NATIONAL MILITARY UNIVERSITY
"VASIL LEVSKI"
FACULTY OF ARTILLERY, AD AND CIS

DEPARTMENT OF COMPUTER SYSTEMS AND TECHNOLOGY

Delyan Sabev Slavov

POSSIBILITIES FOR THE APPLICATION OF GEOGRAPHICAL INFORMATION SYSTEMS FOR TROOP MANAGEMENT

ABSTRACT

of dissertation

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Scientific supervisior

Prof. Eng. D.Sc. Andrey Ivanov Andreev

Reviewers:

Col. Prof. Dr. Eng. Ph.D. Chavdar Nikolaev Minchev
Prof. Dr. Eng. D.Sc. Yuri Ivanov Dachev

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The security materials are available to those interested in room No25210 of the Faculty of Artillery, PVO and KISS of V. Levski National University, tel. 054/801040 tel. 54279.

Author: Delyan Sabev Slavov

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I. GENERAL CHARACTERISTICS OF THE DISSERTATION WORK

1. Topicality

Serious problems in the security of the Republic of Bulgaria in recent years have manifested themselves in the prevention, management and reduction of losses due to natural disasters and technogenic accidents.

A rapid and timely response to natural disasters such as heavy snowfall, floods, earthquakes, landslides, storms and technogenic catastrophes and incidents that cause significant damage to economic, residential and infrastructure sites is essential in the work of the executive authorities. Some of them cover significant territory of the country, last for days, manifest themselves repeatedly, engage significant human, material and financial resources and are a real test of the capabilities of the national crisis management system.

The state's ability to prevent and manage crises and protect its citizens, material and cultural values in critical situations are determined by the existence of a functioning national crisis management system. Its establishment and functioning requires a relevant legal basis, its structural building , regulated powers of the state authorities responsible for management and resource provision. Over the years, the activities of the national crisis management system, natural disasters and technogenic catastrophes can be assessed as satisfactory.

Existing early warning (disclosure) systems of the population have maintained their structure and functions mainly since the 70-80 years of the last century. They essentially use centralised technical approaches, solutions and civil defence tools and cannot be effective under modern socio-economic conditions. For this reason, it is obvious that they do not meet the modern requirements for an adequate response to the expanding challenges, risks and threats facing our country.

Of particular importance for interoperability of systems with those of neighbouring countries and EU countries. It is relevant to pay attention to geographic information systems (GIS), global navigation satellite systems (GNSS) and remote sensing (DS), technical means of registration and transmission of data, unification of databases, methodologies, etc., so that early warning systems can be integrated into a system of prevention and management in the event of natural and other disasters.

Geoinformation systems are modern computer information systems for processing, mapping and analysis of geospatial information. GISs are a natural and necessary component of any information system in which spatial data is available. They can be seen as a modern computer technology for automating mapping and analysis of real-world objects, which combines traditional database operations with the advantages of complete visualization and geospatial analysis.

THE adaptation of GIS, GNSS and remote methods, automatic registration, transmission and processing systems in the structures of departments and institutions at state, regional and local level for timely modeling and formation of optimal solutions by management on national security issues is of utmost importance.

Of particular importance is the creation of models involving the development of methodologies for working with systems for the acquisition, registration and transmission of data in extreme situations, methodologies for the establishment of disaster protection plans, methodologies for assessing critical infrastructure and conducting trainings to increase the administrative capacity of the management bodies at national, regional and local level, competent institutions and organisations for prevention, preparation, management, response and recovery from disasters and accidents.

Assessments of security challenges, risks and threats call for the conclusion that the development of the global and regional security environment will for a long time remain dynamic and controversial with the possibilities of complication.

As a result of the review of the actuality of certain aspects and problems of national security, the purpose and scientific tasks of the dissertation work are formulated.

2. Purpose and tasks of the study

Assessments of security challenges, risks and threats call for the conclusion that the development of the global and regional security environment will for a long time remain dynamic and controversial with the possibilities of complication.

As a result of the review of the actuality of certain aspects and problems of national security, the purpose and scientific tasks of the dissertation work are formulated.

Objective – ***To analyze and evaluate the possibilities for monitoring with modern technical and geoinformation systems for reporting, registration and transmission of data on natural disasters of the type of floods.***

In order to achieve the objective set, the following tasks must be **decided:**

1. Analyse and evaluate methods, institutions and legislation in force to ensure security, natural disasters and crises.

2. Analyze and evaluate the capabilities of technical systems for reporting, registration and transmission of data and geoinformation systems.

3. *Develop a modern methodology for establishing a system for monitoring geospatial objects in critical situations.*

4. To experiment and prove the effectiveness of the methodology and technologies for a specific region of the territory of the Republic of Bulgaria.

The main working hypothesis of the study *is: The existing problems in disaster security - floods and the rich possibilities of theories and technologies that offer the integration of monitoring systems and geoinformation systems to solve them.*

The application of modern data reporting, registration and transmission systems and geoinformation systems gives new insight into the practice and can lead to successful conceptualization of problems, formulation of effective solutions for the prevention of human casualties and material losses. The study of methods of generating security through analytical approaches ensures the reduction of hazards and threats at national and local level.

The generation and modelling of security through the use of modern systems for reporting, registration and transmission of data and geoinformation systems is still not a sufficiently studied problem. This problem is given a major place in the dissertation work.

The subject of this study are disasters of the type of floods affecting national security, analyzed through the prism of technical monitoring systems and geoinformation systems.

The subject of the study is the construction of a technical system and geoinformation technologies for effective resolution of disaster security problems such as floods on regional and local sections of the territory of Bulgaria.

The scope of the study is: theoretical; temporal - from 2019 to 2021, with a special panel of experimental studies to confirm theoretical conclusions and reasoning. Priority is given to the problems of security modelling with the monitoring system and geoinformation systems at national and local level.

Methodological basis of the study are known fundamental theories in security , theory of functionalism and systemic approach.

Scientific methods are used: methods are used entirely to prove the work hypothesis adopted by the author. The performance of specific tasks is achieved by the following analytical research methods: historical and logical analysis of factors limiting dangers and threats to national security; priority factors of security in natural disasters; analysis and synthesis; modelling; comparison; induction and deduction; abstraction; logical analysis; idealisation and formalisation.

Expected results, limitations and users

As a result of the study, it is expected to prove that modern monitoring systems and geoinformation technologies are extremely powerful tools in security modelling in risk assessment, analysis and management in natural disasters.

Limitations in the study are for: (a) the temporal approaches of the comparative analysis; (b) location – activities and objects of potential threats and risks in national security; (c) degrees of influence of various factors; (d) manageable factors in security subsystems; (e) legal acts, national and international legislation to limit the dangers, threats and risks to national security, etc.

With the degree of relevance of the issues under consideration, the subject matter and scope of the study, its objectives, tasks, methodology, theoretical basis and expected results, the range of users of the study is very large. It consists of researchers interested in the problems of monitoring systems and geoinformation technologies in the field of security, heads of state and local authorities, specialists in the field of fire safety and protection of the population. Teachers in higher education institutions dealing with security issues in disasters, accidents and catastrophes based on geoinformation technologies, etc. can also be added to the users of the dissertation.

II. **VOLUME AND STRUCTURE OF THE DISSERTATION**

The dissertation has a volume of 123 pages and consists of an introduction, three chapters, conclusion, annexes, a list of abbreviations used, a list of the literature used.

The introduction justified the topicality of the problem, the subject matter, the purposes and tasks of the study. Each chapter is structured in several sections and conclusions have been drawn at the end of each chapter on the issues under question. The conclusion presents the main conclusions of the study.

The structure of the dissertation work includes:

1. Analysis and evaluation of the possibilities for monitoring geoinformation sites in critical situations

1.1. Security analysis

1.2 Analysis of the status and capabilities of institutions and departments for monitoring geoinformation sites

1.3 Analysis of GIS's monitoring capabilities

1.4 Types of flooding in the Republic of Bulgaria

Conclusions:

2.Methodology for establishing a monitoring system for geoinformation sites in critical situations

2.1 Methods for identifying flood-prone areas

2.2. Early Warning System (JTRS)

2.3. Early warning system model

2.4. Assessment of the reliability and effectiveness of flood monitoring and warning systems

2.5 Methodology for establishing a system for monitoring geoinformation sites in critical situations

Conclusions

3. Experimental studies of the flood monitoring and warning system

3.1 System field model

3.2. Results and analysis of experimental study data

3.3. Computer-simulated flood patterns in the GIS environment

Conclusions

Conclusion

Application

III. BRIEF DESCRIPTION OF THE DISSERTATION

The introduction justifies the actuality of the study, defines the purpose, research tasks, subject matter and subject of the dissertation, the approach adopted and the methods used.

CHAPTER 1. ANALYSIS AND EVALUATION OF THE POSSIBILITIES FOR MONITORING GEOINFORMATION SITES IN CRITICAL SITUATIONS

1.1. Security analysis

Security is characterised by contradictory, dynamic and highly foreseeable changes that are blurred in the conditional divisions between internal and external, military and non-military, traditional and non-traditional risks and challenges. Their continuous evolution requires the search for common approaches to neutralise them and maintain active cooperation between political, military and civilian structures at global, regional and national level.

National security is characterized by three levels of security: the person, the society and the state.

The security of the person is achieved by providing legal and moral norms and building an institution that enables the development of abilities and satisfies the needs of everyone.

The security of the State means the existence of an effective mechanism for the management and coordination of public groups and political forces, as well as of active institutes for their protection.

The security of society means the development of institutes, norms and public awareness in order to realize the rights and freedoms of all groups of the population.

1.1.2. Assessment of challenges, risks and threats

An increasing threat to the security and sustainable development of the Balkan countries and the Republic of Bulgaria were acquiring environmental problems.

Crisis situations resulting from catastrophic natural disasters and industrial accidents increased security risks and required additional resources, resources, adequate capabilities and coordinated efforts to prevent and manage them nationally and internationally.

