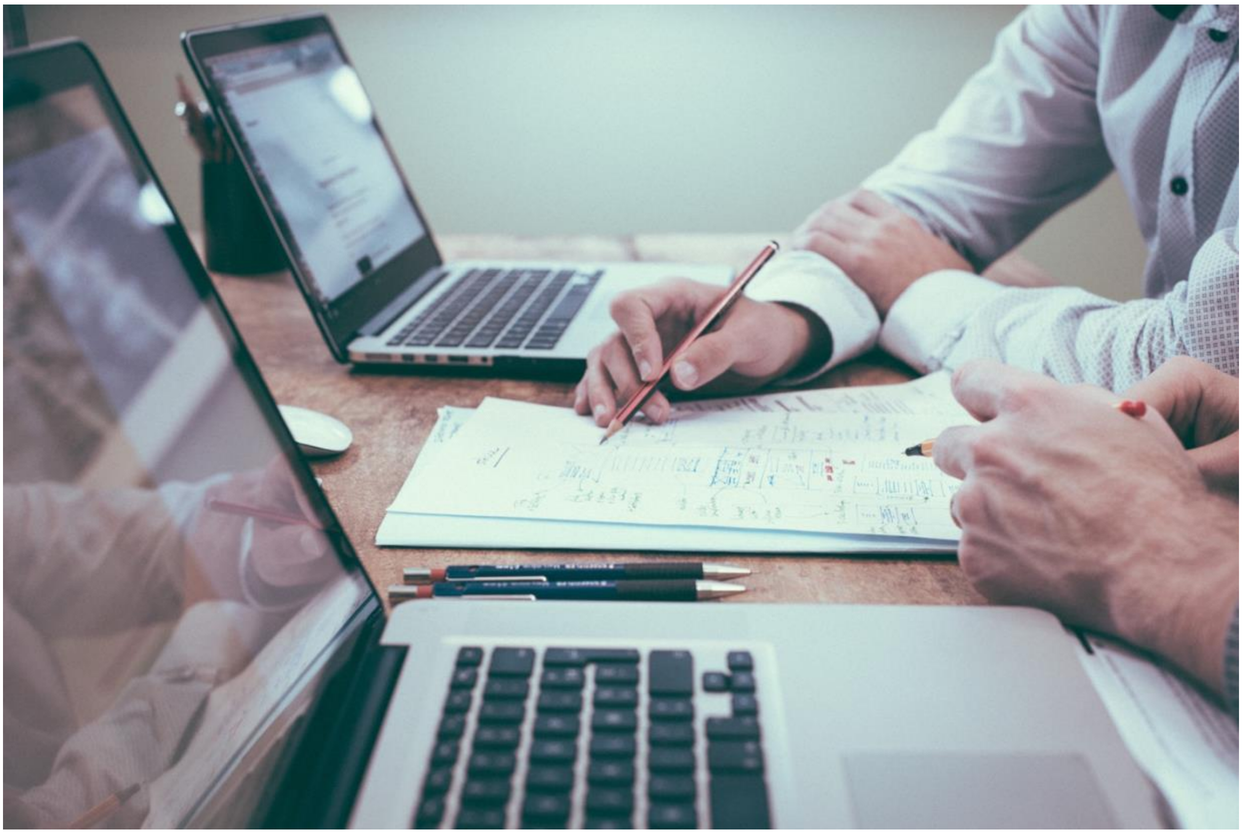
# An Analysis of the Main Types of Risks, Hazards and Natural Disasters along the Bulgarian Black Sea Coast



## Table of Contents

## List of Tables and Figures

## Study Purpose

**The aim of this analysis** is to list, describe and explain the main types of risks, hazards and natural disasters which have their historical and current relevance in the Bulgarian Black Sea coastal regions.

The purpose of the study is to structure a wide range of available data and verifiable sources which allow for an objective analysis of all reference points – registered risks, systemic hazards and natural disaster characteristics – with their most relevant underlying causes, origins and trigger events, again, along the Bulgarian Black Sea coastal line and extended areas. The latter include the Administrative Districts of **Varna** and **Bourgas** but also the **Dobrich** district in the North. The two larger urban centres have more statistical influence in terms of population at risk, socio-economic factors which interact with natural phenomena, as well as a naturally wider area being covered by this study.

For all disasters and risk factors we will attempt to provide proven numerical indicators of their intensity, scale, probability of occurrence, number of victims and economic impact. Where statistical fonts do not allow for a complete quantitative outline of a phenomenon, we will place an emphasis on qualitative studies, publicly available reports and probable future occurrence.

Based on such public statistical data and officially registered sources, we will place particular attention on analysing natural phenomena such as **floods, fires, landslides, ice storms, strong winds, thunderstorms, chemical and industrial accidents** and other reported incidents. Our in-depth analysis should facilitate the definition of appropriate environmental and governance measures, first response mechanisms and action plans able to improve current organisational paradigms in addressing such disasters and risks within the Bulgarian Black Sea coastal areas.

## Analysis Methodology

This study is conducted predominantly through an inductive analytical approach, aiming to systematically generate conclusions grounded in concrete data, scientific and public reports.

- we will provide a consistent presentation and description of relevant natural disasters and anthropogenically determined incidents which characterize the Bulgarian sea coast regions – such as storms, landslides, floods, chemical and industrial accidents, fires, ice storms and others;

- we will conduct a comparative analysis of natural disasters and risks which have proven to be typical for the Bulgarian Black Sea coast, with their main indicators (when and where available): intensity, scale, probability of occurrence, number of victims, etc.

To achieve that, we will also employ the following approaches:

- Historical method – outlining trends, indirectly related to national and European factors but focusing on territorial consistency and relevance. We highlight significant cases with lasting tracks in historical records, especially in view of environmental and human effects, thus substantiating the type of incidental event;

- A related but not identical method is the documentary one – by gathering information accidents, disasters and emergency situations, we determine the place and role of external factors, not initially causing the event. Sources and registers provided by the Public Administration are of crucial significance in this; A secondary record analysis is also conducted to compare registers and third-party conclusions;

- The descriptive methodology is employed to summarize data collected through the above two methods.

## Introductory Premises

An up-to-date assessment of most naturally destructive processes leading to catastrophic events is needed in a number of areas, considering an **increase in activity an impact** in recent years. Said impact is essentially measured in human victims, severe economic consequences and increased social tension – all results of measurable deterioration of environmental conditions, destruction of buildings and infrastructure, disruption of land use and communications channels.

Territorial differences within the same country – whether within macro or micro units – naturally determine predispositions of certain regions to natural disasters, such as (sub)climatic zones and tectonic activity. Landslides are a prime example, with “weak” soils being as localised as widespread a phenomenon globally. They belong to a group of processes characteristic of coastal areas: rivers, lakes, seas (and oceans), all crucial to our study. Geologically, Bulgaria does experience earthquakes, landslides and rockfalls, mud-stone torrents, erosion and abrasion. Those are closely tied, however, to floods, storms and other adverse weather conditions. In such cases, atmospheric influence and local extreme events merely expose and accelerate underlying processes.

Bulgaria is exposed to the majority of known extreme weather events, including floods, droughts, earthquakes, cold waves and many others. Climate risks are expected to increase in the coming decades due to a changing climate, as we will analyse further down the study. The **concomitance of a series of dangerous natural phenomena**, in sequence, may result exponentially more dangerous and destructive to the exposed regions. Examples include: a fault/fracture–earthquake–tsunami; a fault–earthquake–landslides; intense precipitation–floods–landslides–mudslides; intense rainfall–destruction of dams–flooding of settlements; as well as many other real-life examples.

**Climate change**, in that respect, is only expected to exercise an increased influence on uncontrollable natural processes and influence socio-economic functions. Studies conducted by the Department of Meteorology of the Bulgarian National Institute of Meteorology and Hydrology (NIMH) at the Bulgarian Academy of Sciences (BAS) predict an increase in the annual air temperature in Bulgaria between 1.6°C and 3.1°C within 2050 and between 2.9°C and 4.1°C by 2080. Those forecasts are along the outcomes obtained by simulations and predictions for the global and EU trends, with a sharper rise in temperatures expected during the summer months (July to September).

Such scenarios for climate change in Bulgaria outline a tendency to experience increasingly frequent extreme events and disasters, namely more common heavy rainfall, hot and cold waves, floods and droughts, hurricane winds, forest fires and resulting landslides. These are not merely risks but actual and intensifying events which lead to the loss of human life, as well as millions of Euro worth of damages each year, greatly affecting in turn Bulgarian socio-economic stability and growth.

We are placing an emphasis on such processes to monitor along with traditional statistical reports simply because public authorities and societal factors need to be able to differentiate **disasters which are aggravated by climate change** from those which are merely local, presenting largely “static” risk factors – such as relatively isolated economic and human activity, as little as those are protected from outside influences.

The latter argument brings us to the question of **segmenting natural and anthropic risks** where needed, while adding up their effects in other cases, probably the majority.

One such risk factor is the potential exposure to potential fires, natural flammability and natural vs. human causes for these disasters. That is namely why we treat fires in a separate section between these two large causative groups. For example, numerically, the highest percentage of crisis events in Bulgaria for the period between 2004 and 2008 is represented by fires. Certain statistics exclude forest fires, placing them among natural disasters – with this group taking second place and representing about a quarter of all critical events.

Ultimately, no matter how we categorise those, throughout the past few decades, within the majority of events under our review, the **largest groups** of disasters affecting most Bulgarian municipalities are represented by **floods, fores, landslides and storms**. With slight variations which we explore further on, that statement holds true for the Bulgarian Black Sea coast as well, as much as for the rest of the country.

## Regulatory Framework and Definitions

In order for our study to define and describe exhaustively the most relevant types of disasters, hazards and critical events in the area analysed, we need to be able to understand the legal context and administrative procedures that outline and treat those events as such. Certainly, there is a universal natural understanding of what a disaster is and what natural and economic hazards which cannot be confuted are. Nevertheless, authorities and societies categorise such conditions and events according to practical objectives and social responsibilities such as the thresholds for certain critical events, as well as the responsibility for maintenance, reporting and monitoring in relation to those, among others.

The need to outline certain definitions is more pronounced in light of the fact that in the course of our study we have encountered – more than once and in relation to different disaster and risk categories – discrepancies, omission of certain data, different interpretations. Although, clearly and for the most part, statistics and public records adhere to agreed upon standards, and as such are transmitted up the reporting ladder to national and EU statistical bureaus and sectoral agencies.

**The Disaster Protection Act** (DPA or DPL in specialised literature) defines relevant "natural phenomena" as those of geological, hydrometeorological and biological origin – namely "earthquakes, floods, mass movements (landslides, mudslides, avalanches), storms, hail, heavy snowfalls, frosts, droughts, forest fires, mass diseases from epidemic and epizootic, pest infestations and the like caused by natural forces". Not all of those are, however, to be considered incidents of serious proportions, and even less are significant disasters.

Bulgarian lawmakers and authorities define an "Incident" as "an unpredictable (or difficult to predict), limited in time and space activity", involving **[natural] forces** of high intensity or human activity which **endanger the life or health** of people, **property or the environment**. Thus, e.g. prolonged natural phenomena or economic activities – especially those which do not present a clear danger to one of the the above – are not considered as incidents.

“Accidents” are large-scale incidents involving road, highway and air traffic, as well as “fire, the destruction of hydraulic structures, marine incidents, nuclear accidents and other environmental and industrial accidents **caused by human activities or actions**”.

“Industrial accidents” by definition require sudden technological failures or activities involving hazardous substances in “production, processing, use, storage, loading, transport or sale”, whereby these endanger **human life or health**, **animals, property or the environment**.

In a broader definition, a “**hazard**” is a “dangerous phenomenon, substance, human activity or condition” which may cause the loss of life, trauma or other health consequences, along with “property damage, loss of livelihoods and services, social and economic disturbances or damage to the environment”. “**Vulnerability**” includes the “characteristics and condition of a community, system or asset that make it susceptible to the harmful factors of a given hazard”.

Ultimately, we are analysing national and regional reports outlining the “**disaster risk**”, defined as potential losses to a community – “including life, health status, livelihood, assets and services, over a given period of time”, as a result of a disastrous event. Tied directly to the main subject matter of our study, a "**risk analysis and assessment**" is defined as the definition of the “nature and extent of risk as a function of hazard, vulnerability and probability”.

Statistical and scientific reports apart, public authorities assign comprehensibly more significance to the prevention of risks related to “**Critical Infrastructure**” (CI). The latter is defined as “a system or parts of it, which are **essential** for the maintenance of **vital public functions, health, safety, security, economic or social well-being** of the population”. Damaging CI would bring about “significant negative consequences” for the Republic. European CI, furthermore, is recognised as CI systems – located within Bulgarian territory – the damage or destruction of which would lead to the above negative consequences for “at least two Member States of the European Union”.

