the precipitation. In a part of the valley of Goliama Kamchia and its tributaries the predominant precipitation is 150-175 mm.

• Flooding in the fall.

They are caused by slow-moving cyclones, which centers follow the coastline of the Balkan Peninsula, and finally moved to the Black Sea. Convective rainfalls are fueled by warm sea water of the Mediterranean, and then those of the Black Sea. The precipitation mostly affects the lower reaches of the river Kamchia. In the rest of the catchment area dominates the autumn rainfall 125-150 mm.

In the lower parts of the valley of Kamchia the precipitation falls to 550 mm per year, and the modules of the runoff - up to 2 l / s / km^2 along the river Luda Kamchia and up to1-2 ls/km^2 along the river Goliama Kamchia .

Dams and reservoirs [4,5]

After analyzing the pool turns out that the number of potentially dangerous dams is 27, as only two large dams strongly influence the floods in Kamchia. These are:

- Ticha Dam - managed by "Irrigation Systems" EAD;
- Dam Tsonevo - managed by "Irrigation Systems" EAD.

These dams have a large capacity and receive direct flow of rivers in the river basin of river Kamchia. Ticha dam is situated in the upstream and dam Tsonevo in the middle.

This does not mean that other dams do not impact the floods in the watershed. But at this stage are considered only those two big dams and reservoirs that can spill during large floods or can prevent the formation of flooding.

Other dams and reservoirs located in the basin of Kamchia also have a relatively large capacity, but they collect water from much smaller basins (or collect water from other catchments through canals and derivations) and their effect during the relatively large floods is minor compared to that of the two "big" dams.

Statistical parameters for river discharges after the construction of these dams are quite changed and it is obvious that the dams have a positive impact on flood protection, or at least to a certain level of intensity of rainfall. The flood of 2005, when the level of Ticha dam was overtopped led to major damages downstream.

For management of the floods mainly two aspects of the dams are considered.

What is the probability of overflow of dams during heavy rainfall? It is necessary to be known the level of safety of the water, the elevation of the crown of the spillway, the retention curves, the number of locks. This analysis is necessary to determine the different models of floods, to be used in the preparation of maps of flood plains.

What are the rules of action during large floods? We need to know and create a diagram of these rules in order to know how to incorporate them in hydrodynamic models. The construction and maintenance of the operational and technical condition of dams in the Republic of Bulgaria is regulated by Decree №13 of 29.01.2004 on the terms and conditions for the technical operation of dams and related facilities and Rules for safe operation and maintenance of facilities of irrigation infrastructure.

In the design and construction of dams, the requirements of Standards for the design of hydraulic structures are observed and controlled. Basics of 1985 are Norms for the design of embankment dams, as well as Basics of engineering studies for construction sites.

In view of the foregoing, in the study and design of hydraulic structures a controllable risk of flooding is predicted.

This controllable risk is associated with:

a) The quality of surveying and planning;

b) The quality of materials under construction and ground stability;

c) The quality of the construction works;

d) The quality and safety of the built CIS in dams and their regular monitoring and controlling;

e) The application of spatial planning measures related to prohibitions on construction of important for the functioning of society elements of engineering infrastructure and areas of residence of people in flooded areas under the dams.

Out of this controlled risk is the uncontrolled risk of flooding. The management of uncontrollable flood risk is primarily associated with:

a) The quality of the exploitation conducted by teams operating and the capital cost of repair works;

b) The perfection and quality of the constructed announcement and warning systems along and after the dam for an early warning. Their automatization and reliability of information on water levels in dams and river beds;

c) The possibility of retention of water volumes in the reservoir;

d) The improvement of the legal framework for the design and construction of dams, the protective dikes in the revised sections of the river, after the dam's wall, as well as the planning of the territories after the dam;

e) The control on the spatial planning;

f) The control of the technical and operational condition of hydraulic structures;

g) The level of awareness of the authorities required to manage the risk of flooding on the size and scope of the floodplain;

h) The awareness, of the same authorities for permanent protection - the conductivity of river beds, corrected river sections, the thresholds along the rivers, the conductivity and stability of the bridges;

i) The awareness of the authorities directing and conducting the operational protection of the preparation level of all units, including the affected population, for the implementation of urgent and emergency operations in flood protection;

k) Informing the population about the manner of behavior during a flood.