In this regard, the Updated National Security Strategy of the Republic of Bulgaria (SG 26/03/2018) is recorded as vital protection of the population and critical infrastructure in the case of crises, disasters, accidents, catastrophes and other risks and threats. According to THE LAW of Article 6, Defense shall ensure participation in the management and/or prevention of the consequences of disasters) The Minister of Defense shall authorise the participation of military units in the management and/or resolution of the consequences of disasters on the basis of a request received by the relevant state body under the plans for conducting rescue and emergency reconstruction works (PZOS Art. 26)

It is essential in the work of the executive authorities to respond quickly and in a timely manner to natural disasters such as heavy snowfall, floods, earthquakes, landslides, storms and technogenic catastrophes and incidents that cause significant damage to business, residential and infrastructure sites. Some of them cover significant territory of the country, last for days, manifest themselves repeatedly, engage significant human, material and financial resources and are a real test of the capabilities of the national crisis management system. [21]

1.1.3. Acquisition of information from open sources.

A source of information may be any person, group of people, separate means or means and systems that can be used to monitor, register and transmit information about conditions, conditions, conditions, settings and/or actions of a observed object or group of objects. Open Source Intelligence-OSINT are elements of our environment that are of interest to the needs of a system, access to which is conditionally free [10]. Depending on its content, information from open sources may be intended for the mass reader/listener or for a limited range of persons. It can be distributed through radio, television, various print editions, DATABASES, internet, etc.

System information, diagnostics

The other group of information shall be those which make it possible to describe the direct object of activity so as to use the resulting description for effective management. This information is obtained by diagnostics.

A. Nature and basic concepts of diagnostics [17]

The term "diagnostics" means recognition, determination. In the process of diagnosis, the diagnosis is obtained, that is, the condition of the researched object (system) or process is determined.

Diagnostics is a set of cognitive and organizational methods and procedures for identifying the state of a system (organization) by measuring specific, instantaneous values of certain parameters, revealing the sources of interference and outlining the guidelines for their removal. The diagnosis expresses the specific results of the studies carried out. It must answer the following questions: What are the sources of the causes and why did they cause this condition?; What sequence of events has led to the present state?; In what phase of development is the "disease state" (onset, complete development or phase "extinction")?

1.1.4. Basic technologies for the functioning of the security system

In order to avoid unstable states and system decay, it is periodically aligned with the set algorithm of operation. For this purpose, successive operations (workflows) are performed and their respective results are obtained. The latter should be taken as the reason and beginning of the next operation.

1.1.4.1. Monitoring and diagnosis

Surveillance is a process inherent in any system. In this process, three groups of information are obtained as a result, thereby removing the uncertainty of: the environment in which the organisation operates; the control subsystem; the subsystem is managed.

The conditions for a comprehensive description of a system and the environment are basically two: to have material, energy and information exchange between them; information on the organisation and environment at the same time intervals.

1.1.4.2. Information on the environment in which the system operates

Environmental information shall make it possible to describe the situation in which the system operates. In different situations, one or other conditions matter and it is important to establish how they affect the system.

Many factors determine the choice of areas and methods of observation: the rate of environmental change; the area of change; complexity of the decision-making problem; the importance of the problem to the system as a whole; the accumulated knowledge of trends in the development of the environment; time remaining to respond to interference, etc.

The Early Warning System (JTRS) is designed to monitor the organisation's environment in order to locate early and determine the state and trends of development that may jeopardise the achievement of the long-term objectives of the system.

1.2 Analysis of the status and capabilities of the institutions and departments for monitoring geoinformation objects.

1.2.1 Analysis of information systems in institutions and departments providing disasters, accidents, catastrophes and crises as elements of national security

The territory of the Republic of Bulgaria is vulnerable to various natural disasters, such as earthquakes, floods, landslides and falling rock debris, intense rainfall, storms, forest fires and others. The country is also threatened by disasters and accidents of a technogenic nature, which can cause significant losses in terms of human and material resources.

A) In the Republic of Bulgaria, the following information systems (IS) are currently in place in the institutions and departments:

1/ Automated civil protection disclosure system;

2/ Local population disclosure system in the zone of Nuclear Power Plant /PP/ Kozloduy;

3/ National Operational Telemetry System for Sesmological Information (NOTSSI);

4/ National system for control of radiation gamma background;

Global Disaster Notification and Coordination System - GDACS

GDACS is a framework for cooperation under the auspices of the United Nations. It includes disaster managers and disaster information systems around the world and aims to fill information and coordinate the gap in the first phase after major disasters. GDACS provides real-time access to web-based disaster information systems and related coordination tools.

At this stage, the general risk management programme includes the following strands:

2. ***Floods;***
3. ***Earthquakes;***
4. ***Forest fires;***

5. ***Disasters and accidents;***
6. ***Pollution;***
7. ***Landslides;***
8. ***Integrated risk.***

1.2.2 Competent authorities

According to the legislation in force in the country:
a) The Council of Ministers
b) The Ministry of Environment and Water
(c) The Ministers and bodies under Art. 19, of the Administration Act
(d) The Regional Governor
e) The Mayor of the Municipality
(e) Other institutions and organisations

1.3 Analysis of GIS's monitoring capabilities

1.3.1 GIS analysis

Geoinformation systems (GIS) are modern computer information systems for processing, mapping and analysis of geospatial information. GISs are a natural and necessary component of any information system in which spatial data is available. They can be seen as a modern computer technology for automating mapping and analysis of real-world objects, which combines traditional database operations with the advantages of complete visualization and geospatial analysis.

GIS is not a completely new technology, but a set of new-related elements of known technologies.

The rapid development of computer technology over the past two decades has made GIS a strategic scientific strand with wide application in the business of countries.

GIS processes, stores and analyzes geospatial data.

In terms of informatics – GIS is an integral system of application software, hardware and trained staff

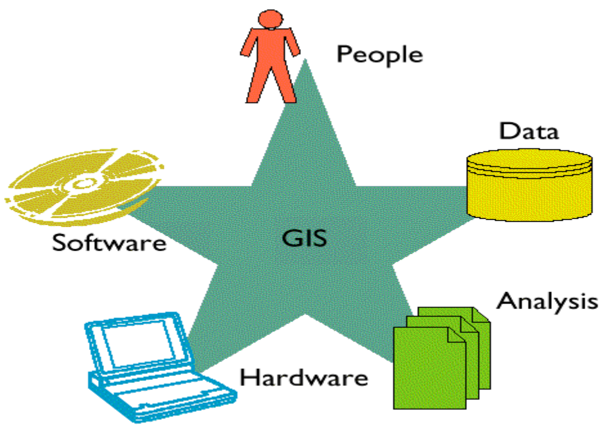

Fig.1.2 GIS components

In most GIS, complex processing of information is performed – from data collection and their storage and processing to their visual presentation. Such GIS are called full (full-functional) or universal. The most famous of these are ArcInfo/Arcview, ArcCAD and WinGIS (ESRI); MapInfo (mapInfo), AutoCAD Map, Intergraph (intergraph MGE), AtlasGIS(n& Strategic Mapping), SICAD/open (siemens), SpanGIS, etc. [43]

Many of the known GIS are desktop, designed for personal computer, mainly used for analysis and presentation of geographical data. [13]

The aim is to create opportunities for the establishment of a national GIS network in Bulgaria, through which to establish links between the different actors in the process of creating, using, distributing and training of NGIS. The network thus built must become part of the infrastructure of the GIS in the European network.

1.3.2 GIS modelling

In GIS modelling, it is possible to separate the following programming and technological blocks.

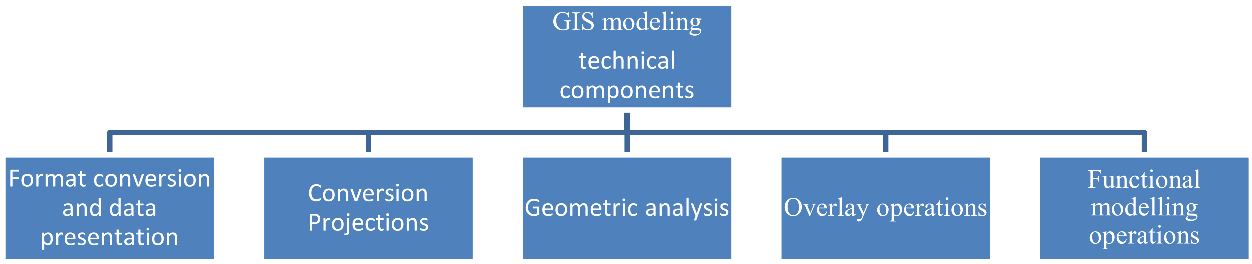

Fig. 1.5. Programming and technology blocks used in GIS modelling

1.3.3 Analysis of remote drilling (DS) integration capabilities with GIS.

Remote sensing (DS) is a scientific strand based on the sum of information about the Earth's surface without actual contact with it.

