

Thematic Mapping for Disaster Management at Local and Regional Level

Silvia Tsvyatkova

University of Architecture, Civil Engineering and Geodesy, Department of Photogrammetry and Cartography, Sofia, Bulgaria

Abstract. In the last ten years 85% of the Bulgarian municipalities were frequently and highly affected by natural and man-made disasters. According to the Bulgarian Disaster Management Act disaster management should be planned at local, regional and national level. Each Municipal Disaster Management plan should include: “Geographic characteristics of the municipality” and “Measures for disaster prevention or mitigation of the effects of disasters”. A main component of these sections should be a graphical part that depicts the characteristics each municipality. Decision making and cooperation between two or more neighboring municipalities in crisis situation are still rendered difficult because of lack of harmonized data and detailed and accurate maps of the municipalities and the regions. The paper examines the necessity of: using a uniform reference system, standardizing the object classification, standardizing the level of detail, unifying the cartographic visualization. Thus, the maps included in the plans would be usable by both local and regional authorities and would facilitate significantly the cooperative disaster management strategy. The paper presents a series of maps of the Municipality of Troyan, Lovech Region, intended to support disaster management activities. The maps are designed in accordance with a methodology for drawing up local disaster management plans. The paper proposes associative map symbols that aim to support decision making in case of emergency and to improve the whole process of crisis management at local and regional level.

Keywords: thematic mapping, cartographic visualization, disaster management

1. Introduction

Disaster management is a complex process including mitigation, preparedness, response, recovery. The actors in these activities need accurate geo-

graphical information. Disaster management at local and regional level is based on disaster management plans that include maps such as hazard maps, maps for protection and evacuation planning. However, most of the paper maps that are included in the municipal plans are very old. They have been created according to different methodology. The maps differ in scale, format, colours, map symbols and cartographic design. The efficient decision-making process in case of natural or man-made disaster requires accurate geographic information and thematic maps designed according to a uniform methodology and symbol system.

2. Cartography and Disaster Management at Local and Regional Level

Disaster management is realized by a series of activities such as:

- **prevention**, including analysis, assessment and prediction of disaster risks; scenarios; categorizing the territory according to disaster risks; planning the disaster protection; planning the emergency aid; implementation of preventive measures to avoid or mitigate the effects of disasters; building up an early warning system, adopting National disaster management program;
- **protection**, including early warning, organizing rescue plans and rescue operations, evacuation, etc;
- **coordination** of the operations of the Integrated Rescue System, defined by the Disaster Management Act (2006)
- **recovery**, including human help, economic support, rehabilitation, reconstruction, strategic development;
- **other** activities (Kotter 2004)

Cartography plays a key role in all main activities of Disaster management. Konecny and Bandrova (2006) explain that the role of cartography in disaster management is to simplify and well-arrange required spatial data thus, the decision-making process to become quicker and better and to lead to damage minimization.

The Bulgarian disaster and crisis management acts were modified in order the decision-making process in case of natural or man-made disaster to become more efficient. In 2006 a Disaster Management Act was introduced in Bulgaria. According to this Act disaster management should be planned at municipal, regional and national level. Each Municipal Disaster Management plan includes Geographic characteristics of the municipality (physiographic, climatic, demographic, economic, hydrological characteristics) and Measures for disaster prevention or mitigation of the effects of

disasters (risk assessment; risk monitoring; early warning system, planning of rescue operations; evacuation routes; evacuation centres; rehabilitation and reconstruction of facilities; etc.) (Disaster Management Act 2006). A main component of these sections is the graphical part that depicts the characteristics of each municipality.

3. Natural and Man-made Disasters in Bulgarian Municipalities

In the last 10 years Bulgaria was frequently affected by natural and man-made disasters that caused considerable losses. The disasters that occurred are landslides, floods, earthquakes, snowstorms, windstorms and thunderstorms, drought, hailstorms, freeze, accidents, pollutions, epidemics and other. *Table 1* presents the registered significant disasters (except fires) in Bulgaria in the years 2003, 2004, 2005, 2006, 2007, 2008, 2010 and 2011 according to information of the National Statistical Institute (2012).