And finally, we record publically critical events ex post facto and analyse disaster risks within a broader time frame based on proven and hypothetical factors. At the actual time of a calamitous event – of any nature – the public authorities should have established an **Early Warning**

**System** (EWS), both for specific disaster types and a general chain of communication and warning channels. "A set of necessary capabilities to create and disseminate timely and meaningful warning information, enabling people, communities and organizations at risk to prepare and act appropriately in order to reduce possible damage or loss". Determining EWS's coverage, functions, trigger events and the vulnerability of subject groups also requires a profound understanding of what these disasters, hazards and risk are and how they develop over time.

## Natural Disasters – Environmental Factors and Hazards

In a report prepared by the World Bank intended to provide advisory support to the Bulgarian MoEW, climate-related events (floods, storms, snowfall, heat waves and droughts) are found to account for nearly 90% percent of all major disasters in the past two decades. And climate change is only expected to exacerbate the situation, leading to an increase in frequency and intensity of weather-related hazards. Such impacts always inevitably spill over to affect economic and social conditions – food and water supply, the functioning of urban systems, epidemics, as well as causing more poverty and human conflict. The above processes are both a global trend, as they are a reality for many Bulgarians.

Consequently, tackling our society's vulnerability and exposure to weather-related threats is a mutual priority, both in terms of climate change and integrated disaster risk reduction. Bulgaria is exposed to a number of disaster risks, as already noted, including floods, landslides, earthquakes, fires, droughts, storms, heavy snowfall and extreme temperatures, amongst others. And while statistically the first three are most pronounced, **human activity** plays a decisive role and is a cornerstone factor in **creating, replicating and preventing risks**, even if essentially generated by nature.

According to the NSI disasters in Bulgaria have caused nearly **EUR 1 billion in damage since 2010**, with 2/3 of that amount already having been spent on rescue, recovery and emergency activities.

The adverse economic effects on the country's economy are one readily apparent reason to implement a more efficient and effective disaster prevention strategy. And failing to tackle these phenomena is as much a socio-cultural demerit as they become an aggravating factor when not being able to **adequately structure urban and rural socio-economic functions**, as well as to optimise all stages of **disaster management: prevention, mitigation, preparedness, response and recovery.**

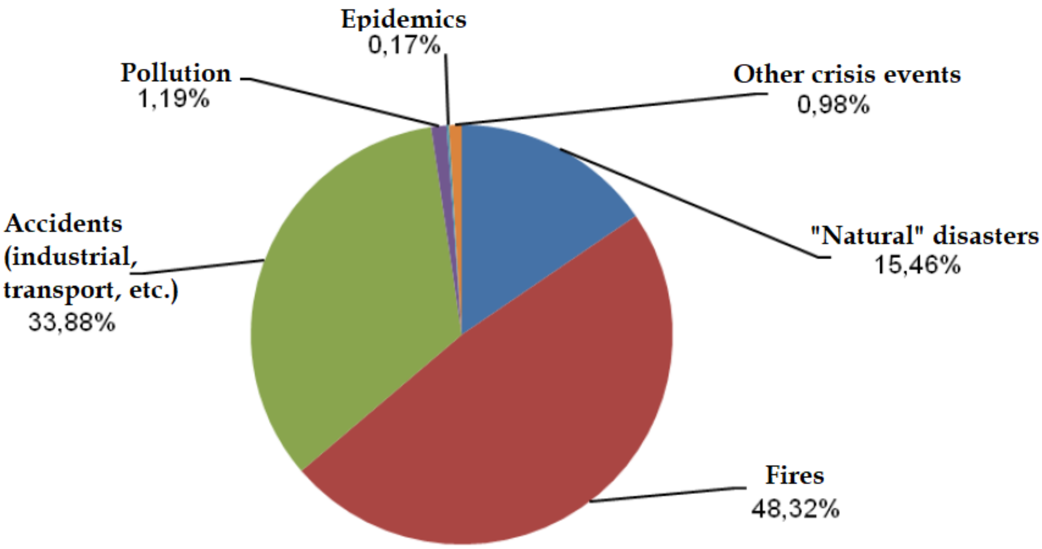
The macro-region in our analysis – the Bulgarian Black Sea coast – is EU's eastern gateway. A crossroads between Europe, the Middle East and Central Asia, the Bulgarian coastal line has crucial transport and energy hub roles, apart from political and cultural ones. This alone is sufficient to bring up the importance of its integrated disaster risk profile and only emphasizes the relatively endangered natural status of the Black Sea – being a "closed basin with unique dynamic and sensitive ecosystems threatened by continental pressures and conflicting coastal and marine activities".

Moreover, such geopolitically strategic importance is not only relevant in light of regional stability and cohesion; it is highlighted in the context of sustainable "blue growth", inevitably relying on a safe coexistence between natural marine forces and human (urban and rural) activity – and that includes **monitoring and managing integrated risk** in the region.

We have already mentioned some of the historically observed and recorded natural disasters – both nationwide and along the coasal regions. **Floods** persist as the most frequently relevant, followed by **fires**, **landslides** and **earthquakes**. In addition, there have been some significant cases of prolonged **droughts**, **storms**, **heavy snowfall**, **extreme temperatures** (on both ends of the spectrum) and **hailstorms**.

While certain disaster causes and outcomes remain unclear and not precisely categorised in the short run, if we take a look at a period of several years to several decades, they presents a clearer picture of the **main types of critical and disaster events** that hit Bulgarian territories, first and foremost.

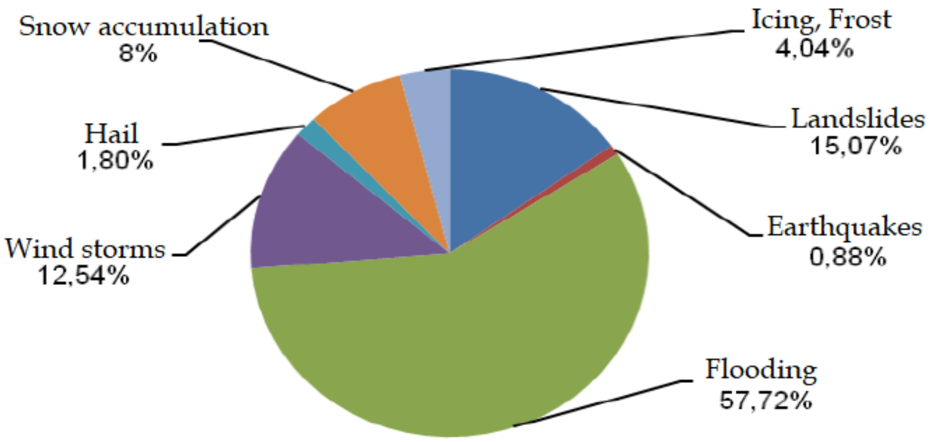
*Figure 1 – Relative share of crisis events by type (2004-2016) – NSI, 2017*



**Fires** include both those caused by nature, as well as smaller urban and rural cases, bringing their numerical count higher up in the statistics while this is not their statistical proportion in terms of impact and severity, as we will see below.

On the other hand, the group of **"natural" disasters** have been broken down further by the NSI into **floods**, **landslides** and **snow accumulation** related emergencies toppint the list in the period in question. The first two are true natural calamities with sudden and often significant proportions which should serve as basis for further preparedness and capacity analysis.

*Figure 2 – Relative share of natural disaster events by type (2004-2016) – NSI, 2017*




Looking a litte further back, out of all recorded disasters that occurred on Bulgarian territory over the period between 1974 and 2006, at least 78% of them fall under the category of "natural disasters". With regard to data specifically on fires, it has always been difficult for statistically relevant databases to segment how many of them are of natural and how many are of anthropogenic origin. What remains a constant, however, is that floods have still comprised the largest relative share of natural disasters.

One aspect must be clarified with regards to Bulgarian statistical recording of critical events, both on a national and regional scale. Their distribution sometimes appears rather uneven, as for example we can observe an average decrease in most natural disastein the mid-2000s and early 2010s. This is largely due to diverse reporting mechanisms over the years – the responsibility shifted from national agencies and ministries to local and regional entities, mostly municipalities. Moreover, there has been a varying number of reporting Municipalities – from 74 to 141 in different annual NSI reports!

That being considered, **floods** still remain the most frequent local and national disaster that **combine natural and man-made causes**. Landslides come second in the "natural" category, while fires – being both out in the open and within city limits – are not placed in the same group but are even more relevant in their number and frequency.

One of the most reputable international disaster databases and monitoring systems, **EM-DAT**[1], has also kept a statistical order over the past decades regarding Bulgaria. EM-DAT reports 45 major disasters that have been registered since 1977, with more than **85 percent** of them related to **meteorological phenomena**. These disasters alone have caused **direct damage** of around **EUR 1.5 billion**, with floods and extreme temperatures being the most common. The former are also responsible for the largest share of direct damage and population affected.

*Table 1 – Major Disaster Statistics for Bulgaria, up to 2016 (EM-DAT)*

| **Period** | **Type of Disasters** | **Number of events** | **Casualties** | **Population affected/injured** |
|---|---|---|---|---|
| 1997 – 2016 | Floods | 19 | 77 | 60 017 |
| 1928 – 2016 | Earthquakes | 6 | 131 | 3962 |
| 1981 – 2016 | Storms etc. | 6 | 3 | 5890 |
| 1998 – 2016 | Extreme Temperatures | 9 | 76 | 393 |
| 1999-2016 | Fires (outside of urban settings) | 4 | 10 | 176 |
| 1916 – 2016 | Landslides | 1 | 11 | - |
| 1916 – 2016 *Not counting the Hitrino disaster* | Transportation incidents | 6 | 154 | 138 |
| 1996 – 2016 | Industrial incidents | 2 | 15 | 200 |

The below table shows the complete and official statistical order available as per **NSI methodology** revealing the total disaster count including all types of crisis events between 2010 and 2018.

[1] *The International Disaster Database (EM-DAT) is maintained by the Centre for Research on the Epidemiology of Disasters-CRED, a research unit at the University of Louvain, Belgium*

*Table 2 – Crisis events in Bulgaria over the period 2010 – 2018 (NSI, 2020)*

| **Indicators** | **Crisis Events** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** |
| Total | 4571 | 8268 | 10826 | 2728 | 4356 | 4008 | 3577 | 1594 | 1420 |
| Fires | **1630** | **2185** | **3010** | **764** | **2245** | **2474** | **2448** | **741** | **480** |
| Landslides | 59 | 76 | 72 | 51 | 75 | 125 | 71 | 32 | 27 |
| Earthquakes | 12 | 4 | 22 | 6 | 4 | 1 | 2 | . | . |
| Droughts | 6 | 30 | 23 | 3 | 1 | . | . | 28 | . |
| Floods | **651** | **382** | **692** | **547** | **360** | **266** | **184** | **159** | **84** |
| Storms, tornado, windspout, whirlwind | 47 | 48 | 528 | 89 | 14 | 12 | 29 | 6 | 13 |
| Hailstorms | 16 | 13 | 14 | 13 | 8 | 21 | 5 | 14 | 8 |
| Snowstorms (snowfall) | 103 | 94 | 93 | 50 | 26 | 56 | 87 | 52 | 13 |
| Icings, frosts | 18 | 134 | 186 | 20 | 3 | 7 | 2 | 52 | 20 |
| Accidents | 7 | 24 | 312 | 314 | 76 | 33 | 1 | 48 | 68 |
| Accidents with vehicles | **1937** | **5218** | **5858** | **841** | **1530** | **994** | **734** | **455** | **701** |
| Pollutions (w/ chemical materials, dangerous or municipal waste, other) | 45 | 42 | 7 | 19 | 3 | 8 | 5 | 2 | 1 |
| Epidemic human diseases | 12 | 7 | 7 | 6 | 3 | 5 | 4 | . | 2 |
| Epidemic animal diseases (incl. birds) | 5 | 2 | . | 1 | 6 | 2 | 3 | . | 1 |
| Calamity | 2 | . | . | 2 | 1 | 2 | 2 | 1 | 1 |
| Other crises and natural disasters | 21 | 9 | 2 | 2 | 1 | 2 | . | 4 | 1 |

As we start narrowing our analytical consideration of these statistics towards our direct subject matter (territorially and topically), we must be aware that not all of the above are typical, frequent and socio-economically relevant. Not nationwide and certainly not all of those are leading for the Black Sea coast.

Those that are more socio-economically relevant – and damaging – have been reported by the NSI in a dataset going from 2010 to 2016. They include fires, mostly outside urban settings, and do not include transportation accidents, industrial incidents and pollution (although the latter group is highly visible and more frequently exposed in the media).