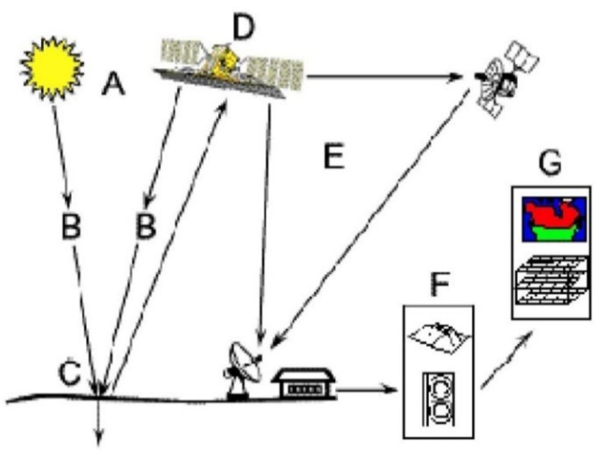

Fig. 1.6. Stages of the State Security

Areas for the application of satellite remote sensing (SDS):

9. ***obtaining information on the state of the surrounding environment and land use;***

10. ***assessment of the agricultural harvest;***
11. ***studying flora and fauna;***
12. ***assessment of the consequences of disasters (earthquakes, floods, fires, epidemics, etc.);***
13. ***assessment of land and water pollution damage;***
14. ***oceanology, etc.***

1.3.4. Satellite image analysis

For the efficient use of DS data in GIS, it takes a skill to extract useful information from the satellite image. The process of interpretation and analysis of images by the State Security is defined as digital image processing and consists in the identification and/or measurement of parameters in the observation area

1.4 Types of flooding in the Republic of Bulgaria

Theoretical approach to flood typing

Different types of flooding can be typed on the basis of different signs:

- ***source;***
- ***reason for the formation of the water mass;***
- ***geographical area of the event;***
- ***in a manner of manifestation over time;***
- ***TSC and technical infrastructure.***

Classification signs for flood typing are presented in Table 1.2.

Table 1.2. Identification of flood types

Sign	I type	II type	III type	IV type	V type
Source	marine	River	Atmospheric	Underground	Infrastructures
Area	Coastal	Estuary/Delta	Surface	-	-
Weather	Gradual	Sudden	Sudden		Sudden
		Gradual			Gradual
TYPE	marine /coastal/	river/oral	/surface /rainy/	Underground	Infrastructure / sudden
	Gradual	river /oral/ gradual	Sudden		infrastructure/ gradual

The relative share of the individual types of floods is presented in Fig. 1.8

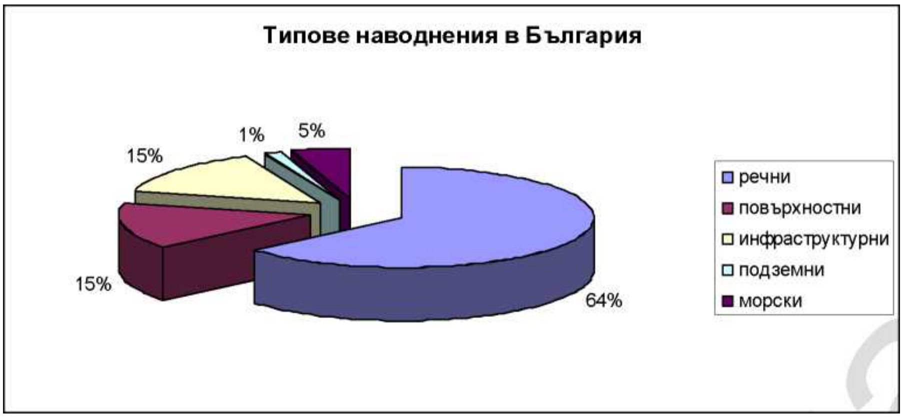

Fig. 1.8. Types of floods in Bulgaria

River floods are the main type of floods for Bulgaria. Their share accounts for 64% of the total number of cases.

Conclusions:

1. Threats of disasters and accidents in recent years have a significant impact on the security of the country. The introduction of new, modern methods for generating and modelling security and information communication technologies is needed.

2. Through interoperability with the relevant systems of THE EU, the UNITED NATIONS and other international organizations and countries, the Republic of Bulgaria must ensure the prevention and relatively effective action of the state in crises of a different nature.

3. Existing early warning/disclosure systems are old, as are their structure and functions and cannot be effective under modern socio-economic conditions. For this reason, it is obvious that they do not fully meet the modern requirements for an adequate response to the expanding challenges, risks and threats facing our country.

4. Geoinformation systems are modern computer information systems for processing, mapping and analysis of geospatial information. GISs are a natural and necessary component of any information system in which spatial data is available. They can be seen as modern computer technology for automating mapping and analysis of objects in crisis situations.

5. It is necessary to establish a modern technical system (monitoring and warning systems) integrated with the GIS for disaster and accident prevention.

CHAPTER 2. METHODOLOGY FOR ESTABLISHING A SYSTEM FOR MONITORING GEOINFORMATION SITES IN CRITICAL SITUATIONS

It's a general.

Floods are most often the result of rainstorms, melting snow or prolonged rainy weather. They pose a serious danger to the property and lives of people in some regions.

2.1 Methods for identifying flood-prone areas

2.1.1 Horizontal distance criterion

The simplest method for assessing the threat of flooding is the introduction of a horizontal distance criterion.

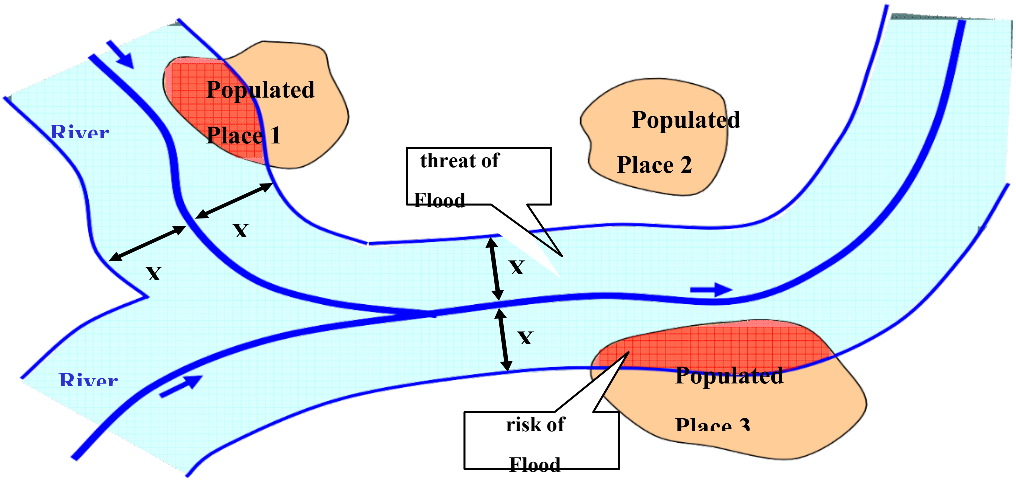

Fig. 2.1. Schematic sketch of the horizontal distance criterion

2.1.2 Vertical distance criterion

In this method, it is assumed that there is one, considered from the lowest point of the river valley, a constant depth of pouring - vertical distance. By comparing the defined constant depth of pouring with the digital model of the terrain, areas at risk of flooding (Figure 2.2) can be directly identified.

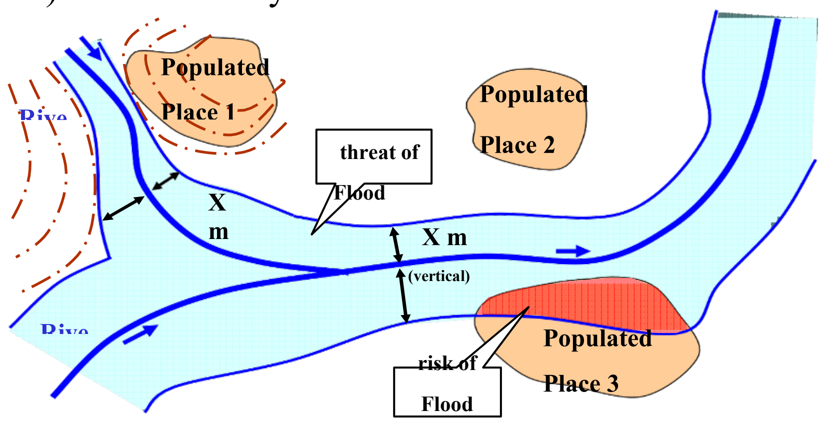

Fig. 2.3. Schematic sketch of the vertical distance criterion

2.1.3 Standard method for determining the potential threat of flooding in GIS - environment

As a standard method for determining the potential threat of flooding, the normal depth calculation method based on high-altitude SRTM data is proposed. The chosen method allows to approximately set the flood areas for high wave with a security of 1%, respectively with a recurrence period of 100 years.

2.2. Flood early warning system (EWS)

The Early Warning System (JTRS) is designed to monitor the organisation's environment in order to locate early and determine the state and trends of development that may jeopardise the achievement of the long-term objectives of the system. [51]

2.2.1 Key elements of the system

Each early warning system consists of four elements: Risk Assessment, Monitoring and Warning Services, Dissemination and Communication, and Response Readiness

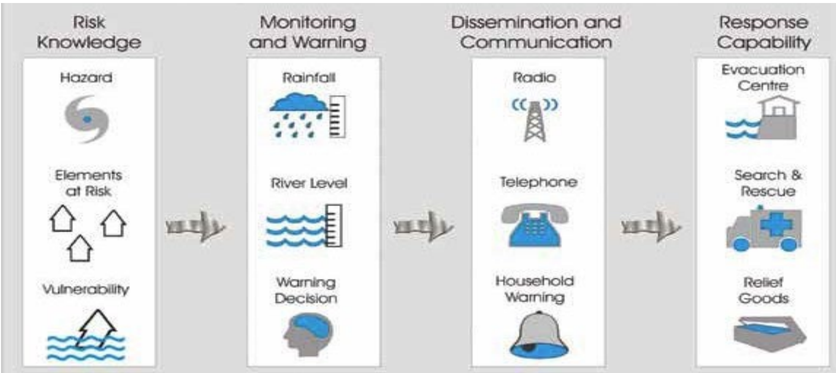

Fig.2.5 Key elements of an early warning system

2.2.2. Analysis of components and technical means of monitoring and warning systems

Monitoring and warning systems can be built by various technical means, the complexity of the system depending on the accuracy of the prediction and the timely alarm that needs to be achieved.