Type of Disaster	Total number							
	2003	2004	2005	2006	2007	2008	2010	2011
Natural disaster	964	1128	2539	1694	1103	1054	912	781
Landslides	239	238	392	374	151	177	59	76
Floods	285	531	1657	945	591	322	651	382
Earthquakes	14	31	9	3	1	14	12	4
Snowstorms	99	82	121	49	68	153	103	94
Windstorms, thunderstorms	111	115	204	136	137	190	47	48
Drought	13	-	-	-	42	5	6	30
Hailstorms	17	40	45	17	13	17	16	13
Freeze	16	1	15	8	28	77	18	134
Other natural disasters	170	90	100	162	72	99	-	-
Accidents	6 292	1 530	1 341	4 086	1 077	1 156	1 944	5 242
Pollutions	139	106	92	271	201	152	45	42

Epidemics	47	21	13	18	14	10	17	9
Other	461	36	54	37	23	14	21	9
Total	7 903	2 821	4 039	6 106	2 418	2 386	2 939	6 083

Table 1. Significant disasters registered in Bulgaria in the years 2003, 2004, 2005, 2006, 2007, 2008, 2010, 2011.

For the period 2003-2011 (except the 2009 for which information is not available) the total number of the registered disasters (except fires) is 34 695.

According to the administrative division of the country for the period 2003-2008 the average number of the affected municipalities per year is: 77 – by landslides, 146 – by floods, 8 – by earthquakes, 33 – by snowstorms, 52 – by windstorms and thunderstorms, 5 – by drought, 16 – by hailstorms, 7 – by freeze, 24 – other natural disaster, 65 – by accidents, 31 – by pollutions, 12 – by epidemics, 17 – by other disasters (National Statistical Institute 2012). *Table 2* shows the number of the affected municipalities from 2003 to 2008.

Type of Disaster	Number of affected municipalities					
	2003	2004	2005	2006	2007	2008
Natural disaster						
Landslides	93	80	84	100	58	49
Floods	102	147	217	168	143	100
Earthquakes	12	22	6	3	1	6
Snowstorms	34	30	53	18	18	47
Windstorms, thunderstorms	45	53	57	49	48	58
Drought	5	-	-	-	21	5
Hailstorms	14	20	28	9	11	13
Freeze	10	1	7	6	6	14
Other natural disasters	18	21	27	33	22	21

Accidents	99	54	56	61	54	65
Pollutions	58	30	31	25	22	22
Epidemics	17	14	5	15	12	6
Other	29	19	14	14	12	12

Table 2. Bulgarian municipalities affected by disasters from 2003 to 2008.

Decision-making and cooperation between two or more neighboring municipalities in crisis situation are still rendered difficult because of lack of harmonized data and detailed and accurate maps of the regions. To reduce the number of human loss and property damages and to improve the decision-making process in case of emergency the Disaster management plans at local and regional level should be supported by detailed thematic maps created in accordance with a uniform methodology and uniform cartographic visualization. These maps would facilitate the cooperation of local and regional authorities in efforts to mitigate shared disasters.

4. Local Disaster Management Plan

The town of Troyan, Lovech region is situated in a mountainous area in North Bulgaria, 160 km northeast of Sofia. It is a municipal center of 21 settlements with a total area of 893 square kilometers and population of 32 400 inhabitants.

The Disaster management (DM) plan of the municipality of Troyan is created under the terms and conditions defined in the Bulgarian Disaster management act (2006). The main tasks of the the DM plan are:

- analysis, assessment and prediction of disaster risks for the territory of the municipality of Troyan;
- building up an early warning system and coordinating the disaster management activities;
- early warning
- defining measures for disaster prevention and measures for mitigation of effects of disasters;
- other.