*Table 3. Natural critical event damages 2010-2016 (NSI, 2017)*

| **Year** | Total emergencies | Damages (*BGN, thousands*) | Recovery Funds (*BGN, thousands*) | Rescue and Emergency Costs (*BGN, thousands*) |
|---|---|---|---|---|
| 2010 | 2 582 | 99 642 | 73 956 | 7 479 |
| 2011 | 2 984 | 486 862 | 423 974 | 11 666 |
| 2012 | 4 649 | 103 669 | 34 447 | 104 197 |

| | | | | |
|---|---|---|---|---|
| 2013 | 1 554 | 412 259 | 398 778 | 21 814 |
| 2014 | 2 747 | 189 868 | 59 582 | 21 629 |
| 2015 | 2 973 | 190 915 | 23 823 | 7 734 |
| 2016 | 2 837 | 45 181 | 9 766 | 2 964 |
| **Total** | **20 326** | **1 528 396** | **1 024 326** | **177 483** |

*N.B. For this chart, and everywhere costs and expenditures are reported in BGN, the official exchange rate is to be considered 1 EUR to 1 BGN = 1.95583. It has been fixed at this level ever since Bulgaria's accession to the EU.*

This last dataset has been highlighted as an example of the altered data collection method, enacted after 2010. Nevertheless, even as some perceivable differences in critical event trends might be present for the period before 2010, most natural disaster causes have kept their "leading positions", namely floods, landslides and storms.

For the period **2004–2008**, out of all disaster events resulting from a natural causes (a total of 6,952), **58%** have been as a result of **floods** (4,046), **19%** (1,332) – from **landslides** and **11%** (782) – from **storms**, mostly wind storms.

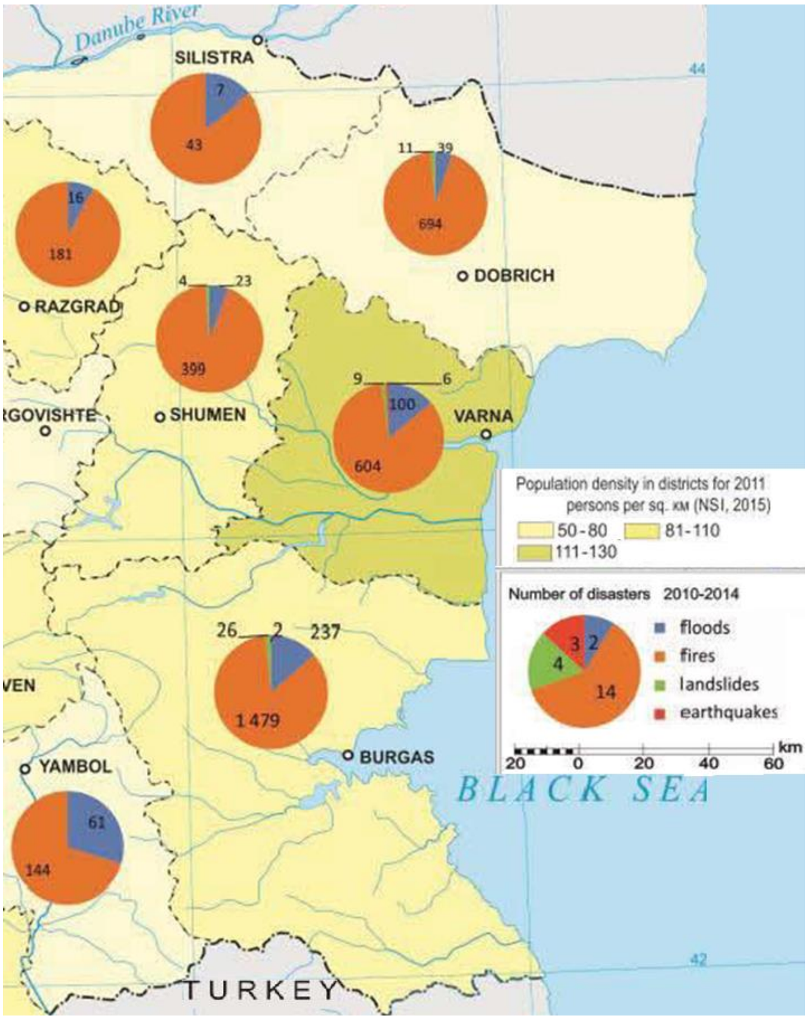
For the period **2010–2016**, as we saw the extended statistics above, the paradigm is similar – out of the total number of disasters (5,398) from natural causes there have been **57%** (3,082) due to **floods**, **14%** (767) – of wind **storms** and **10%** (529) are due to **landslides**. By merging the statistical datasets we arrive at the numbers presented above in Fig. 2: the largest relative share of natural disasters is caused by floods (58%), followed by landslides (15%) and wind storms.

## The Regional and Local Perspective

We need to verify these trends **on a local scale**, directly related to our two subject territories – **Varna, Burgas** and **Dobrich** Municipalities and, contextually, their surrounding **District areas**. Accordingly, such trends will provide out study with the evidence of the influence that leading types of disasters and risks exercise on the local social and economic urban centres.

Below is a graphical representation of the main disaster events and actual scenarios that have occurred in Varna, Burgas, Dobrich and neighbouring districts (National Statistical Institute (NSI) data, 2015).

Figure 3 – Natural disasters by District/Region – 2010 through 2014. (NSI, 2015)




Once again, we continue focusing our considerations on natural disasters, being the leading macro category. Hence, the above critical events do not include car accidents and industrial incidents, as well as pollution instances. With the above in mind, we need to integrate the picture with some inherent specifics of events (primarily) determined by human activity but we will present our findings after this section. If only because District and Municipal administrations have centered their risk management and reporting mechanisms (i.e. emergency preparedness and capacity) largely in response to natural risks and their effects on the urban centres.

As we can clearly see from the above tables, fires (of all scale and source causes) lead the statistical distribution in purely numerical terms. Nevertheless, a closer look at data breakdown provided by the Ministry of Environment and Water (MoEW) – or even media reports – shows that these have mostly occurred in open natural spaces: fields, forests, agricultural farms and facilities. City fires are smaller in scale and mere numbers, although sometimes quite significant in damages caused.

The below table presents the causes of critical events, as reported by Bulgarian Municipalities in 2008 (alone):

*Table 4. Reasons for and causes of critical events, 2008 (Municipal Data, NSI)*

| Identified Cause | Manifestations of Cause | |
|---|---|---|
| | *Count* | *Relative Share (%)* |
| Tectonic rise | 1 | 0.0 |
| Fault movement | 3 | 0.0 |
| Earthquakes | 20 | 0.3 |
| Erosion | 23 | 0.3 |
| Abrasion | 3 | 0.0 |
| Heavy and prolonged rainfall | 743 | 10.1 |
| Dissolution | 4 | 0.1 |
| Strong storms (e.g. tornado) | 187 | 2.6 |
| Snow melting | 67 | 0.9 |
| Snow storms | 241 | 3.3 |
| Fluctuations in ground and surface water levels | 10 | 0.1 |
| Fog, darkness | 25 | 0.3 |
| Other natural causes | 694 | 9.5 |
| Undermining the foundation | 7 | 0.1 |
| Overloading the upper parts of slopes | 6 | 0.1 |
| Groundwater “behaviour” change | 1 | 0.0 |
| Dynamic impacts | 60 | 0.8 |
| Other physical-geographical reasons | 75 | 1.0 |
| Intentional actions | 732 | 10.0 |
| Political situation | 2 | 0.0 |
| Personal interests | 82 | 1.1 |
| Technical reasons (e.g. malfunction, poor lighting) | 1663 | 22.7 |
| Social reasons | 28 | 0.4 |
| Economic reasons | 11 | 0.2 |
| Demographic reasons | 4 | 0.1 |
| Ethnic reasons | 2 | 0.0 |
| Industrial pollution | 28 | 0.4 |
| Other man-made causes | 2602 | 35.5 |
| **Total specified reasons:** | **7324** | 100.0 |
| Unspecified disaster causes | 1381 | |

Anthropic causes aside, the above data only confirms the overall picture on relative share distribution between the types of disasters. “Heavy and prolonged rainfall” is even more pronounced **in 2005**, with 1391 instances of critical situations and disastrous events caused by it, representing 47.1% of all cases. However, that has been a particular year, since certain Bulgarian regions were subjected to catastrophic rain amounts and subsequent floodings, unheard of in decades.

As a comparable reference, we can quote 2008 local data for the causes of accidents **on the national road network** which, numerically, are a significant representation of the other macro category of critical events. Yet even here, we can see that natural phenomena and weather related conditions have caused the absolute majority of such accidents.

*Table 5. Causes of crisis events on the national road network (NSI, 2008)*

| Identified Cause | Manifestations of Cause | |
|---|---|---|
| | Count | *Relative Share (%)* |
| Heavy and prolonged rainfall | 34 | 17.3 |
| Snow melting | 3 | 1.5 |
| Snow storms | 57 | 29.1 |
| Fluctuations in ground and surface water levels | 6 | 3.1 |
| Fog, darkness | 5 | 2.6 |
| Other natural causes | 85 | 43.4 |
| Dynamic impacts | 4 | 2.0 |
| Economic reasons | 1 | 0.5 |
| Other man-made causes | 1 | 0.5 |
| **Total specified reasons:** | **196** | 100.0 |
| More than one reason indicated per given crisis event | 133 | |

## Significance of Extreme Water Phenomena

Many legislative categories and regulation standards have a direct relevance to disaster management and risk prevention, besides the DPA. As we can clearly deduce from historic data, however, few other natural resources could have the claim to more influence on extreme natural phenomena as much as water resources. We will confirm this further on with concrete statistics but need to emphasise the importance of the **Water Law (WL)** at the inception of such an explorative study. Furthermore, it has a strong influence on the management of the Black Sea coastline and most marine activity.

WL's purpose is to ensure "integrated water management" and the "protection of the health of the population". To be able to achieve this, the Ministry of Environment and Waters (MoEW) have among its main responsibilities – along with any other relevant authorities, experts and citizens designated by the Law – the duty to ensure the "protection of surface and groundwater and the waters of the Black Sea"; as well as the protection from pollution of the marine environment with natural or synthetic substances. As an example of direct relevance to **marine and coastal ecological integrity** we can point out to the procedures of **decontamination** – a process carried out "before discharge into surface waters and the Black Sea". Mandatory decontamination is more strictly controlled and more frequently performed before and during the holiday season along the Black Sea coast.

Even more pertinently, the Water Law aims to protect the population and the economy from any potential **harmful effects of water resources**. Such systematic involvement includes:

- "protection from floodings;
- protection from icing and related phenomena;
- protection of river beds and banks from erosion;
- coastal protection from wave impact;
- protection against dangerous increase or decrease of groundwater levels;
- protection of watersheds from water erosion;
- protection against artificial discharge of ground waters;
- protection against sea-induced floods in coastal areas."

Although a couple of those legal definitions and requirements have been added in the last decade, a quick look at the statistics reveals that these are among the most frequent natural phenomena which harm the population and the economic activities, with the low-lying sea coastal areas even more exposed to most of them than the rest of the country.

**Floods** are a leading type of a disastrous scenarios – nationally – and are divided theoretically into two causative groups:

A. "**Natural floods**" – generated mainly by rainfall, melting ice and snow, the formation of ice drifts or freezing;

B. The so-called "**technogenic**" flooding, **man-made**, caused by influences other than the above – e.g. damaged hydraulic facilities which can lead to an accident.

Any flood risk assessment includes a preliminary stage which includes a number of legally required components:

1. **Mapping** of the Water Basin Management Areas indicating topography, land use, boundaries of river basins and sub-basins, as well as banks and coasts where existing;
2. **Past floods** description – those with recorded significant adverse effects on population health and the environment, as well as technical infrastructure, economic activity and cultural heritage. Those are indispensable considering their potential recurrence;
3. **Expected flood** scales – distribution and assessment of adverse effects according to magnitude;
4. **Possible adverse effects** of future floods on the same aspects as above (health, environment, infrastructure and economy, cultural heritage).

Hypothetical evaluations and model assessments are not always absolutely precise, undoubtedly. However, they rely on concrete data from at least three main indicator groups:

- **Topography**: location of water courses, general hydrological and geomorphological characteristics, including the capacity of lowlands as natural water retention surfaces;

- **Man-made infrastructures** and their effectiveness – as single facilities or integrated systems – intended for flood protection, as well as settlement location, business and long-term development areas;

- **Climate change impact** on the occurrence and characteristics of floods. We will explore further how this feature assumes an ever increasing importance in the mapping, prediction and prevention of flooding and related adverse impacts.

According to Art.146e of the Water Law, flood risk maps cover areas that should be clearly designated according to the frequency and probability of such scenarios. Floods with a low probability have a recurrence period greater than or equal to 1000 years, unforeseen events apart; medium probability floods have a recurrence period greater than or equal to 100 years; floods with a high probability of occurrence might happen anytime after the first 20 years.

The last detailed national mapping of flood risk areas has been completed and published in 2010. Trends and factors have been updated, as all risk maps need to be legally updated reviewed by the Director of the respective territorial Basin Directorate every 6 years. Regional mapping areas, however, are deemed sufficiently representative at present.