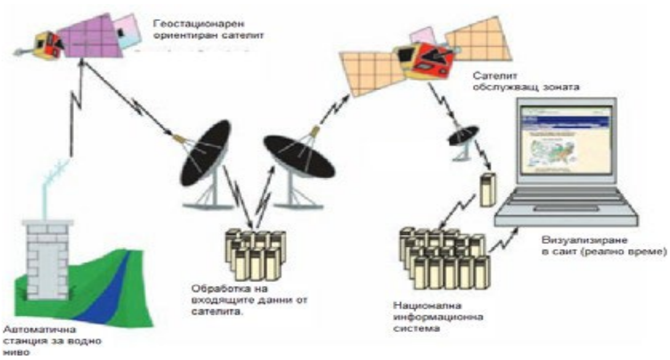

Fig.2.6 Indicative scheme of an automated information system

Different sensors are used in the monitoring and warning systems depending on the complexity of the system and the required accuracy.

2.2.2.1. Recording devices - sensors for measuring the level of bodies of water:

Float level meters
Capacitive level meters
Hydrostatic level meters
Ultrasonic Level meters
Radar level meters
Dynamometer level meters
Magnetic level meters
-Rainfall measuring stations

Weather stations retrieve data through sensors, which are processed by a microcontroller and via GSM the information is transferred to a server.

Fig.2.7 Weather station

2.2.2.2 Transmission environment and means of transmission of information to a processing and storage and warning centre

-Network transmission environment

The network transmission environment provides signal transmission between computers and other devices connected to the computer network. [30]

Network wiring

When building a computer network, the main way to connect between computers is by using a cable.

Fiber optic cable

Fiber-optic is different from other forms of network wiring because it transmits pulses of light rather than electrical impulses. This allows for much higher data transfer speeds – the optical cable can transmit data at speeds of up to 40 Gbps.

Wireless transmission environment

Wireless computer networks are becoming more popular these days. They have a number of advantages:

- ***the need for wiring is eliminated;***

- ***computers are not tied to a specific workplace;***
- ***a new computer is easily connected to the network.***

WPAN - Bluetooth devices

Bluetooth wireless technology is designed to connect computers, phones and mobile accessories over short distances, creating a PERSONAL LOCAL AREA NETWORK.

GSM communication

The signal in the GSM network is digital – a number of bits corresponding to speech or data. As for most low-frequency communication signals, it must be "uploaded" to a higher frequency carrier signal (modulation) and thus "convey" on the network. Which electromagnetic spectrum ranges are best suited for the frequency channels capable of "conveying" speech on mobile networks? which at first some might be surprised. It turns out that it is best to have the frequency channels for mobile communications in a not particularly wide range from 400-450 MHz to 2000-2100 MHz.[12]

2.2.2.3. Means of powering the components of the system.

The power supply of the system components can be done in several ways:

- ***-power supply from the central electricity distribution network;***
- ***-battery power;***
- ***-power supply through solar collectors.***

Fig. 2.12. Power sources for a warning system

2.3. Early warning system model

2.3.1. System requirements

- The system should be easily upgraded and integrated with other information systems relevant to disaster and accident prevention at local, regional and national level;

- To ensure the collection of information from monitoring points at a certain period of time, meteorological stations and deployed cameras for monitoring stations and water levels and sending it in real time in a communication environment;

-The communication software should ensure the transmission and validation in real time of data collected from the monitoring points to the Operational Center, to be located in the technical infrastructure of shumen municipality;

2.3.2. Structural scheme of a monitoring and warning system

The monitoring and warning system must include the following key components:

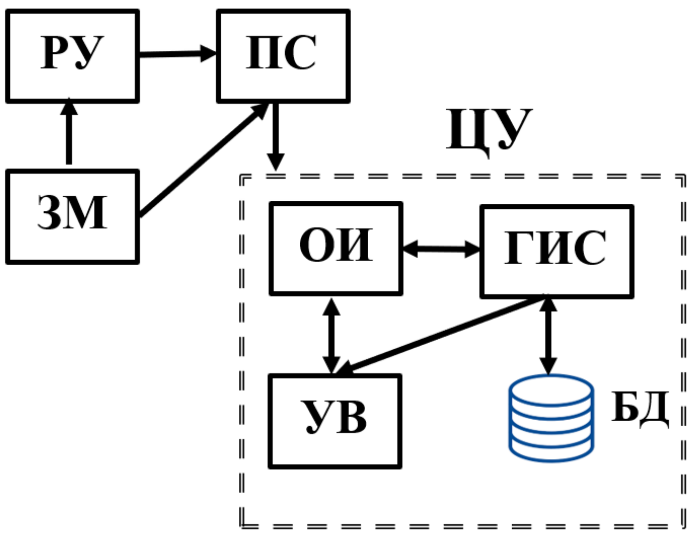

Fig. 2.13. Structural scheme of a monitoring and warning system

РУ-registration unit, ПС- communication channels, ЗМ- power supply module, ЦУ-management center, ОИ- information operating, ГИС- GIS, УВ- visualization module

,2.3.3. Technical characteristics of system components

A) Sensors for measuring liquid level

Fig.2.13. RAVEN-EYE sensor

The RAVEN-EYE sensor measures the flow rate in open channels using radar technology. The appliance is designed to withstand immersion during overload conditions. Additional level sensors show the UNI-TRANS monitor data for measuring water level during normal operation.

(B). Sensors for measuring rainfall

Wireless Electronic Rain meter - Weather Hub - 30.3306.02

Fig. 2.14. Wireless electronic rain meter

2.3.4. Power supply to system components

PHOTOVOLTAIC SYSTEM WITH 100 WP MONOCRYSTALLAL SOLAR PANELS

This photovoltaic system includes a 100Wp solar panel, a 10A solar controller, a 12V 75Ah rechargeable battery and an inverter - a voltage converter from 12V to 220V with a power of 300W, guarantees you normal biting in conditions without power supply.

Fig. 2.17. Photovoltaic system

The system includes:

1 pc. Monocrystallal photovoltaic module 100 Wp - 1 pc.; Traction gel rechargeable battery 12V 75Ah - 1 pcs.; PWM Solar controller 12V 10A -1 pcs.; Modified inverter - converter from 12V to 220V with power 300W

Transmission of information

It is important to note that in the actual construction of the system, sensors and weather stations equipped with gsm transmitter and date lager should be selected, which is laid down in the requirements of the draft contracting er in accordance with the financial frameworks.

Software

Unique systems for forecasting and warning of impending floods have been set up under EU-funded projects. Thanks to real-time monitoring and timely warnings, systems such as Imprints, WeSenseIt and UrbanFlood can save lives and prevent damage to property, infrastructure and the environment.

The Imprints platform helps to respond to flash floods in about 2 hours and even less – thus people will have more time to leave the danger zone. The system is based on better rainfall forecasts and the use of weather models and radar networks to monitor the weather.

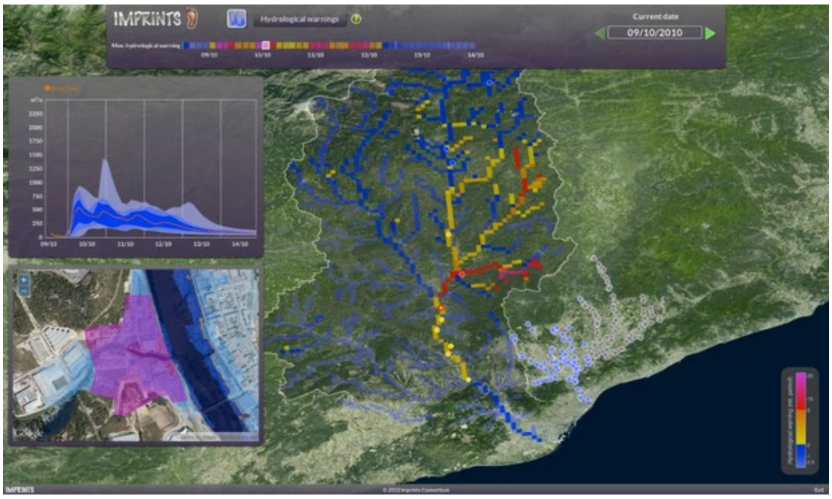

Fig. 2.18. Imprints Platform

2.4. Assessment of the reliability and effectiveness of flood monitoring and warning systems

Introduction

Monitoring and warning systems (IPs) are often implemented as cost-effective measures to reduce the risk of natural disasters and provide timely information to reduce loss of life and damage from future or ongoing ones.

2.4.1. Reliability of flood monitoring and warning systems

According to [50], reliability is defined as 'the ability of an element to perform a required function under certain conditions for a certain period of time'.

$$POD = E\left[\frac{\text{number of detected events}}{\text{number of events}}\right] \quad (2.3)$$

$$PFA=E\left[\frac{\text{days with false alarms}}{days\ without\ alarms}\right] \quad (2.4)$$

where E[•] is a mathematical expectation.

Both VR and IFA are influenced by the interpretation of monitoring data. This is shown in Fig. 3. 2.19, which demonstrates the basic concepts of signal recognition theory. The measured signal may be due to either *disaster H* or noise *N* . The decision to issue a warning is based on the threshold t. If the measured signal is greater than t, a warning is issued. in the event of a disaster event H, *and* $f_{S1H1}(s)$ is a conditional PDF function of *S without* a dangerous phenomenon, (H1) it is [74,61]

$$POD_{(t)} = \int_t^{\infty} f_{S1H}\,(s)ds \quad (2.5)$$

$$PFA_{(t)} = \int_t^{\infty} f_{S1H1}\,(s)ds \quad (2.6)$$

The performance curves of the receivers summarise the reliability of the SMR for different thresholds and graphically represent the reliability of the system as a compromise between vr and IFA.

The overall reliability of the system as a combination of technical reliability and internal reliability of the system is also expressed by ROC curves. In view of this, VR and IFPs shall be calculated as the notional probability of warning in the event of a disaster, including the likelihood of failure of the system components.