The actors in these activities need specialized geographical information and thematic maps that would support their concrete actions. However, the maps included in the DM plan differ in their source, scale, level of detail, accuracy. To facilitate significantly the disaster management strategy it was

created a new map which depicts the topographic characteristics of the municipality of Troyan (*Figure 1*). The map is intended to be printed at scale 1:50 000.

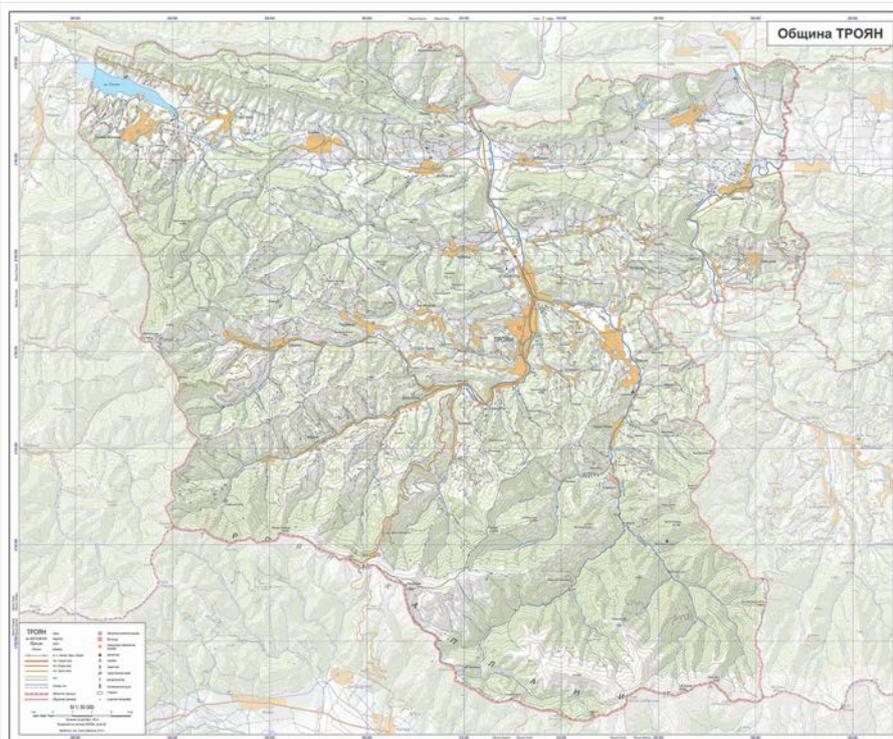


Figure 1. New map of the municipality of Troyan.

5. Content of the Base Map

The methodology for drawing up disaster management plans at municipal level requires clear definition in the maps of: location, boundary and area of the municipality; relief and water resources; technical infrastructure, including rail and road system; hydrotechnical structures, etc.

The base topographic map of the municipality of Troyan contains the following features:

- Hydrography
 - rivers, channels, reservoirs, lakes
- Relief
 - contour lines
 - hill shading

- Settlements
 - classification according to: number of population, administrative status, type
 - type of built-up areas: residential areas, industrial areas
 - Unified Classification of Administrative-Territorial and Territorial Units in Bulgaria (UCATTU)
- Railway network
 - railways, railway stations, railway stops
- Roads
 - motorways, national roads with classification, municipal roads, paved roads, cart tracks
 - national road numbers
- Administrative boundaries
- Forest
- Factories storing dangerous materials (*Figure 2 a*)
- Protection Services
 - Emergency Aid Service (*Figure 2 b*)
 - Police (*Figure 2 c*)
 - Fire Safety (*Figure 2 d*)
 - Civil Protection (*Figure 2 e*)
 - Mountain Rescue Service (*Figure 2 f*)

The presentation of all these features is based on integration and harmonization of data provided by various sources (Marinova 2011).



Figure 2. Map symbols on the base map.