**Flood risk maps** contain the following indicative elements for every probability period:

- Flood spread;
- Water levels or water depth;
- Where applicable – speed or water quantity of the current.

Adverse consequences of potential floods – for each of the probability periods – are also described in terms of an approximate number of potentially affected residents and type of economic activity potentially affected.

There are additionally sub-regional maps created for areas under threat of floods caused by underground currents and water deposits.

Since extreme **water-related phenomena** present important impact factors both horizontally (via direct territorial effects) and vertically (among other natural hazards and events), they are held in high consideration **in all risk prevention and planning**.

Territorial development plans for the entire Black Sea coastal region cover urban and rural areas. Crucially, prevention and planning considerations are dedicated to **beaches**, sand **dunes** and nearby **sea waters**, as well as adjacent **coastal lakes**, **lagoons**, **estuaries** and **wetlands**.

There are several areas of national Water Basin Management and planning. The **"Black Sea Region" Basin Directorate** (BSRBD) is based in Varna and covers the catchment areas of rivers flowing into the Black Sea from the northern to the southern border, including inland waters and the territorial sea. Its activity is controlled by the MoEW.

The BSRBD does not only prescribe, provide opinions, evaluations and monitoring. It actively participates in district, municipal and regional councils for spatial planning, considering the significance of extreme water-based phenomena in local and regional safety and socio-economic stability.

Completing the regulatory framework and public institutional involvement in risk monitoring and reporting is the **National Statistical Institute** of Bulgaria (NSI). It is a cornerstone of public records in many sectors and disaster management is not an exception. The NSI publishes official annual data on crisis events on the territory of our country in the Section "Regional Statistics and Monitoring Indicators". For the past decade there is sufficient and detailed data which has been submitted annually by Municipal Commissions for population protection and assistance in case of disasters. Before 2010 such data has been recorded primarily by national institutions, as well as collected and synthesized with the participation of third-party sources. Presently, crisis event data covers:

- damages from recorded events;
- reimbursement provided and segmented by funding sources (e.g. Government Commission to the Council of Ministers, paid insurances, EU aid);
- rescue and emergency work costs (provided for in Municipal Protection Plans, with additional fund allocations under certain conditions).

Local authority involvement in presenting and recording critical events has led to an efficient segmentation of such occurrences by **District** and **Regional** significance and location. This also allows us to have a clearer view of the disaster impacts in the Black Sea coastal areas.

### Floods and Causes of Flooding

Floods rank second or third, statistically, in some sections and survey groups. However, they are almost always the most relevant to populated areas with **higher density** such as **Varna** and **Burgas**, the two urban settlements and district centres. Both cities border on the Black Sea, have a number of municipal lakes, dams, riverbeds and city canals that run through their territories and around them, and tend to include complex and extended sewage systems, vulnerable underground structures and purification stations, to name only a few dynamic water systems.

While floods are the most common natural disasters, globally and locally for the region in our analysis, the more frequent type among them is the **rain-river** type. Inherently, any **sizeable floods** are also of the rain-river type, since both nationally and locally there are natural conditions for the formation of large water masses in the river valleys.

We cannot avoid citing the **2005 series of floods** caused by torrential rains in the summer. They have been of catastrophic proportions throughout – large-scale and ubiquitous, torrents flooded **75% of the territory** of the country, including some municipalities in **Burgas district**. Railway lines connecting Sofia to the North-East (Targovishte, Shumen and **Varna**) were flooded and the communication links are cut off. A state of emergency was declared in a number of municipalities. Overall, those floods claimed the lives of 30 people, left 14 000 homeless and affected **a quarter of the country's population**. Even though 30% of the NIMH weather stations failed during certain torrents, in September they still reported 2 to 3 times above the average precipitation quantities in North-eastern Bulgaria.

When the year is relatively "normal" in terms of rain levels, the latter still regularly cause dozens of floods and critical situations along the Black Sea coast alone.

*Table 6. Floods – country total and by regions/districts.*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| National Total | 651 | 382 | 692 | 547 | 360 | 266 | 184 | 159 | 84 | 108 |
| **Burgas** | **82** | **22** | **77** | **37** | **19** | **14** | **42** | **55** | **3** | **4** |
| **Varna** | **30** | **16** | **11** | **15** | **28** | **47** | **4** | **2** | **1** | **1** |
| **Dobrich** | **10** | **21** | **3** | **2** | **4** | **2** | **2** | **1** | N/A | N/A |

*Table 7. Economic Losses caused by Floods (in BGN Thousands).*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| National Total | 38,882 | 206,659 | 20,898 | 15,285 | 177,604 | 171,032 | 30,617 | 135,530 | 28,384 | 21,173 |
| **Burgas** | **493** | **140** | **384** | **13** | **16205** | **136129** | **807** | **117959** | **2418** | **2455** |
| **Varna** | **2615** | **1315** | **1226** | **1369** | **37797** | **3548** | **4664** | **669** | **11** | **317** |
| **Dobrich** | **405** | **499** | **1** | **216** | **7854** | **1951** | **34** | **800** | N/A | **207** |

Frequency and impact is high – both with direct damage and the population affected. But for Varna and Burgas floods are even more relevant given their low-lying coastal location. Understandably, with floods and extreme temperatures being the most common disaster types (high temperatures also tied to fire incidents in natural settings), one can see significant Municipal and Regional capacity being dedicated to such phenomena, above and beyond standard response mechanisms.

Moreover, most forecasts regarding **climate change** scenarios in Bulgaria predict an increase in the frequency of such extreme events – only corroborated by the **increasingly frequent intense rainfall**, floods and droughts, **warm and cold waves**, landslides and forest fires.

An additional increase in flood risk is driven by **urbanization** and the greater exposure of all civil assets and the population in flood-prone areas. Between the two latter factors, however – and this is especially true in the case of Varna and Burgas in the coming years, considering the growth of their city agglomerations – the impact of **climate change will outpace urbanization** as a major source of increased flood risk. Even if we consider such climatic trends mere fluctuations on a larger timescale.

While it may seem an untimely discourse deflection if we turn to **landslides**, the latter cannot be considered merely as a separate phenomenon of landmass instability. Landslides and rockfall incidents are quite relevant for almost any Bulgarian region, even more for the coastal areas.

Whether it is freshwater floods, sea wave activity or a combination of erosion factors, water-related and induced critical events have a direct effect on the geomorphic integrity of the territory in our analysis.

A prime example are the sediment shortages which are characteristic of the sea coast. Beach depletion is also a secondary result of inefficient human intervention in coastal protection. However, the main cause are the important sediment movements which are hard and expensive to tackle. Their long-term management is mostly of national jurisdiction (being State territorial waters and beaches), but they have predominantly local socio-economic importance and environmental impact. Furthermore, the entire Bulgarian coastal area is exposed to frequent storms and constant wave action, both of which might incur significant economic losses due to infrastructural damage and consequent decrease of tourist spaces and facilities – the latter being of extreme importance to Burgas and Varna.

We have already established that NSI data indicates floods as leading natural disasters – between 2010 and 2016 alone, floods caused damage of more than BGN 661 million (about EUR 340 million). Government agencies (e.g. the **Black Sea Basin** Water Management Directorate, or **BSB**) publish maps of flood risk areas for the 4 major river basins in observance of the EU Floods Directive. In 2013, the Bulgarian government prepared such flood risk maps for the four river basins. Flood simulation models were also developed for some locations (165 at the time). For the North-East (Varna), the Kamchia river catchment area is of crucial significance; while for the South-East, several lakes and dams around Burgas are to be taken into consideration. All of the above are plotted in relatively updated mapping and monitoring practices. However, the existence of the latter alone is insufficient to support adequately national or municipal disaster prevention and contingency planning. If only because their management is left entirely up to the local administrations, with little coordination and top-down support.

### 2014 – The year of severe floods

The entire national territory experienced a series of 4 floods **between February and October of 2014**. Intense rainfall, exceeding four times the monthly climatic norms, affected most regions in Bulgaria, causing serious floods and disturbances. Bulgaria applied for EU support in late

August, after carefully considering its internal capacity to cope with the first series of floods which started on June 19. In mid-September the Bulgarian authorities provided updated information.

The Bulgarian authorities estimated the total direct damage caused by the floods to amount to EUR 311.3 million. The natural-cause floods fall within the scope of the Solidarity Fund and were therefore eligible for Union financial support. Bulgarian authorities reported that “from 19 June 2014 onwards, due to severe weather conditions, a number of towns and villages were severely affected by floods, in particular in the **Eastern, North-Eastern** and Central part of the country”. Among the districts listed as most affected were namely Varna, Dobrich and Burgas.

The number of casualties amounts to more than 18 people, with Varna and Dobrich reporting 13, and Burgas 3 people. Damaged and destroyed structures included many homes and public buildings, with roads closed, many facilities seriously damaged and with subsequent **intensification of landslides**. Damage was caused to important facilities in the sectors of energy and water services, telecommunications, transport, healthcare, education and emergency services, as well as cultural heritage sites and protected natural areas. Large amounts of soil and waste waters were swept up, causing the overflowing of sewers. Wastewater disposal facilities could not handle the flow and resulted in worsened sanitary conditions in all affected areas. The floods activated not only minor landslides but also wider erosion processes. Heavy rains in almost all Bulgarian Black Sea resorts blocked thousands of tourists.

Reports of the above critical situation are not only present in national media outlets, they are accounted for in the Draft amending Budget **N°7 to the General Budget 2014 of the European Commission.**

Varna's Asparuhovo district was also subjected to torrential rain and tidal waves, as it is located at the sea front. Houses and industrial facilities were destroyed, with serious damages incurred by flooded buildings and streets, as well as hundreds of vehicles. The disaster caused power and communication outages in the region.

Ultimately not only the two urban centres experienced such critical conditions. The entire Black Sea coastal region was hit by severe floods, overflowing rivers and landslides. Besides the reported casualties and damages, thousands of citizens were directly affected by the disaster, with hundreds having to be evacuated and placed in temporary shelter.

The Bulgarian authorities were able to submit detailed damage costs for EU support: both in terms of emergency and recovery actions were eligible. The largest share of support expenditures was requested for prevention actions and infrastructure (over EUR 87 million); while it was estimated that more than EUR 70 million would be needed to rebuild the transport infrastructure.

Additionally, further flood risk assessment has more recently been performed by the World Bank Group under the Global Disaster Reduction and Recovery Instrument. The report on "Europe and Central Asia (ECA) Risk Profiles" (2016). It estimates that an average of about 80,000 people a year will be affected by floods in Bulgaria, with an average annual impact on gross domestic product (GDP) of around USD 400 million. The WBG models predict that the effect of floods with a reference recurrence period of 50 years could impact as much as USD 2 billion of GDP. Moreover, by 2080 (with due socio-economic and climatic conditions considered) the amount is said to supposedly double or even quadruple (depending on a closed set of preset future scenarios). Current flood risks are mostly driven by urbanization and greater **exposure of assets and people in flood-prone areas**. However, in the coming years the impact of **climate change** is also estimated to outpace urbanization as a major driver of increased flood risk.