2.4.2. Effectiveness of flood monitoring and warning systems

It is assumed that the effectiveness of risk mitigation measures is equal to the relative reduction of overall risk [37, 60]. It is proposed to calculate the effectiveness of E_W*R-1 MPa,* which is the overall risk without the MPA, but is the risk with the SMR system installed $R^{(w)}$

$$E_W = 1 - \frac{R^W}{R} \quad (2.7)$$

A warning system with a specific response time is considered, during which the only possible action is to reduce the *probability of presence from a peij value without warning* to a value . Combining $pe_{ij}^{(w)}$ equation (2.7) with equations (2.1) and (2.2), the effectiveness for this case becomes effective.

$$E_W = 1 - \frac{\sum_{j=1}^{n_{scen}} \sum_{i=1}^{n_{obj}} p_j \times pe_{ij}^{(w)} \times v_{ij} \times A_i}{\sum_{j=1}^{n_{scen}} \sum_{1=1}^{n_{obj}} p_j \times pe_{ij} \times v_{ij} \times A_i} \quad (2.8)$$

Most warning systems are mainly installed to alert people. Therefore, $_{nobj}$ is the number of people exposed to flooding and it is reasonable to assume that the probability of exposure is the same for different i, that is. $pe_{ij} = pe_j$. Addresses a situation with only one relevant scenario j = 1, and the alert efficiency decreases to:

$$E_w = 1 - \frac{p_j \times pe_j^{(w)} \times \sum_{i=1}^{n_{obj}} v_{ij} \times A_i}{p_j \times pe_j \times \sum_{i=1}^{n_{obj}} v_{ij} \times A_i} = 1 - \frac{pe_j^{(w)}}{pe_j}$$

(2.9)

$$E_w = POD \times 0.95(-0.34FAR^2 - 0.66FAR + 1) = POD \times (0.95 - 116PFR^2 - 11.9PFA), \ PFA \leq \frac{1}{19}$$

(2.15)

2.5 Methodology for establishing a system for monitoring geoinformation sites in critical situations

This methodology shall be established in order to define the stages for the establishment, use and servicing of the flood-type disaster monitoring system.

2.5.1. Determination of possible sources of flooding in the territorial unit

- examination of bodies of water;
- familiarization with the geography and parameters of the objects;
- tracking the history of objects;
- obtaining information on hazardous areas on the basis of data from previous years;
- tracking of flood data in the region for recent decades;
- identifying the most likely sources of flooding in the area;
- average rainfall during the different months of the year.

2.5.2. Preparation of source geoinformation materials

- sum of topographical and cartographic materials – classic maps and plans, digital models of the locality, information from Google maps Google Earth, etc.

- data from remote earth observation methods – space images, images from THE MARSH, etc.

- - examination of the specificities of the relief and facilities;
- -determination of soil type;
- -monitoring of run-off and water levels in recent years.

2.5.3. Selection of technical means for implementation of the system.

- examination of the parameters and value of technical means
- development of a scheme of system components;
- analysis and comparison of components;

- device selection and control software.

2.5.4. Installation and protection of the technical means of the locality system -

- selection of points from the locality for installation of the components of the system;
- selection of power sources;
- laying down measures to protect the components of the system;
- installation of the components.

2.5.5. System construction – connection of components and software

- planning and development of the system;
- definition of system functions and requirements;
- implementation of the system;
- testing of the system;
- determination of the reliability and effectiveness of the system;
- commissioning of the system

2.5.6. Determination of time interval and frequency of measurements;

- determination of the measurement period;
- determination of rainfall and water level monitoring frequency.

2.5.7. Presentation and processing of results

- analysis and presentation of results;
- display and visualisation of the data;
- generating alerts for disclosure in the event of a flood hazard;
- Interaction with other systems.

2.5.8. Actions in case of potential flood risk

Conclusions.

1. The analysis and classification of technical means shall allow for the correct choice of effective technical networks and systems for monitoring water levels.
2. The establishment of a model monitoring and early warning system shall comply with modern requirements of efficiency, accuracy, reliability and reliability and allow the integration of modern components, technologies and software.
3. The need for a modern system to predict and alert natural disasters has been demonstrated, which is built in accordance with modern European requirements.
4. On the territory of the Republic of Bulgaria, the current system is old and inefficient, built on old communication technologies and there is no methodology developed for its use and improvement.
5. The methodology developed for the establishment of a flood-type early warning system shall present the technology for the construction, use and servicing of the system.

Chapter 3. EXPERIMENTAL STUDIES OF THE FLOOD MONITORING AND WARNING SYSTEM

3.1 System field model

The field model of the system is based on the developed model and methodology in Chapter 2. The restrictions imposed are on the sensors and stations, which are placed on the area according to the financial frameworks of the experimental study.

3.1.1 Defining the likely sources of flooding in Shumen region

Significant possible sources of flooding

-Ticha Dam - volume 311 800 000 cubic meters - sudden rupture of the dam will cause flooding and will be affected part of the municipalities of Veliki Preslav, Shumen and Smyadovo, whereby electricity will be cut off. the power supply and water supply in the settlements of Khan Krum, Maram, Salmanovo, Radko Dimitrievo, Ivanski, Culnovo, Smyadovo, Yankovo and White Beach, as well as a interrupted part of the road communications;

-Golyama Kamchia River

The Big Kamchia River starts at Lisa Mountain. The River Golyama Kamchia from the springs to the town of Tchacha flows in an eastern direction, and after entering Gerlovo, it takes a northeastern direction, which is preserved to the Ticha dam. As you get closer to the Ticha dam, the slopes of the valley become taller and steeper.

- River Crow;

The River Vrana is the main drainage channel of the Targovishte region. It is one of the small rivers in Bulgaria. Its birthplace is in the area of Treadchiştiovo village, which is located at 526 m above sea level at the foot of the Omurtag Ridge. For starters, it serves a small spring located at 580 m., almost in the saddle between the peaks of Sary Baba - The Yellow Boy, 613 m high and the Big Rut - 596 m

3.1.2 Overview and capture of the area

The inspection of the area is carried out by crawling and monitoring the area.

In order to acquire a complete picture for the area and its shape and relief, a shooting of the area with FANTHOM IV pro V2 was taken.

Fig. 3.4. Orthophoto map of the area

3.1.3 Installation of the technical means of the locality.

For the purposes of the study, 4 meteorological stations were installed, two of them along the River Vrana and two along the Golyama Kamchia River near where the River Vrana flows.

Fig. 3.5. Digital wireless rain meter DROR

Fig. 3.6. Orthophoto map of a area of the Golyama Kamchia River with sensors 1 and 2

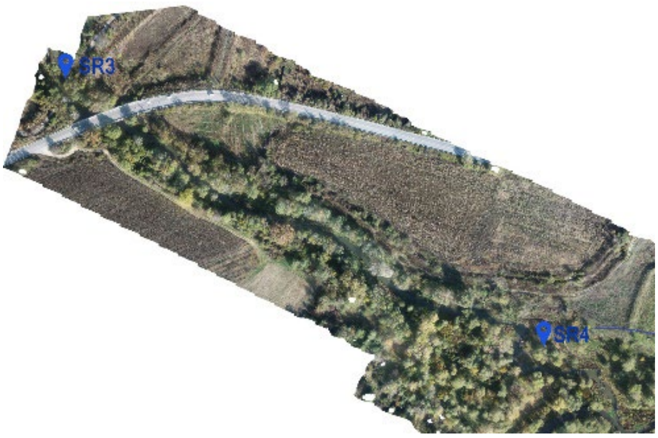

Fig. 3.7. Orthophoto map of a area of the Vrana River with sensors 3 and 4

Two measuring lati were also placed to monitor the level of the rivers, one on the bridge of the Golyam Kamchia River to the village of Khan Krum and one on the bridge of the River Crow.

Fig. 3.8. River level measurement lati

Fig. 3.9. Location of the lata of the Golyama Kamchia River

Fig. 3.10. Location of the lata of Vrana river

As well as a surveillance camera placed on the spillway on the wall of a dam Ticha.

3.1.4. Determination of time interval and frequency of studies

The time period for carrying out the surveys is about 4 months, with a season with more expected rainfall selected.

3.1.5. Action in case of potential flood hazard

The information received from sensors and systems shall be transmitted to the crisis centre of the district or municipality and, after the analysis and risk assessment, decisions on disaster actions shall be taken.

3.2. Results and analysis of experimental study data

The data obtained for the measurement period are presented separately for each month in tabular and graphical form, showing the difference between the estimated amounts of rainfall, the data from the NIMH and the values actually measured by the digital rain meters, as well as the relationship between the amount of rainfall in *mm* and the level of the Rivers Golyam Kamchia and Vrana in the region.

The change in river levels follows changes in rainfall levels, as high as the level of the River Golyama Kamchia – 248 cm measured on the bridge at the town of Khan Krum and the River Vrana -152 mm, at a measured amount of rain 22.9 mm on April 5 and 19 mm of rainfall on the previous day, with the Golyama Kamchia River emerging from its trough and a spill in the adjacent territory of the river after the bridge of Han Krum and Vranaand it is on the border of exit from the trough, and there is a real threat of flooding.