6. Data Harmonization

The newly created topographic map is used as a base for a series of maps intended to support the activities of prevention, protection, coordination and mitigation defined in the additional sections of the DM plan. The maps combine regional and local data provided by various services, agencies and organizations such as: Ministry of environment and water, Ministry of agriculture and food, Chief directorate Fire safety and civil protection, Bulgarian red cross, Mountain rescue service, regional and local administrations, private companies, etc. Some information sources are:

- geographic database
- topographic maps
- thematic maps

- Unified Classification of Administrative-Territorial and Territorial Units (UCATTU)
- Disaster management plan of the Municipality of Troyan
- statistical data, etc.

In order all this data to be integrated and presented on the maps it is harmonized according to the main aspects of data harmonization:

- georeferencing the information into a uniform reference system;
- standardizing attribute structure;
- standardizing object classification;
- standardizing level of detail;
- unifying cartographic visualization (Gruber et al. 2006)

Thus, the maps included in the plans would be usable by both local and regional authorities and would support decision-makers in case of emergency.

7. Graphical Part of Disaster Management Plans

The DM plan of the municipality of Troyan includes separate specialized sections - Disaster management plans in case of earthquakes, floods, fires, industrial accidents. Each of these sections contains graphical part that aims to support the activities defined by the DM plans. Based on the new topographic map of the municipality a series of maps are created. They are designed according to a methodology for drawing up disaster management plans at local level.

7.1. Earthquake Disaster Management Plan

The map designed for disaster management in case of an earthquake includes critical and potentially hazardous infrastructural objects and facilities:

- Transport sector – rail and road infrastructure;
- Energy sector – substation, gas and petrol stations;
- Water systems sector – reservoirs on the territory of the municipality, etc.
- Food provision sector
- Health sector – hospitals and polyclinics;
- Buildings storing industrial poisons. On the territory of the municipality of Troyan potentially hazardous objects are: a factory for production and export of plywood, chlorinating plant in the town of Troyan, chlorinating plant near the village of Cherni Osam.
- Public buildings, schools, nursery schools etc.

This map includes evacuation routes and safe zones. All the safe buildings that are suitable to be used as public shelters (according to the DM plan) are shown on the map. For each building basic information is available - name of the public shelter, number of beds, telephone numbers, etc.

7.2. Flood Disaster Management Plan

The map designed for disaster management in case of floods includes critical and potentially hazardous features: rivers and reservoirs on the territory of the municipality of Troyan. For each reservoir it is shown name, V – volume, H – height, L – length of the dam. The map also includes information about average annual flow at specific places of the major rivers on the territory of the municipality – rivers of Cherni Osam, Beli Osam and Osam. It shows zones that may be affected by flood and safe zones. All the buildings that are suitable to be used as public shelters (according to the DM plan) are presented on the map, including information such as name of the public shelter, number of beds, telephone numbers.

In order to support the activities of prevention, protection and preparedness this section of the Disaster Management plan at municipal level should also include flood hazard and risk maps which are a part of Flood risk management plans according to Directive 2007/60/EC.

7.3. Fire Disaster Management Plan

In order to support the activities defined in the Disaster management plan in case of fires it is created a Fire danger map based on the topographic map of the municipality of Troyan. Maps of fire-fighting arrangement at scale 1:25 000 are used as main source. They are produced by Agrolesproekt EOOD for the needs of the State Forest Directorate of Troyan and State Forest Directorate of Borima, Lovech region. The maps cover the territories of forest areas “Osam”, “Balkan”, “Koman”, “Borima”. They are created under the general requirements of forest maps design, thus they are complicated and not very clear for the general public. They are much more of use to professionals of Forest Directorates than to local and regional authorities.

The design of the new Fire danger map is in relation to the potential users - officials involved in the activities of prevention, protection and preparedness. Based on the maps of fire-fighting arrangement all forests and bare areas with some vegetation are divided into 5 groups according to the fire-danger classes (*Figure 3*) - I - very high, II – high, III – moderate, IV – low, V - very low, determined by type of plants, height, density, height of grass, undergrowth, branches on the ground, etc.