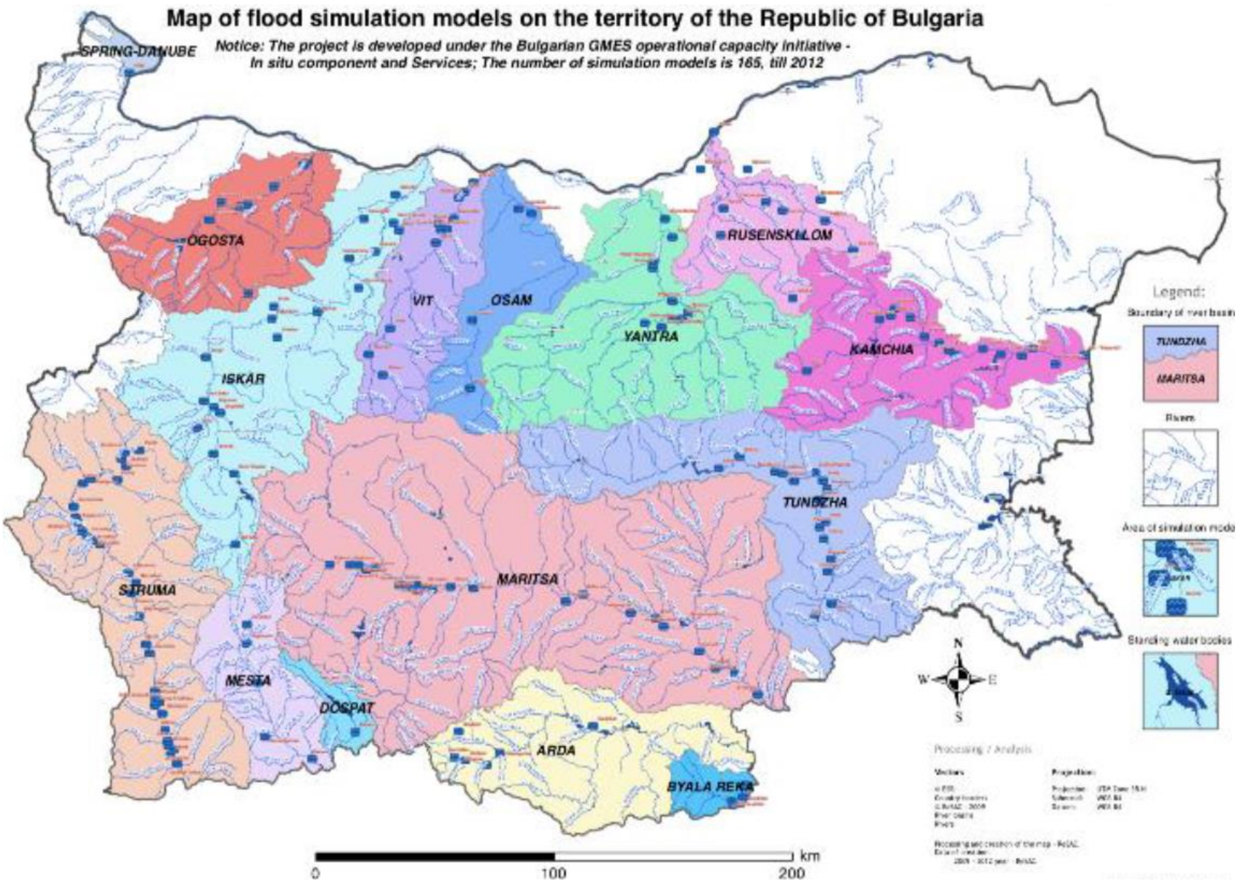
Empirical observations and (unofficial) media reports also indicate that sudden and urban floods in Bulgaria have increased over the past 10-15 years. Sudden floods in rural areas are mostly due to intense rainfall, adding up to the diminished vegetation coverage in various places. On the other hand, in urban heavy rainfall is aggravated by impermeable surfaces – roads and concrete mostly. The latter increase the chance of flooding, not the least because many urban wastewater systems in Varna and Burgas were designed for smaller quantities (or may be clogged) and cannot take on larger flows.

As explained above, slopes are also affected by natural and man-made factors which contribute to landslide occurrence, with floods a leading cause for their activation. Natural factors are namely related to the destabilization of the slope base due to river abrasion and ravine bank erosion. That is especially true when such sediment deposit erosion is relatively easy, although that would mean less serious landslides and rockfalls. Man-made factors and causes of landslide activation include construction and deep excavations (always construction related), road construction, extraction of minerals and aggregates, as well as many other complex (mostly) economic activities.

The combination of the above factors often leads to critical situations and disastrous environmental conditions which endanger population lives and health, as well as property, infrastructure, cultural and material values, as well as the environment itself.

The below map – provided by the Ministry of Environment and Water – shows general area mapping of simulated flood risk territories for the country. It combines NSI data, MoEW research and the findings of the Satellite Imaging Application Centre (ReSAC) based in Sofia.

*Figure 4 – Flood simulation models for the main River Basins – 2013 (ReSAC, MoEW, NSI)*




Commission Directive 2007/60/EC on the Assessment and Management of Flood Risks has some clear prescriptions. Both applicable to inland water bodies and all coastal waters, it indicates the need to elaborate flood risk maps to help with preparedness. As we can clearly see the above map, coastal areas are left behind in these mapping and monitoring activities, at least on national level – although they suffer many critical water-related events each year.

It is important to emphasise that along seaside areas, earthquakes are expected somewhat less frequently. Landslides and rockfalls persist as natural events with high relevance, frequent occurrence and in some cases literal disastrous effects

**Landslide** hazards are therefore directly proportional to water crises and shoreline specifics. Along the Danube (river) shores in North Bulgaria, over the past 30 years, there have been about a dozen landslides with practically catastrophic effects on local settlements and infrastructure. Such natural events are regularly also recorded along the Black Sea coast, especially in the North, where the shoreline is steeply formed and tied to tectonic instability.

**Rockfalls**, lastly, are observed where deeply cut and transverse gorges are found, such as canyons or troughs. While rivers end up in the sea precisely on the East coast of Bulgaria – in and around the two Municipalities and their District jurisdiction and economic influence – their riverbeds are not that vertically laid out, as much as characterised by declining slope stability. Sea shores are no different, and critical conditions are associated with rainfall periods, any magnitude of earthquakes and even simple gravitation. Thus, the marginal escarpments of Northeast Bulgaria's plateaus – including and especially the Black Sea coast – are considered risk areas (ibid).

Out of nearly 800 recorded floods along the Black Sea coast over the past century (see precise source below), around a quarter have been significant in damages, affecting heavily local population and surface areas. The below table outlines the main scenarios relevant to the Black Sea Basin Water Management Directorate which have the highest probability of occurrence due to natural causes. We have to emphasise, however, that these exclude some surface, underground, sudden or infrastructurally determined floodings, deemed much less likely than these leading types for the listed reference areas.

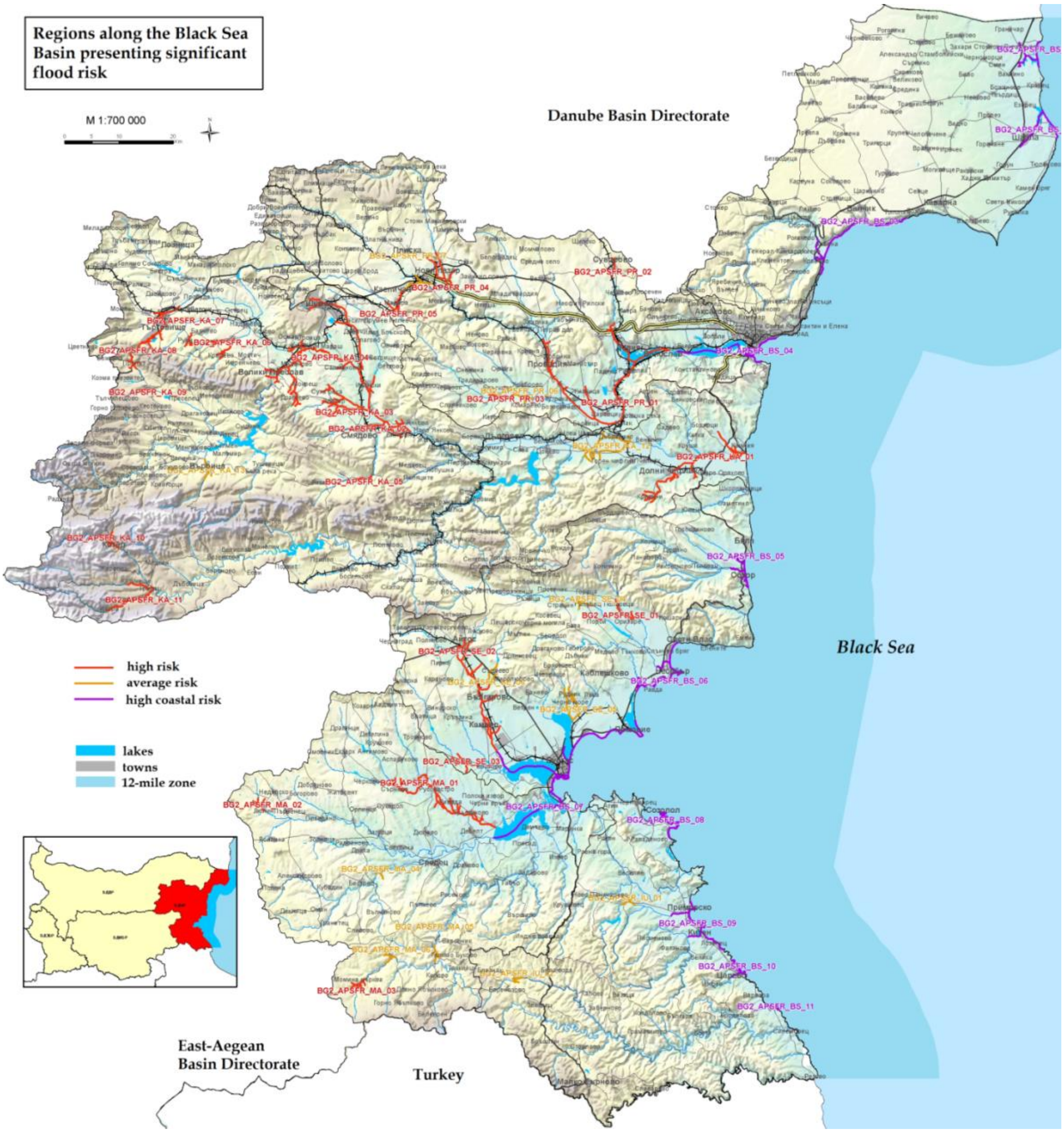
*Table 8. Most relevant flood scenarios within BSB territory.*

| Flooding Scenario | Water Body | Vulnerable Inhabited Zone | Flooded Area ($m^2$) | Number of people affected | Total damage (in EUR) |
|---|---|---|---|---|---|
| by Sea | Durankulak lake | Durankulak lake | 5,685,000 | | |
| by Sea | | Burgas | 2,643,044 | 2,989 | 13,268,081 |
| from Dam Enevo | Provadiyska river | Provadiya | 1,520,090 | 1,719 | 28,152,067 |
| by Sea | | Pomorie | 1,500,630 | 1,697 | 34,274,389 |
| Q100 flood | Provadiyska river | Provadiya | 1,152,405 | 1,303 | 21,342,541 |
| Q100 flood | Vrana river | Targovishte | 1,078,330 | 1,220 | 19,970,672 |

** a Q100 flood is an event with a 100 year Average Return Interval (ARI): it has a 1% chance of occurring, or being exceeded,* ***in any one year****.*

Additionally, we can present the **BSB flood risk map** for its entire territory. High and average risk areas are differentiated from “high coastal risk”, since the dynamic marine behaviour goes beyond standard vulnerability characteristics.

*Figure 5. Floor Risk Map within the Black Sea Basin water management territory.*




The below table lists these flood risk areas. We can see that, out of a total of 45, there are **21 in Burgas District, 8 in Varna and 3 in Dobrich**. There are flood zones in Shumen and Targovishte districts which do not lie along or even near the Black Sea coast but are monitored by the same Basin Directorate. We hereby include only areas with risk levels designated as "High".

*Table 9. A list of high flood risk areas along the Black Sea coast (source: BSB WMD).*