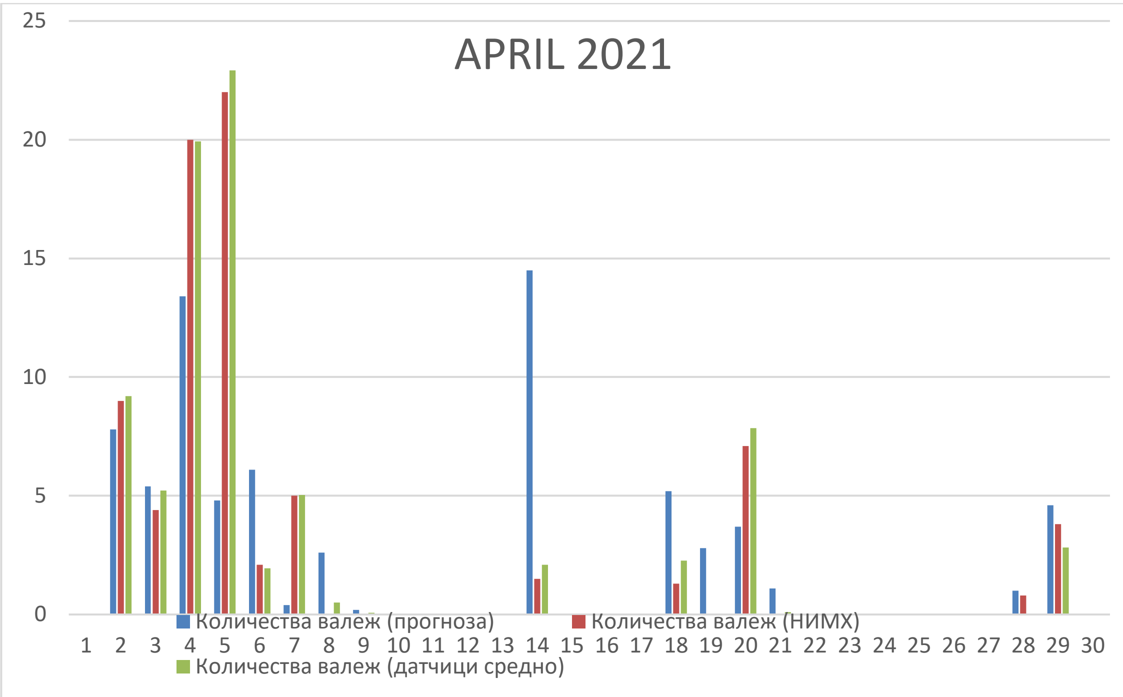

Fig. 3.13.in Quantities of precipitation by day for April

There have been slight changes in river levels during rainy days, with the highest level of the Golyam Kamchia river – 185 cm measured on the bridge at the town of Khan Krum and the Vrana River -133 mm, with a measured amount of rain 9.9 mm on May 16 and 4.4 mm in the next, and there is no risk of flooding.

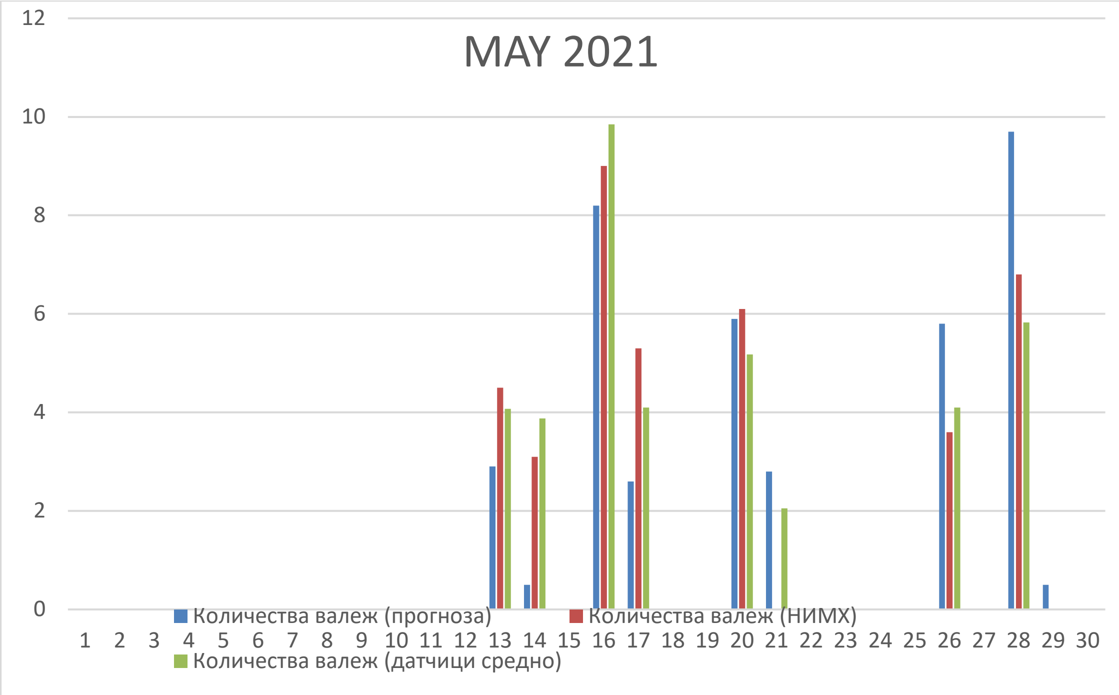

Fig. 3.14.c. Amounts of precipitation by day for May

Dynamic changes in river levels are observed during rainy days, with the highest level of the Golyama Kamchia river – 243 cm measured on the bridge at the town of Khan Krum and the River Vrana -159 mm, with a measured amount of rain 13.9 mm on June 20 and a total of over 57 mm in the previous 7 days, with the Golyama Kamchia River and the River Vrana coming out of their trough and spills observed in the area of the two the bridge, the spill is negligible, with no consequences and damage, but it is a signal of danger.

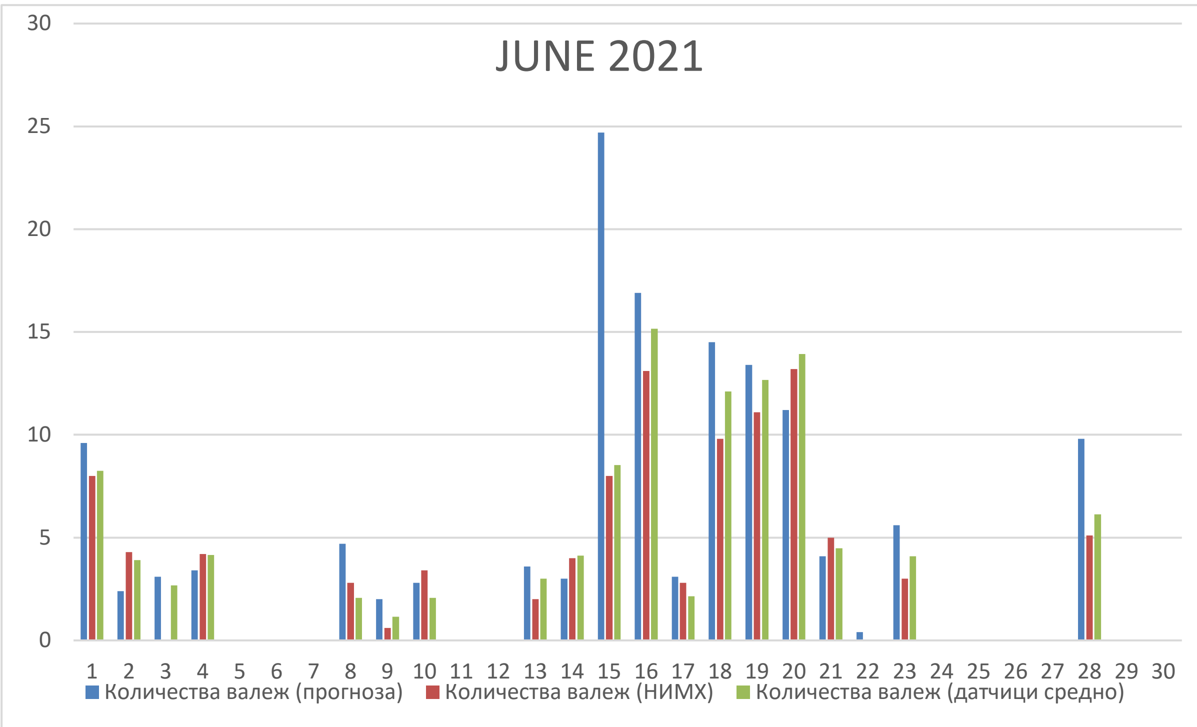

Fig. 3.15.c. Amounts of precipitation by day for June

They observed changes in river levels on rainy days, with the highest level of the Golyama Kamchia River – 192 cm measured on the bridge at the town of Khan Krum and the Vrana River -133 mm, with a measured amount of rain 7.85 mm on July 8, and there is no risk of flooding.

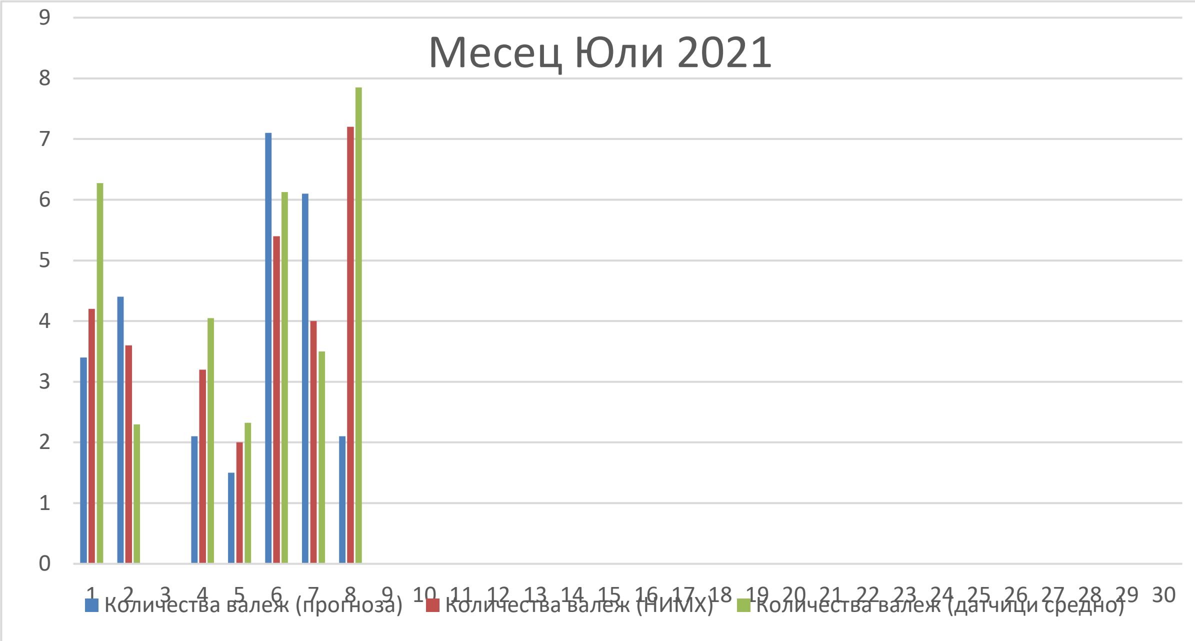

Fig. 3.16.c. Amounts of precipitation by day for July

On Fig. 13, 201 3.17. The quantities of rainfall by month for the last years (for which there is archival information) in Shumen region are depicted. In April, May, June and July, a lot of precipitation is observed, and in some months the amount of total monthly rainfall exceeds 100 mm, indicating that during the months of measurements rainfall is quite intense and emergencies can be expected.