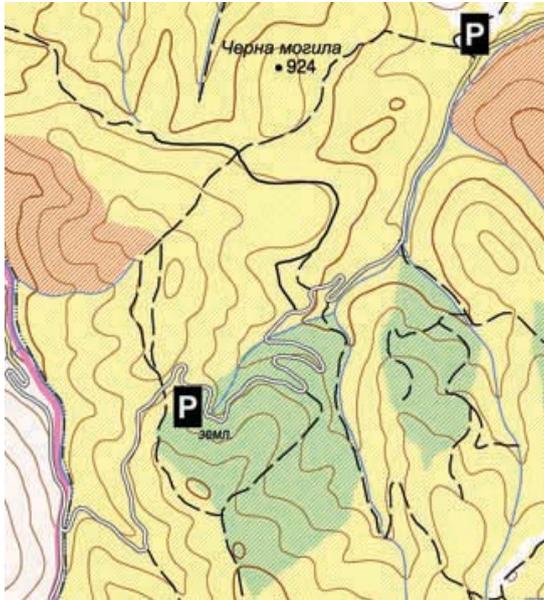


Figure 3. Fire danger classes.

The new map presents office of Regional Directorate Fire Safety and Civil Protection, offices of State Forest Directorates, paved roads, cart tracks, parking areas for fire-fighting trucks, helicopter landing sites (diameter – 45 meters at least), reservoirs for water supply, platforms for fire-fighting tankers (minimum size – 12x12 meters), depots of fire-fighting equipment (Figure 4). Figure 5 shows a part of the map key.

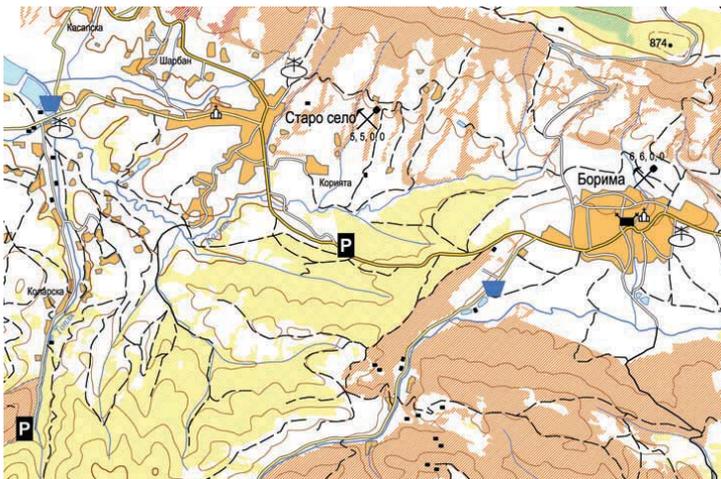


Figure 4. Fire danger map of the municipaliy of Troyan (fragment).