| National Code System | Flood Region Name | Affected Area Length (km) | River Valley / Sea Shore | Nearby Inhabited Place | Municipality | District |
|---|---|---|---|---|---|---|
| BG2_APSFR_BS_01 | Black Sea - Durankulak | 14 | Dobrudja Black Sea rivers | Durankulak | Shabla | Dobrich |
| | | | Black Sea | | | |
| BG2_APSFR_BS_02 | Black Sea - Shabla | 15 | Dobrudja Black Sea rivers | Shabla | Shabla | Dobrich |
| | | | Black Sea | | | |
| BG2_APSFR_BS_03 | Black Sea - Balchik | 31 | Black Sea | Balchik | Balchik | Dobrich |
| | | | | Albena Resort | | |
| | | | Dobrudja Black Sea rivers | Kranevo | | |
| | | | Black Sea | Karvuna Resort | Kavarna | |
| BG2_APSFR_BS_04 | Black Sea - Varna | 36 | Black Sea | Varna | Varna | Varna |
| | | | Provadiyska River | | | |
| | | | Provadiyska River | Kazashko | | |
| | | | Provadiyska River | Ezerovo | | |
| | | | Provadiyska River | Strashimirovo | Beloslav | |
| BG2_APSFR_BS_05 | Black Sea - Obzor | 18 | Black Sea | Obzor | Byala | Varna |
| | | | North-Burgas rivers | | Nessebar | Burgas |
| BG2_APSFR_BS_06 | Black Sea - Nessebar | 27 | Black Sea | Slanchev Bryag (Sunny Beach) | Nessebar | Burgas |
| | | | North-Burgas rivers | | | |
| | | | Black Sea | Aheloy | Pomorie | |
| | | | North-Burgas rivers | | | |
| | | | Black Sea | Nessebar | Nessebar | |
| | | | Black Sea | Ravda | | |
| BG2_APSFR_BS_07 | Black Sea - Burgas | 73 | Black Sea | Pomorie | Pomorie | Burgas |
| | | | North-Burgas rivers | | | |
| | | | Black Sea | Burgas | Burgas | Burgas |
| | | | North-Burgas rivers | | Kameno | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Mandra Dam rivers | | Sredets | |
| BG2_APSFR_BS_08 | Black Sea - Sozopol | 16 | Black Sea | Sozopol | Sozopol | Burgas |
| BG2_APSFR_BS_09 | Black Sea - Primorsko | 24 | Black Sea South-Burgas rivers | Primorsko | Primorsko | Burgas |
| | | | Black Sea South-Burgas rivers | Kiten | | |
| | | | Black Sea | Lozenets | Tsarevo | |
| BG2_APSFR_BS_10 | Black Sea - Tsarevo | 9 | Black Sea South-Burgas rivers | Tsarevo | Tsarevo | Burgas |
| BG2_APSFR_BS_11 | Black Sea - Ahtopol | 4 | Black Sea | Ahtopol | Tsarevo | Burgas |
| BG2_APSFR_KA_01 | Kamchia - Dolni Chiflik | 50 | Kamchia river | Kamchia Resort | Avren | Varna |
| | | | | Detelina | Dolni Chiflik | |
| | | | | Krivini | | |
| | | | | Dolni Chiflik | | |
| BG2_APSFR_MA_01 | Russokastren-Russokastro | 53 | Mandra Dam rivers | Sarnevo | Karnobat | Burgas |
| | | | | Russokastro | Kameno | |
| | | | | Livada | | |
| | | | | Trastikovo | | |
| | | | | Konstantinovo | | |
| BG2_APSFR_MA_03 | Fakiyska - Momina Tsarkva | 9 | Mandra Dam rivers | Momina Tsarkva | Sredets | Burgas |
| BG2_APSFR_PR_01 | Provadiyska – Provadiya | 69 | Provadiyska River | Provadiya | Provadiya | Varna |
| | | | | Zhitnitsa | | |
| | | | | Tsarevtsi | Avren | |
| | | | | Yunak | | |
| | | | | Kazashka Reka | | |
| | | | | Sindel | | |
| | | | | Trastikovo | | |
| | | | | Razdelna | Beloslav | |
| | | | | Beloslav | | |
| | | | | Devnya | Devnya | |
| BG2_APSFR_PR_02 | Devnenska – Suvorovo | 4 | Provadiyska River | Suvorovo | Suvorovo | Varna |
| BG2_APSFR_PR_03 | Glavnitsa - Blaskovo | 10 | Provadiyska River | Blaskovo | Provadiya | Varna |
| BG2_APSFR_SE_01 | Byala - Orizare | 8 | North-Burgas rivers | Gyulyovitsa | Nessebar | Burgas |
| | | | | Orizare | | |
| BG2_APSFR_SE_02 | Aytoska - Aytos | 49 | North-Burgas rivers | Aytos | Aytos | Burgas |
| | | | | Balgarovo | Burgas | |
| | | | | Kameno | Kameno | |
| | | | | Svoboda | | |
| | | | | Burgas | Burgas | |
| BG2_APSFR_SE_03 | Chukarska-Ravnets | 12 | North-Burgas rivers | Ravnets | Burgas | Burgas |

The above zones are defined as having a significant potential risk of flooding as per parameters and definitions of the Water Act (Art.146). These integrated risk factors are an aggregate result of seashore exposure, dynamic meteorological water phenomena, underground currents and the fundamental influence that the **rivers flowing into the Black Sea** have in determining the boundaries of such risk areas.

In particular, an abundance of water flow at the river mouths may meet waves classified as above the 6$^{th}$ degree of the Douglass sea scale – namely “from very rough” to “high” or wave height above 6 meters.

On the other hand, torrential floods are not related to the existence of nearby rivers, as they occur mainly during intense rainfall resulting in abundant and excessive surface water accumulation. Such transitory large water volumes fill lower lying terrain forms when the accumulation speed of the former exceeds the capacity of the natural drainage module of the latter; or the drainage capacity of any supporting man-made sewage and drainage system. Torrential floods result especially dangerous in populated areas where the watertight surfaces of roofs and streets create favourable conditions for quick water accumulation and almost no possibility of soil infiltration.

A survey conducted in Black Sea Basin region municipalities (including regional FSCP structures and the State-owned company “Irrigation Systems”) has shown that the macro region reported **761 floods** worth of note (between **1914** and **2010**). The main reasons remain torrential rains, followed by the Sea and human negligence. The reference EU Directive (2007/60) leaves somewhat open the flood classifications, considering the possibility of specific local types and causes. **Lake floods** and **sloping floods** have been added and highlighted specifically for the Black Sea coastal region. The 761 cases are split between **5 main flood types**, thus:

• river floods – 423 (55.59%);

• sloping floods – 279 (36.66%);

• “infrastructural” floods – 38 (4.99%);

• sea floods – 16 pcs (2.10%);

• lake floods – 5 (0.66%).

The most relevant type involves river overflows, with waters overflowing above river banks and riverside terraces. Natural causes include mostly snowmelt or heavy rainfall, followed by flow obstructions of various types: riverbed overgrowth, clogged street drainage (e.g. by sediment deposits), ice drift or wind impact. The first two obstruction types occur equally nationwide, while ice drifts and obstructions are not typical for the Black Sea coast but wind impact is regular in the winter and significant in its contact with the large water bodies.

Studying past floods provides valuable information on the potential risk of these floods recurring with serious consequences. Data from the Preliminary Flood Risk Assessment of the BSB showed that the number of affected settlements has significantly increased since 2005. The highest total number of flood affected settlements was in 2006 – 26 – mostly concentrated in the Southern Black Sea coast, within the wider coverage of the municipalities of Malko Tarnovo, Tsarevo, Sozopol and Nessebar.

In particular, the Municipality of Tsarevo leads in number of flood affected settlements in the past couple of decades, followed by Burgas, Nessebar and Pomorie municipalities. River floods are the leading cause of significant flood damage, across the board, with Tsarevo again the most affected. Burgas is subjected to the highest impact of floods damages out of all the Black Sea coast settlements, as it also has incidents related to infrastructure failures, as well as lake floods – both are locally more relevant than river overflow cases.

Overall, man-made infrastructure faults result as second by damage caused, with sea-induced floods ranking third. (Slope-related floods are more relevant for the territories further away from the shoreline, statistically). Pomorie is the town which has been affected the worst among predominantly tourist settlements, followed by Obzor and the resort Sunny Beach.

### Earthquakes: Zonal significance and impact.

As frequent as they might according to official records, earthquakes are naturally not spread out evenly, nor are they all significant enough to be even noticed. The territory of Varna Municipality, however, falls within the **Shabla seismic zone**, part of the larger Bulgarian North-East seismic region. The earthquake potential of the latter reaches a maximum possible magnitude of up to $8^{th}$ of the Richter scale, and intensity might go up to $9^{th}$ degree of the Modified Mercalli Intensity Scale.

As rare as earthquakes have been in recent years (all through the country, in fact), statistical reports and deductions impose a more profound analysis of the phenomenon. A national report going back 200 years shows that earthquakes have claimed hundreds of lives and damaged tens of thousands of buildings. Bulgaria has been subjected to some of the strongest earthquakes in European history. One significant example is the **1802 earthquake** which almost destroyed the towns of Ruse, Silistra, **Varna** and Vidin with a reported **magnitude of 7.9**.

*Table 10. Earthquakes – total for the country and the analysed districts.*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Country Total | 12 | 4 | 22 | 6 | 4 | 1 | 2 | - | - | - |
| **Burgas** | - | - | **2** | - | - | - | - | - | - | - |
| **Varna** | **4** | - | - | **1** | **1** | - | - | - | - | - |
| **Dobrich** | - | - | - | - | - | - | - | - | - | - |

*Table 11. Economic losses caused by Earthquakes – total for the country and the analysed districts. (in BGN Thousands).*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Country Total | 224 | - | 59037 | 915 | 62 | - | - | - | - | - |
| **Burgas** | - | - | - | - | - | - | - | - | - | - |
| **Varna** | **224** | - | - | **100** | **62** | - | - | - | - | - |
| **Dobrich** | - | - | - | - | - | - | - | - | - | - |

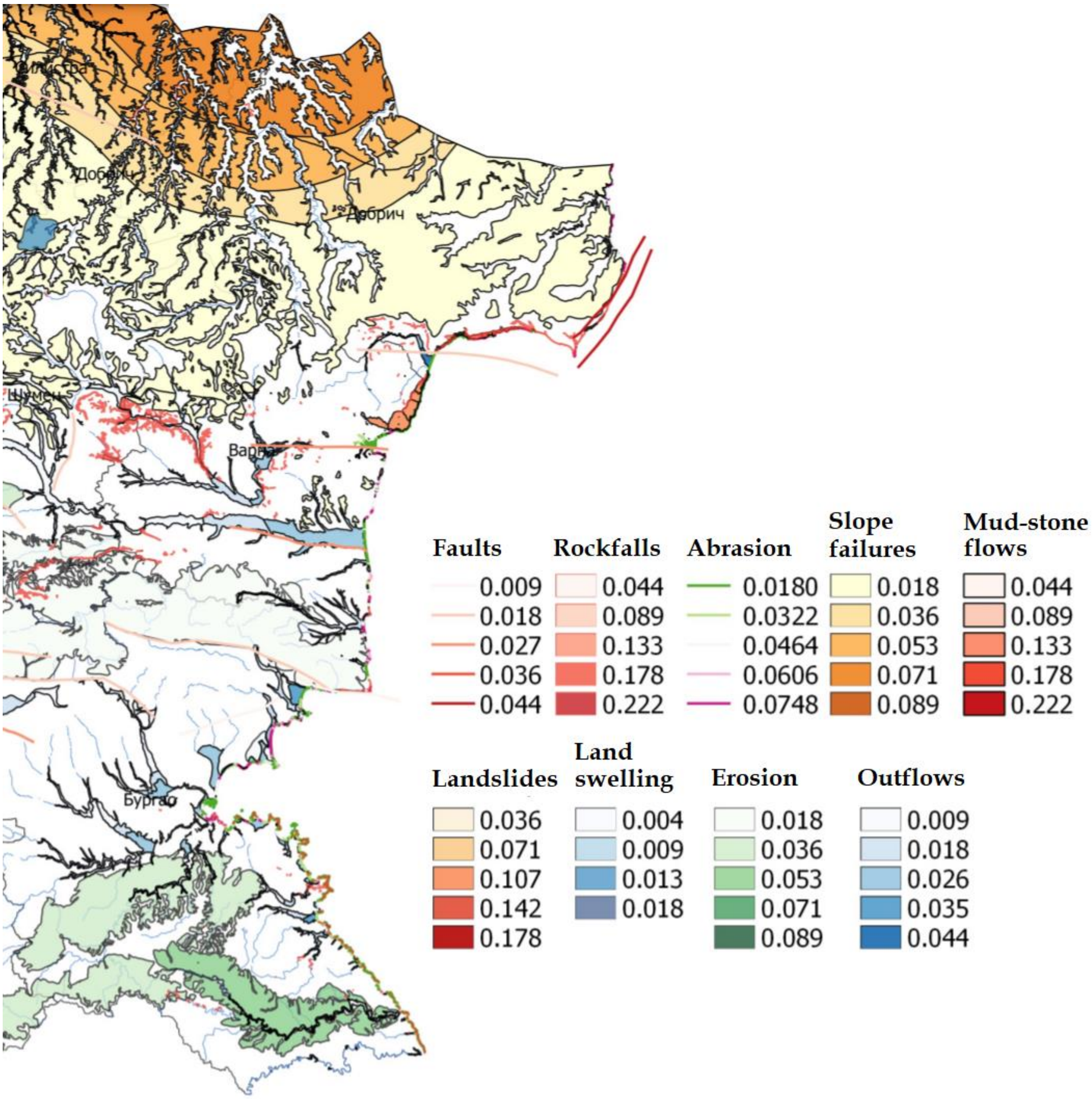
### Processes determining the degree of geological hazard

The abrasion processes registered along the Black Sea coast affect about 234 km of the coastline. The principal processes of landslide and general abrasion which are reported nationally are caused by complex geological structure, intensive tectonics and certain persistent natural and man-made factors.

With quite a few settlements, suburbs and resorts located in highly urbanized areas nearby or directly on top of slopes, said areas result even more vulnerable to potential landslides.

The below table shows the geological hazard levels and their causes in East Bulgaria.

*Figure 6. Geological risk zones and geomorphological risk factors in East Bulgaria.*




Among the more significant geological risk processes we can specifically name:

- the several **fault lines** in the North-East (east of Dobrich);
- the South-East **erosion** area;
- the characteristic **landslides** north of Varna;
- the **slope failures** in the North-East (due mostly to **loess** deposit subsiding and sediment yielding);
- as well as the liquefaction of “weak” soils and subsequent outflow along water bodies all throughout the macro-region.

The Black Sea landslide region is actually the largest in the country, both considering area coverage and population affected. The dimensions of current and potential landslides extend over kilometres in length and range, with the sliding depths reaching more than 50-60 meters. Overall, currently and potentially affected **population** is estimated to be around **61,394** only considering landslides. Sea abrasion remains the principal determining factors for this kind of landmass instability.