Fig. 3.17. Amount of precipitation in 2007 -2012

3.3. Computer-simulated flood patterns in the GIS environment

The study, analysis, assessment and forecasting of flood risks shall be carried out on the basis of computer-simulated floods using geoinformation models and through locality expertise.

3.3.1. Determination of flood risk based on the potential flood threat

Once the assessment of past floods unambiguously indicates a significant potential flood risk for parts of the Kamchia River, probability assumptions and studies can theoretically be carried out. The study also shows a method for identifying potential flooding areas of the area. To this end, a standardised method for determining the potential flood threat was applied and an assessment of the risk involved was then carried out.

For this purpose, a digital model of the relief in the area studied was used. In preparation of the actual studies for the entire catchment of the Kamchia River were created by the method of triangulation of height SRTM points, height TIN and permission of the raster network - cell size - 1 m and 5 m.

With the help of the Panorama PK for the kamchia river catchment, an automatic regular network was created, which in each cell specifies the corresponding part of the area of the catchment. Using the specified criterion "water catchment area > 10 km²", the river network is obtained for the calculation of the potential flood threat. In compliance with the river network, there is a potential threat only to the Kamchia River.

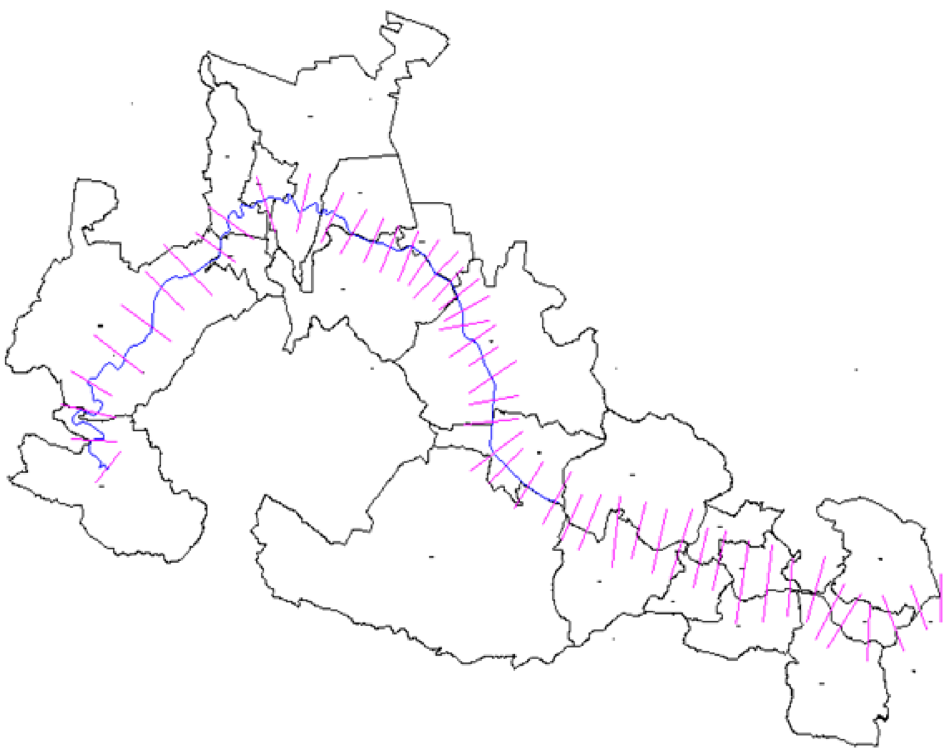

Fig. 3.18. Cross profiles of the Golyama Kamchia River

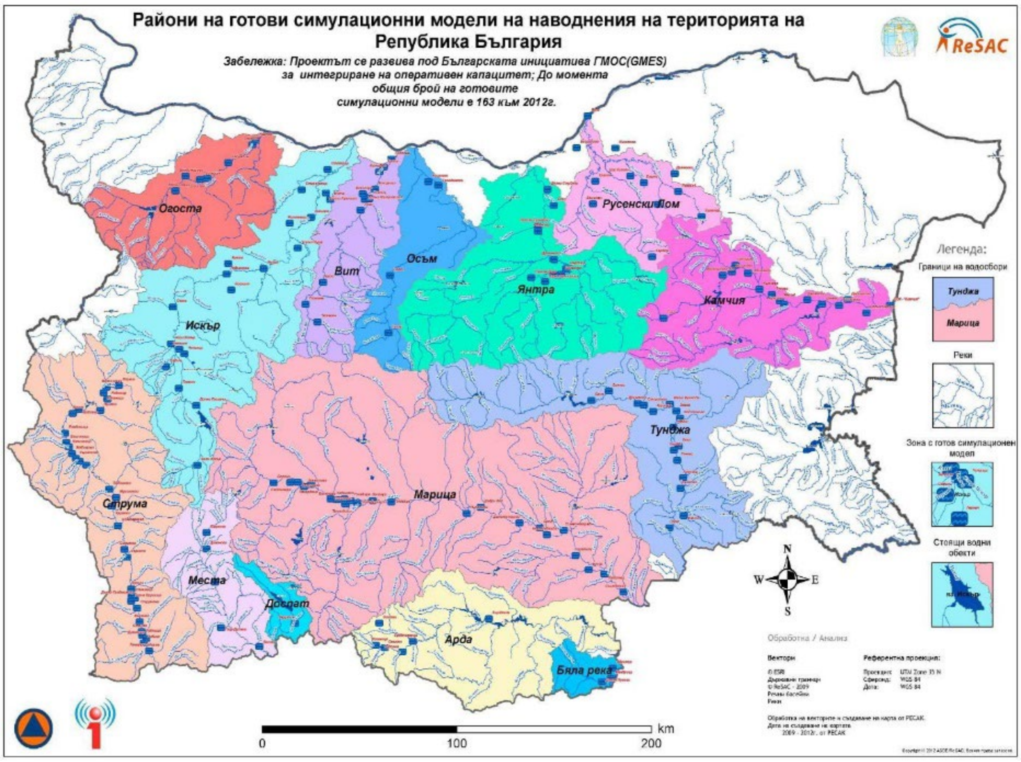

Fig. 3.20. Simulation model areas

On the basis of the automatically recorded area of the catchment, the relevant drain per 100-year period (Q100) for the river section concerned may be calculated.

Using a TIN model of the resulting new water technologies, a continuous water surface for the surveyed river area is obtained, which is compared with the digital model of the terrain. By means of a computational network determining the differences between the ground and the ground, a network of water depths is obtained. From this network of water depths, floodwaters are automatically obtained at a 100-year high wave.

On the basis of the calculated flood areas per n.e.m., the risk of flooding can be assessed. When comparing the built-up areas with the calculated flood-prone areas of the order of 10 ha. With an available population density of 393 inhabitants/ha, there are 3,930 endangered inhabitants. Furthermore, the imposition of flooded area and land use data (CORINE 2006) and further processing based on Google Earth information shows that in the settlement area. there is a risk of flooding for important industrial enterprises of high economic importance for the region, providing a large number of jobs. No detrimental effect on cultural heritage and the environment is expected in the event of flooding.

On the basis of the calculations made, the following results shall be obtained from the verification of the significance of the flood risk:

- 3,930 residents (> 100 affected residents) are affected, meaning a significant flood risk in relation to the protected categories of Human Health and Business
- important industrial areas concerned result in a significant risk significance

in relation to the protected category "Economic activity"

Thus, the area of kamchia explored in the settlement area is determined, regardless of the results of the assessment of past floods, as a section with a significant potential risk of flooding.

3.3.2. Use of a geoinformation model to simulate floods

For the successful identification of flooded areas, it is important to have a sufficiently accurate height model of the terrain (DEM). It is obvious that the more accurate the model of the terrain, the more precise and accurate the information that the created flood maps give. For this purpose dem is used on the territory of Kamchia river, developed by one of the two methods – digitization of topographic maps or photogrametric.