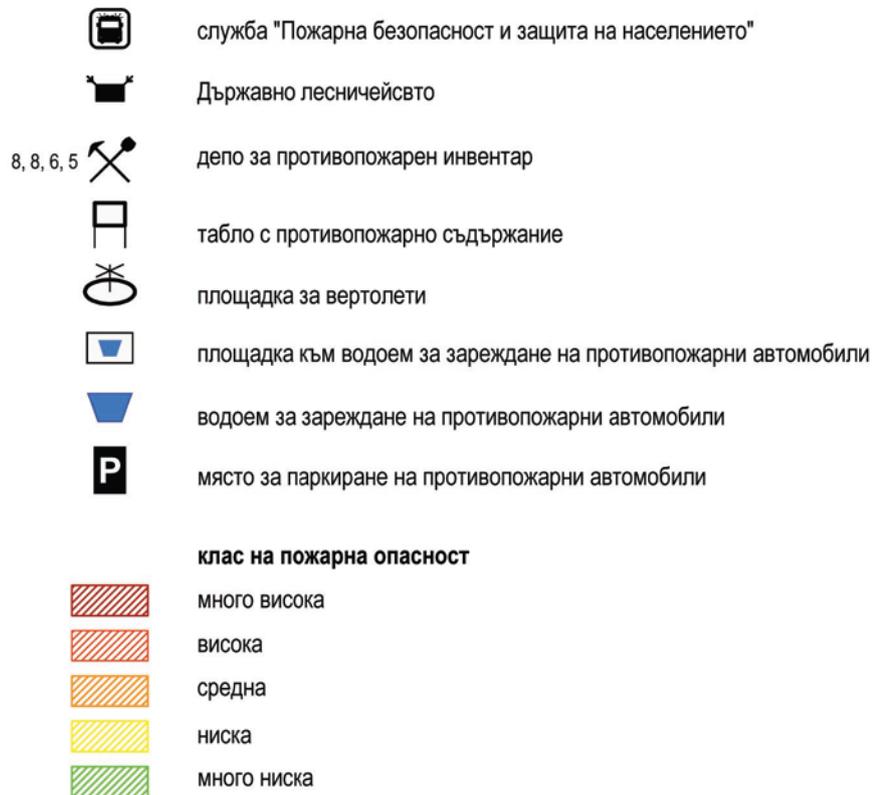


Figure 5. Map key to Fire danger map of the municipaliy of Troyan (fragment).

7.4. Disaster Management Plan in Case of an Industrial Accident

The Disaster management plan of Troyan considers the following possible industrial accidents that may occur on the territory of the municipality: accidents caused by ammonia leak, accidents caused by chlorine leak, other accidents caused by dangerous goods. The map depicts the dangerous industrial objects, their names, type of stored materials, storage method, amount, danger class. It shows the zones of potentially harmful concentrate spread as well as the public buildings, schools, nursery schools and residential buildings that need to be evacuated in case of an accident. Evacuation routes to safe zones and evacuation shelters are drawn up for each object.

7.5. Evacuation Maps for Trainings

The DM plan of Troyan requires periodic trainings of people involved in disaster management activities. The efficient dealing with disasters depends on the availability of appropriate maps. It is proposed a cartographic design of a map for rescue operations based on a scenario. *Figure 6* presents of the map symbols of the evacuation map.

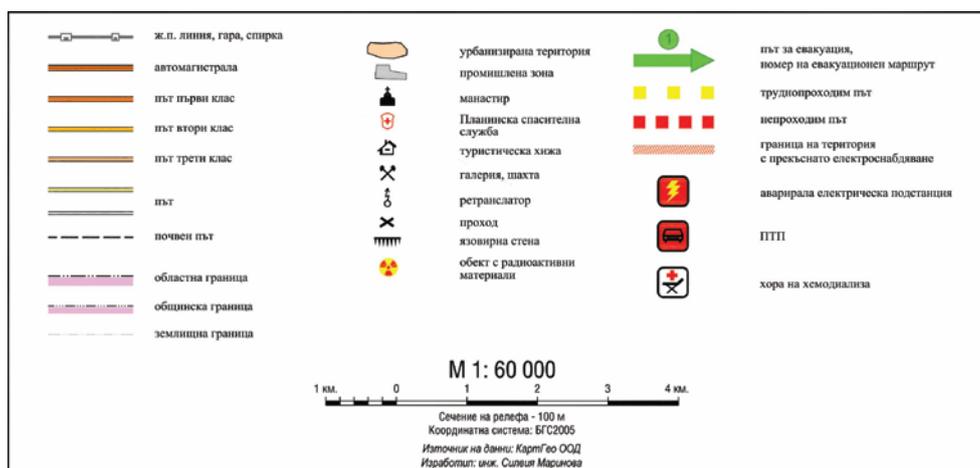


Figure 6. Key to a map for rescue operations.

8. Conclusion

Cartography plays a key role in all main stages of disaster management. The efficient and cooperative prevention, preparedness and planning activities of local and regional authorities require accurate geographic information and thematic maps. The maps usually combine heterogeneous data provided by various services, agencies and organizations. In order all this data to be integrated and presented on a coherent map it should be harmonized. A series of maps based on municipal Disaster management plan are presented. They are designed according to a uniform methodology and symbol system. Thus, the maps are intended to facilitate significantly the cooperative disaster management strategy at local and regional level.

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