As reported by the Bulgarian Academy of Sciences (BAS), the Dobrudzha coastline is characterized by a "complex" tectonic environment and the possibility of **earthquake** generation followed by significant and devastating **tsunamis**. Such a sequence has caused severe damage to the shores in the not so distant past and maintains the same devastating for the future.

Moreover, the continental slope extending about 50 km north of Varna presents numerous **faults** which are associated with earth gas emissions. These same faults present sufficient conditions for landmass instability, namely earthquakes.

Currently, there is no dedicated early warning system for both high wave activity and tsunamis potentially affecting coastal areas. And that is the reality for the entire Black Sea coast, not just the North. And while such events are rare and have prerequisite and accompanying critical events, there have been quite destructive cases in the past. The most notable is accounted for by Greek historical chronicles: in the year 543 Varna (named Odessos at the time) was hit by a tsunami, with waves entering **6-7 km inland**.

The total area which the sea devours annually is estimated at about 20 decares of Bulgarian national territory, with the process predominantly affecting the Northern Black Sea coast.

*Table 12. Landslides – total for the country and the analysed districts.*

| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
|---|---|---|---|---|---|---|---|---|---|---|
| Country Total | 59 | 76 | 72 | 51 | 75 | 125 | 71 | 32 | 27 | 31 |
| **Burgas** | **5** | **4** | **9** | **3** | **5** | **6** | **1** | **1** | **2** | **1** |
| **Varna** | **4** | **3** | - | **1** | **1** | **3** | **1** | - | - | **1** |
| **Dobrich** | **5** | - | - | - | - | - | **3** | - | - | - |

*Table 13. Economic Losses caused by landslides – total for the country and the analysed districts (in BGN Thousands).*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Country Total | 2182 | 224790 | 17384 | 294459 | 9291 | 10011 | 9632 | 7720 | 6248 | 8101 |
| **Burgas** | **370** | **1200** | **2529** | **291089** | **943** | **287** | **100** | **146** | **175** | **162** |
| **Varna** | **50** | **50** | - | - | **90** | **238** | **200** | - | - | **38** |
| **Dobrich** | **20** | - | - | - | - | - | - | - | - | - |

The above data is obtained on the basis of the annual reports submitted to the NSI by the municipal administrations. We can notice that **2013** has been reported as a particularly difficult year in mitigating and recovering from landslides. However, these are continuous processes, many times monitored and periodically evaluated both in terms of severity and damage extent, and are rarely the result of sudden processes – even in the above case of torrential rains affecting the soil. Moreover, reporting mechanisms have been altered through the years. The fact remains that 2013 is essentially unsurpassed in damages over the past decade.

### Other Relevant Natural Phenomena Leading to Disastrous Events

There are several other categories of disastrous phenomena which are sufficiently regular or probable in their occurrence. Nevertheless, they have either less impact and frequency than water and geological events, or are the result of a combination of factors which do not distinguish them as a simple event (e.g. natural vs. man-made causes of fire, incidents as a result of human negligence or technical failure, a combination of several factors, etc.).

The average annual number of days with **strong wind** for non-mountainous parts of the country is between 5 and 20 days. The lowest number of windy days are reported in depressions. That being said, there are anywhere between **20 and 30 days** with strong winds observed in **some areas along the Black Sea coast**. The coast is essentially open with few large gulfs and numerous exposed capes.

Winds are mostly responsible for **icings** in the winter, even in the coastal regions where temperatures are milder and snow precipitation is moderate. Icings are particularly relevant in urban and suburban settings, as we analysed in the relative part above dedicated to water-induced phenomena.

As a combination of precipitation and wind factors, **storms** are sometimes separated into a specific subcategory. The entire national territory is susceptible to regular exposure to (strong) storms. Most recently, in early 2018, a surge of late winter storms damaged a number of villages in Dobrich District, leaving many households without electricity and with other collateral damage.

**Forest fires** have been generally increasing in number, frequency and intensity. The trend is particularly pronounced in the period from 1999 to 2001, as well as in 2007. Those years report fire risk levels, nationally, similar to that of Mediterranean countries. The highest number of fires was in 2000 and 2007 - respectively 1,710 and 1,478. Those events affected total areas of 57,406 ha and 43,000 ha respectively.

Crucially, reports and analyses have established that over 90% of all forest fires in the last 25 years are a result of human activity. Such factors include deliberate actions, e.g. clearing agricultural lands of stubble, shrubs and grass. Consequently, the most fire-vulnerable forests are located around agricultural land, statistically. Moreover, official reports tell an eloquent story: no more than 4% of all forest fires occur naturally. The purely anthropogenic nature of fires is stably over 90%, which categorises most forests situated near urban areas as ones with high risk. Quite importantly, these are about three quarters of all forest areas in Bulgaria.

Fire hazard maps have been elaborate for the entire national territory. However, they mark areas affected by past fires. As much as statistical track records are not questionable, these vulnerability areas do not reflect a dynamic interaction with human factors (e.g. changes in concentration of flammable materials, as well as vulnerable or risky economic activity). Moreover, considering the changing climatic conditions which are expected to lead to prolonged dry and hot periods, fires are expected to become more frequent and occur in areas which historically have not been exposed and predisposed to such critical events.

The seaside is not any different from the rest of the country in terms of being susceptible to **droughts**. Due to its climatic, geographical and topographical traits, the national territory has experienced several significant prolonged droughts in the 20$^{th}$ Century – largely defined as lasting from 1902 to 1913; from 1942 to 1953; and from 1982 to 1994.

Since the turn of the century, although shorter in duration, droughts have become more frequent and more intense. That is, however, a more far-reaching phenomenon and includes many parts of the EU. Notably, the 2003 widespread drought affected more than 100 million people and a third of the EU territory, as per World Bank data.

Forecasts and future climate change scenarios go further – in less than 60 years we can expect today's mild droughts to shift to severe ones. Estimates show a 20 percent chance of a significant and prolonged drought over the next 10 years, which might hit the Western and South-eastern EU regions the hardest. Not only in severity: droughts are also expected become more frequent numerically.

**Heat waves** are already a reality in Bulgaria, as they are expected to worsen with global warming. In 2000, notoriously, Bulgaria and the rest of South-East Europe were hit by record high temperatures, leading to numerous casualties as a result of heat stroke, high blood pressure or heart attack.

## Varna Municipality and District Specifics

Varna and its surroundings are particularly susceptible to a few of the main categories of natural disasters and critical events. Listed in the order of their **potential economic impact** (and not in order of probability), they are:

- **Earthquakes**. Strength and frequency is uncertain, as we are considering a sudden release of geomorphic energy. However, even short seismic waves present significant risk to the population and its economic activity, keeping in mind the concentration of inhabitants and capital around the urban centre;

- **Floods**. Statistically the most relevant, temporary floodings of some areas occasionally incur significant damage, destruction of homes, production facilities and infrastructure. Unfortunately, even in recent years we have had human casualties;

- **Landslides**. Large earth mass instability is characteristic of the coastal area north of Varna and most of the way to the border with Romania;

- **Fires**. Mostly occurring in wooded zones and low vegetation fields near built-up areas. We emphasise the above data that more than 90% of all fires occurs with the “contribution” of human activity, usually the principal cause.

While definitely having less potential impact on Varna District in terms of direct damage and human casualties, we should consider **snowfall** (accompanied by wind, low temperatures and icings) as well as potential radiation and pollution incidents (even local) to be relevant enough for Varna District, although not particularly frequent and severe enough.

## Specific Flood Risks Factors for Varna

The western part of **Varna Bay** gradually transforms into a **Canal** which links the sea to the original **Varna Lake** (initially a liman). The present shape of this sea inlet is also defined by a low-lying sandy spit ranging in width between 2,000 and 2,700m and located almost at the mouth of the Canal. There are two separate navigable canals running around the sandy spit that connect Varna bay to Varna Lake. The latter is also linked to **Lake Beloslav** to the west (also a part of the liman originally). The total length of both lakes and the canals is about **30km**. This area represents the largest transport and port agglomeration in Bulgaria by surface: the Varna–Beloslav–Devnya industrial complex covers an area of 150km$^2$.

With that in mind, and given the fact that more than 50% of the Varna District sea coasts coast is affected by wave-induced **erosion**, we can define this trait as its main characteristic.

In reality, this is the case for most of the Bulgarian coastline – out of 378 km total length, some 226 km is reported as being subjected to active abrasion. The total length of beaches and hydro technical facilities is estimated at 152 km.

We also need to highlight the importance of the Kamchia river valley for the entire region, as well as the Dams “Kamchia”, “Tsonevo” and “Ticha”. The above considerations on water-related disaster scenarios and the impact of existing large bodies of water make their monitoring and maintenance a high priority activity for State agencies, institutions and public companies – more than for the local Municipalities – such as the BSB Directorate of the State enterprise “Irrigation systems”.

A relatively recent example of this vulnerability is the flood that occurred on **19 June 2014**. Heavy precipitation, clogged suburban drainage canals and infrastructure problems in Asparuhovo killed 13 citizens and caused significant damage. As much as heavy rains had previously (and often in the summer) affected the drainage systems of the city, certain currents bring exceedingly large amounts of water down to the lower parts and neighbourhoods of the city – the central parts and the shorefront.

Urban and peripheral canals are not part of a carefully planned network with a sufficient capacity. Heavy rainfall is often responsible for drastic changes in flow regimes, with the watertight city landscape and the obsolete sewage systems unable to handle the large-scale waterways, their rapid accumulation and little or no soil infiltration. As much as such rains are short-term events, their intense effects are “felt” by the urban drainage system, as it is unable to handle the intake from the entire agglomeration catchment area.

Often enough, such ruinous water flow is directed through city streets, overflowing sewage systems and rising above curb levels. Thus, basements and even ground floors tend to flood, especially in the central and lower parts of the city. Frequently, these water flows destroy street infrastructure, extract earth masses and, along with construction and municipal waste, further clog the sewage network, both underground and over ground gutters. Municipal reports outline parts of the city which are vulnerable to such scenarios: the central part between “Primorski” Blvd., “Slaveykov” Square, “Devnya” Street, “Vladislav Varnenchik” Blvd. and “Maria Luiza” Blvd; over on the other side of the Varna Channel, in Asparuhovo, all streets under “Narodni Buditeli” Blvd.; and any other sections which represent the lowest points of the natural urban catchment area. Such floods are probable in the spring and fall (with leaves clogging drainage systems further) but are ever more frequent in the summer months with more short but torrential rains a regular event over the recent years.

Flooding of road and pedestrian underpasses, moreover, results in significant traffic difficulties. Even what may initially seem as a less relevant problem – the formation of large puddles and mud deposits – ends up considerably disrupting traffic in affected areas, thus directly and largely reducing institutional and civil response capacity to the event and any related secondary effects. Varna Municipality has identified 21 specific areas which are subjected to such effects more frequently than others. Amongst those are the Ring Road in 2 of its sections; the Seafront road in 4 sections; 6 vehicle and 5 pedestrian underpasses; as well as several other road junctions and drainage areas.

A quick look at media reports show which city underpasses tend to get affected by heavy rainfall. A prime example is the Shipka Street motorway underpass which often gets flooded, as important as it is for the traffic circulation in the central parts of Varna. However, any regular short-term floodings are dwarfed by the unprecedented torrential rain of **August 20, 1951**. The rainfall itself lasted nearly 10 hours without interruption. Later, it continued on the 22nd, as in the space of those two days the meteorological station in Varna measured an amount of 292 litres per square metre. The same time frame saw the rain gauge station in the "St. St. Constantine and Elena" resort (known as “Druzhba” back then) recorded the amount of **389 L/m$^2$**!

### Geomorphological specifics and related risks for Varna District

We have already analysed the principal structural features and statistical occurrences that define geological risks along the Black Sea coast and the North-East in particular. Varna District specifics complement the picture rather than differing from the conclusions we are led to define in terms of relevant disaster risk factors.