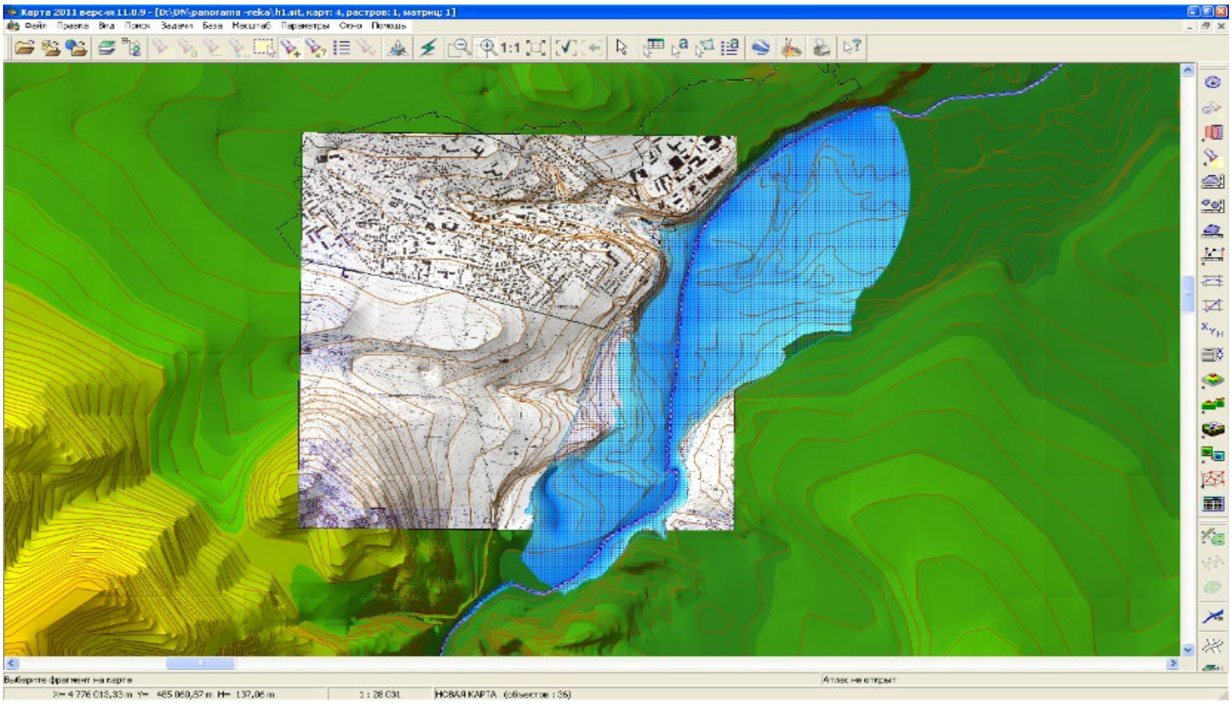

Fig. 3.21. Map of flooding in the area of Veliki Preslav

Determination of flood damage

With a geoinformation model created and a simulated flood with a certain wave height, the affected area can be defined in the form of a contour boundary.

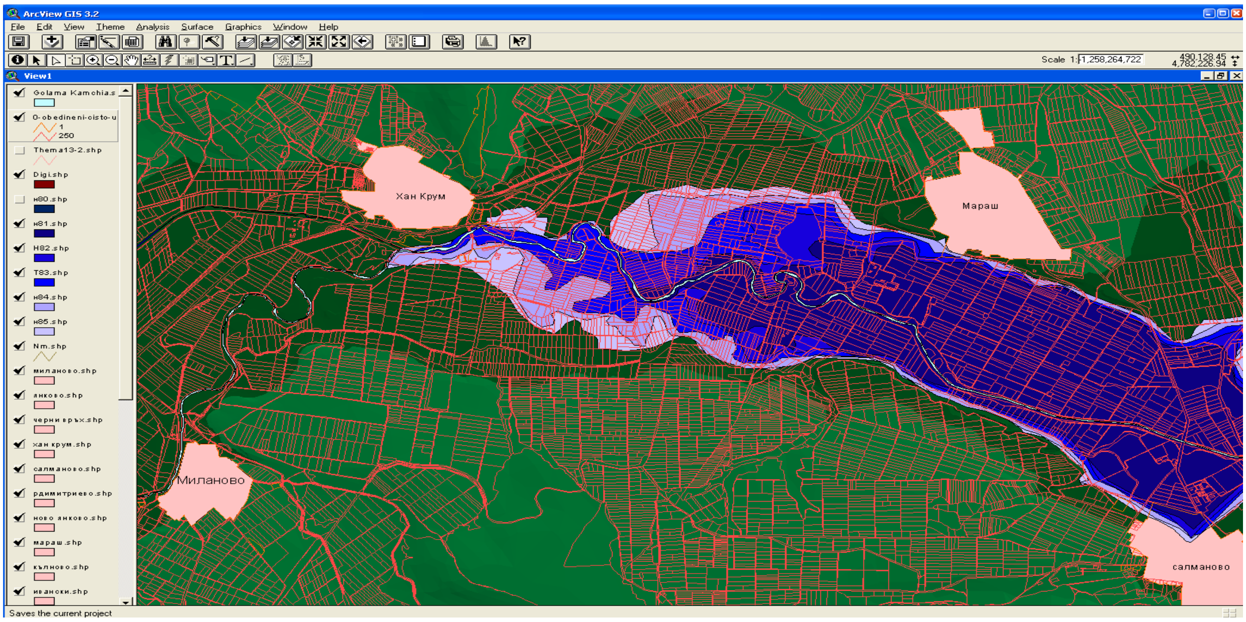

Fig. 3.22. Simulated flooding in the Han Krum area at wave height 1, 3, 5 and 10 m in the GIS environment

Conclusions:

1. On the basis of the developed methodology, real experimental studies have been carried out in the area of the Golya Kamchia River, collected data on the amount of rainfall and the level of the river using technical means (sensors and systems) within a certain time interval.
2. The results obtained after the processing of the data from the measurements during the period clearly show the relationship between the intensity, frequency of precipitation and dynamic changes in river level and flood hazards that cause material damage in extremely large sizes regionally.
3. For prevention and adequate response at institutional level (district, municipality, etc.) continuous monitoring and forecasting of disasters is necessary by building a modern system for monitoring and recording water level and predicting flood risks.
4. The risk assessment and determination of flood damage was implemented with an appropriate methodology in the GIS environment, using relief models, river system model, transverse profiles and cadastral maps of the area.

CONCLUSION

The problems associated with security risks and threats have always been relevant globally, regionally and locally. The development of the global and regional security environment will for a long time remain dynamic and contradictory with opportunities for complication. Under the influence of globalisation, the world is becoming more interconnected and the security of each individual country depends to a significant extent on the state, interconnections and cooperation between global, regional and national security systems.

In recent years, the threats of natural disasters and technological catastrophes have had a significant impact on Bulgaria's national security; demographic problem; organised crime; corruption, the dangers of epidemics; terrorism, etc. At the same time, the national security system needs adaptation, a new approach in providing anti-crisis resources and improving the legal framework, conceptual and doctrinal documents for its functioning as a single organisation. The introduction of new, modern methods for generating and modelling security and information communication technologies is needed. In the presence of security for citizens, society and the state guarantees the preservation of national identity, the protection of national interests, successful integration of the Republic of Bulgaria into Euro-Atlantic structures and its equal participation in international political life. In this regard, scientific analyses and research are needed to create theories, methods and technologies to ensure the reduction of hazards and threats at national and local level

On the problems of security generation and modelling through the use of modern monitoring systems and information systems such as geoinformation system (GIS) are dedicated research in the dissertation work.

In connection with the main objective – to analyze and evaluate the possibilities for monitoring with modern technical and geoinformation systems for reporting, registration and transmission of data on natural disasters of the type of floods, the following scientific research tasks have been solved:

-Some aspects of security, security generation methods, regulations and activities of institutions and departments in this regard have been analysed and evaluated. From the conclusions drawn, greater attention should be paid to modern methods and technologies that increase security efficiency;

-As a potential opportunity to ensure the requirements set out above are the capabilities of the technical systems for reporting, registration and transmission of data and geoinformation systems.

-The possibility of disaster risk prevention with the implementation of a monitoring system and technologies has been analyzed. The research is mainly on the problems associated with the flood disaster.

-The developed methodology for establishing a system for monitoring geospatial objects in critical situations provides the theoretical guidance for achieving this goal.

-To prove the theoretical stagings in the dissertation work, experimental studies have been carried out on one of the relatively large river systems in the Black Sea river basin – the Golyama Kamchia River. Experimental studies prove the effectiveness of a methodology for establishing a system for monitoring geospatial objects in critical situations.

These studies on the monitoring system, methodology and recommendations should be used by the troops, departments, institutions and organizations dealing with disaster risk prevention problems such as the Kamchia River floods, such as: military units providing disaster relief, the regional departments "PFNS" in Shumen region, the municipalities of Veliki Preslav, Shumen, Smyadovo, etc., directorates from the Black Sea region, RIOSV, MOSV, etc.

The developed methodology can be successfully applied to other disasters, accidents and catastrophes, because the technology is open and easily adapted to them, complemented by some specificities.

REPORT ON CONTRIBUTIONS TO THE DISSERTATION WORK

Contributions shall be of a scientifically applied and applied nature and shall relate to:

- Proving with new means new countries of already existing scientific fields, problems, hypotheses, etc.
- Obtaining and proving new facts.
- Receipt of confirmatory facts.

SCIENTIFIC AND APPLIED CONTRIBUTIONS

1. On the basis of analysis and evaluation of security aspects, systematic knowledge of their management, identification characteristics, regulatory, functional and informational status of modern monitoring systems and GIS are described.

2. The possibility of disaster risk prevention has been analyzed with the implementation of monitoring systems integrated with geoinformation systems and technologies. The research is based on the problems associated with the flood disaster.

3. A methodology has been developed for the establishment of a system for monitoring geospatial sites at risk of flood-type disasters.

APPLIED CONTRIBUTIONS

4. Based on the results of their own real experiments and research, a system was established for monitoring part of the terrain of the Golya Kamchia River. Technology has been developed for registration, processing and transmission of data, determination of flood damage and preparation of balances, reports and analyses in gis environment.

5. The final result of the study is related to supporting the activities of the troops, departments, institutions and organizations dealing with the problems of disaster risk prevention - floods along the Kamchia River, such as army units, "PFSN" School in Shumen region, basin directorate from the Black Sea region, RIEW, MOEW, etc.

List of publications on the subject of the dissertation:

1. Slavov D., Flood Analysis in the Republic of Bulgaria, International Scientific Conference "Defense Technologies", Faculty "Artillery, PVO and CIS, Shumen, 2021.

2. Slavov D., Methodology for establishing a flood monitoring and early warning system, International Scientific Conference "Defense Technologies", Faculty of Artillery, PVO and CIS, Shumen, 2021.