The need of studying the risk of flooding scenario to destroy the dams is explained by the following facts:

1. The two dams were built in the fifties and sixties of the last century. To a considerable extent they are clogged with sediments and impoundment volumes decreased by 30% to 50% (big dams - less, but little ones - more). Events for cleaning deposits are not meant. The documents for the construction of small dams are lost or destroyed. The data for a number of annual measurements on various elements of the dams are not available.

2. Much of the small dams are owned by associations for irrigation and municipal property used for fish breeding. For this reason, these reservoirs are held on maximum volume, to the level of an overflow edge, due to this their retention capacity is reduced to a minimum. Moreover, nets are put on the overflows in order to protect the fish not to come out of the reservoirs. But at high flood wave the nets keep trees and branches and clog the overflows. Consequently, the water overflows in the crown of the dam and causes their damage and destruction, this leads to a drastic reduction in the ability to manage the risk of flooding in the valleys behind them.

3. Some of the small dams are functioning without major outlets. The main outlet is a mitigation facility, which like the overflow helps to ensure retention volumes in the reservoir and helps for the successful management of the flooding risk. The lack of working main outlets is the cause of ineffective risk management before emergency situation.

4. There is no information for what kind of security the dikes and levees on river adjustments are designed and constructed. It is important for determining to a large extent the approach and activities of managing the risk of flooding.

5. There is no accurate information from "W and C" companies of their water intake and treatment facilities of drinking and waste water near river beds, as well as their protection from high waves. This information is also very important for the activities of managing the risk of flooding.

6. A significant proportion of river beds has reduced conductivity due to strong afforestation with trees and shrubs, as well as construction waste and illegal buildings. Method used until now for cutting trees and shrubs in river beds does not give good effect due to the prolonged low water in them. Cut

willows and other water-loving trees and shrubs increase their root system. Every year this activity needs to absorb significant amounts of the budgets of municipalities and the state.

7. The dam walls, which are from a high quality, have overflow facilities for security 1%, 0.1% or 0.01%, and the protective embankments on the rivers adjustments under the current regulations, should have been built for security 5 % (for farmland and meadows) or 1% security (for settlements and industrial sites). This means that each wave with high security 4%, 3%, 2% and below 1% will threaten crops in farmlands, settlements and engineering infrastructure after dams.

8. Usually, the construction of residential or service buildings, engineering infrastructure (water supply, sewage systems, roads, railways, gas, heat supply, product, bridges, etc.) in our country are build for a lifetime of 50-100 to 150 years, which requires their sustainable and efficient use. When they are located in the floodplain of rivers is necessary to take additional measures for sustainability, which significantly increases the cost of society. At the stage of the Preliminary assessment of flood risks for the comparability of results across the country is entrusted to study the flood risk with regulated probability (frequency) of the event once in a hundred years. Therefore, in this study, the destruction of potentially hazardous dams that are in default condition can be modeled, an event whose probability is estimated in the order of 1%.

In the next, more detailed stage of determining the hazard and flood risk - developing maps of areas at risk of flooding - and events with less than 100 years probability should be modeled, and then it should take into account the contribution of seismic hazard in assessing the impact of dams on the risk of flooding. For the purpose of risk management is necessary to analyze to what extent the risk of potentially dangerous dams is controlled and to what extent uncontrolled. To simulate the destruction of potentially dangerous dams that are not significant, and the overflow of major dams in the area of Kamchia, which threaten populated areas and industrial sites, as well as objects of engineering infrastructure.

Based on raw materials and assessments the surveying, hydrological and hydraulic studies and modeling were made. [3, 7, 8]

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