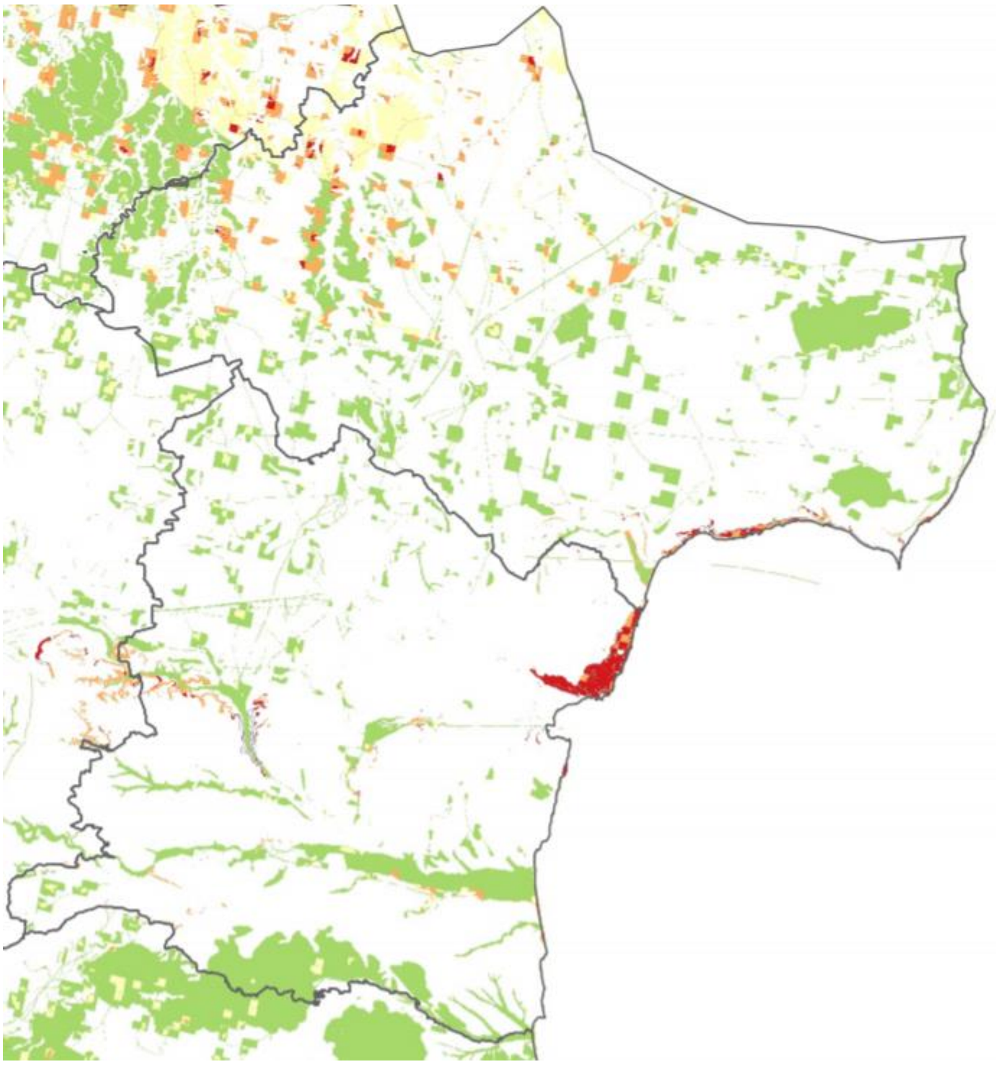
The specific **geological diversity** of Varna agglomeration area is quoted as presenting a "rugged terrain, [with] fluctuations in groundwater levels, [relatively] high seismic activity". These determinants cause "frequent landslides and earth collapse incidents of different scale, area and depth". The Municipal Council task groups report in the local Plan for Disaster Prevention (MPDP) that such activity is "largely **conditioned by anthropogenic factors** (illegal construction, increasing urbanization processes")).

Additionally, as we saw above, geomorphic specifics interact with water-induced phenomena such as wave activity or water-stimulated landslide and erosion action. Varna District is reported as having a specific combination of low-laying beaches – including the above-mentioned artificial sandy island (mostly occupied by industrial activities), as well as a dense residential, touristic and park areas located under or directly on top of land-sliding cliffs. These are particularly relevant in the North-West part of the city (the plateau) and the resorts north of Varna.

Local ecosystems present a natural buffer and play a certain mitigation role which is currently being depleted by illegal construction or unclear management decisions in construction regulation. Moreover, old and poorly designed or maintained protection structures expose insufficient defence mechanisms, especially considering local ability to preserve and sustain natural beaches. The latter have been seriously depleted in the past couple of decades alone.

Tidal fluctuations are practically irrelevant. The largest waves, on the other hand, are typically observed during storm season (October through March) and can reach 7m in height. Officially reported **sea-level rise** is estimated at 1.2mm per year.

*Figure 7. A colour coded Land erosion risk mapping in North East Bulgaria.*



We can see clearly that the area north of Varna bay is designated as a critical zone because of its erosive coastal line. It is important to understand the scale and relevance of land erosion and particularly landslides along the Black Sea coast. Despite statistical frequency and economic effects, a coordinated Municipal action and State support is indispensable in tackling the phenomenon. Ultimately, although it is largely natural in origin, the process is definitely aggravated by human activity. While funding is currently possible mostly top-down because of the significant amounts needed to face the issue, fighting landslides starts from local authorities and control agencies.

The landslide areas and instances officially registered in the districts of Varna and Burgas have been divided into four main categories according to gravity and scale (with Cat.I being the most serious). Varna and Burgas have the following officially registered number of landslides:

*Table 14. Landslides by severity Varna and Burgas districts (I-IV: severe to moderate)*

| *District* | *Category I* | *Category II* | *Category III* | *Category IV* | *Total* |
|---|---|---|---|---|---|
| **Varna** | 53 | 10 | 22 | 65 | **150** |
| **Burgas** | 27 | 4 | 10 | 34 | **75** |

Another type of disasters which are predominantly determined by natural causes is represented by critical scenarios in the winter months. **Intense snowfall** is less frequent along the Black Sea coast. Nevertheless, it is often accompanied by strong winds and results in icings in many urban areas. Even in coastal zones the temperatures happen to drop occasionally to dangerous lows for what the local temperate zones are used to, along with certain socio-economic customary modes of operation. When that happens, even for short periods of time, the critical conditions which are manifested can and sometimes do lead to "freezing and demise of people and the need to provide the population with basic necessities: food, water, medicines and services" in a regime of relative emergency.

Historical accounts of **heavy snowfall** in Varna often report high winds and low temperatures as well, with the city and its surroundings having experienced dire situations with interrupted transport links (on main and secondary roads and city streets) which have had damaging effects on logistics, support systems and social services in the Municipality for days in a row. Transport links to the "Vladislav Varnenchik", "Mladost", "Vinitsa", "Asparuhovo" and "Galata" districts have suffered such interruptions with relative frequency, along with suburb settlements like Zvezditsa, Kamenar and Konstantinovo, Rakitnika, Borovets and Dobreva Cheshma. These areas have been identified as especially vulnerable, being also located on the outskirts of the central urban zones. These neighbourhoods and suburbs have been hit in the past with snow drifts as large as 12 to 20 m in length. Such conditions inhibit, in turn, almost all transportation, service and provision options for their inhabitants. Considering the essential need for food and medical care, these are dire conditions, surely worthy of the "disaster" label, unfortunately.

Lastly, they require increased power consumption. Consequently, electrical transformer stations tend to get overloaded, while **icing** leads to power line breaking and interruption of electricity supply. Suburbs, villa zones and urban areas with airborne power supply are most vulnerable, with a population of up to 18 thousand permanent residents potentially being left without power supply in severe weather conditions. In turn, aggravated risk factors and technical failures due to missing electricity supply may even induce water supply interruptions for domestic and industrial use. Hence, the aggravation of winter conditions and subsequent technical failures in urban conditions may lead to a series of critical events.

## Burgas Municipality and District Specifics

First and foremost, we must emphasise that both cities – Varna and Burgas – share many regional and thematic priorities, as well as operational similarities. Most prominently, they belong to the same "**Black Sea Basin**" Water Directorate, as well as the same agency "**GeoProtection – Varna**", appointed by the Government (and the DML) as the competent local public geodefense operator.

The Burgas District risk specifics are also founded on its natural characteristics. Local authorities and state agencies have to consider first and foremost the **large water bodies**, besides the Sea – both for statistical and administrative reasons, as much as for risk factor monitoring and prevention – **Lake Pomorie** (an ultrasaline lagoon), **Lake Atanasovsko** (a nature reserve and Ramsar site), the **Burgas** and **Vaya lakes**, the latter being the largest natural lake in the country by area. Significant attention must also be given **to Lake Mandrensko**, now a fresh water reservoir (the largest of its kind in the District), as well as the **Poroy Dam**.

The geographical specifics of Burgas – the Black Sea coastline and the urban population concentration – present ample prerequisites for floods in the event of prolonged and intense sea waves. Burgas Municipality is lying sufficiently low and rising very little from the Sea level to suffer significant disturbances in public and economic life on its territory caused by floods.

Additionally, we need to consider that Burgas is surrounded by a number of lakes and salt marshes. Torrential or prolonged rainfall, as well as heavy snowmelt – and especially together – bring up a dangerous combination in early spring and its upcoming rains. Such a chain of events tends to flood a number of neighbourhoods and suburbs/villages of Burgas Municipality. A particularly hard to manage region is the area of "Dolno Ezerovo", "Lozovo" and the E-87 ring road along Lake Vaya.

Black Sea waves alone are able to flood sites and facilities: residential neighbourhoods and important social, residential or economic infrastructure in vital parts of Burgas. More than once, even recently, the sea waters have flooded completely the municipal road from the Sea Garden to "Black Sea Salt Works" AD (a company exploiting large areas with low-lying salt evaporation ponds). As a result, the road has been covered sand and other sediment, making it impossible to move upon or clean easily. The Municipality has had to perform emergency restoration of existing sand ditches – in 20 specific points where they were destroyed by the high waves – in order to be able to stop flooding in adjacent terrains.

Looking back in history, a notorious disaster with similar flooding dynamics has been recorded in the year 557 as hitting the southern Black Sea coast, around Tsarevo. Chronicles describe the sea as "taking over" 4.5 km of land. Strong sea storms were accounted to have destroyed “two-thirds” of Nessebar, the entire ancient town of Anhialo near Pomorie and part of the town of Urdoviza, near Kiten.

A topical study of the Russe University concludes that, overall, **Burgas** is the large settlement which is **most affected** by significant floods along the Bulgarian Black Sea coast. Lake floods and infrastructure related floods are predominant in the area.

Marine floods are, in fact, only third in significance for the South-East. Pomorie is reported as the town or tourist settlement which is affected the worst and most frequently by them. It is followed by Obzor and the group of resorts north of Pomorie.

The risk of lake and infrastructural floods in and around the city of Burgas is determined by several reasons. First and foremost, the low lying shore and extended port area. This adds up to the little difference in height above mean sea level (amsl) between Lake Vaya and the Sea, especially considering the territories of most residential neighbourhoods. The latter are densely populated and supplied with complex engineering infrastructure which is also at risk. Many of these neighbourhoods also have a sewage and drainage system which is outdated or completely depreciated. Over the past decade there have been several relatively small sea floods in the town of Pomorie, with each of those causing damage of over BGN 100,000. Potential risk is also high there, precisely because of the low lying shore levels.

Additionally, according to data published by the “Black Sea” Basin Directorate, “**three flood-prone areas** can be delineated along the Aitoska, Chukarska and Dermendere **rivers**”. This leads to increased risk factors for the population in some neighbourhoods of Burgas, but also the Ravnets and Cherno More suburbs and villages. About 73 linear kilometres along river catchment areas and the entire Burgas District are areas identified as “susceptible to floods”. High-risk factors take into account relief, distance from settlements and presence of large water surfaces leading to the Sea: these are mostly the three lakes of Burgas, Atanasovsko and Mandrensko-Poda, practically framing the metropolitan area by water bodies on almost all sides.

Media **reports** alone tell the story of the regional vulnerability to flooding. The combination of low-lying shores and flat riverbeds in between large lakes has been fatal as recently as 2017.

In October of **2017**, torrential rains and floods in Burgas took 3 victims. A state of emergency was declared in the municipality of Kameno and a partial state of emergency in the municipality of Burgas. In a period of less than 24 hours, large amounts of precipitation hit Burgas and reached or exceeded 100 litters per square meter on average, with some places registering even 180 L/m$^2$. Local rivers flooded yards and houses along its course. The height of the water in Kameno and the nearby suburbs and villages reached 1.6 meters.

In **2014**, another precipitation-induced flooding took three casualties, as rains poured down for over 180 litres/sq.m. in the space of less than 12 hours. The “Pobeda” neighbourhood is below sea level to begin with, and with the torrents cutting off power supply, the ordinary functioning of drainage pumps was interrupted, leaving hundreds of homes under water.

Sloping and infrastructural floods are also common phenomena in Nessebar municipality, particularly in Nessebar town, the nearby village of Ravda, as well as the famous Sunny Beach resort. In **2006**, Sunny Beach is flooded as a result of a heavy sea storm near the shore, combined with torrential rain. Reports account for almost annual river floods along the road between the campsites "Goldfish" and "Garden". In addition to material damage, these floods threaten protected plant species and habitats (e.g. snowdrop or the area named Devil's swamp).

Hence, the coastline to the north and south of Burgas is also quite vulnerable to natural disasters caused by water and weather factors. More importantly, the risk exposure of larger groups of people and infrastructure has increase over the past couple of decades, due to the growth in residential complexes, as well as in the number of tourist (and facilities) during the summer holiday season. Camping "Aheloy", for example, which is part of Pomorie Municipality, is situated in an area with a high potential flood risk. The critical flooding which occurred there between 2 and 4 September of **1999** took four victims and caused damage of around BGN 3 million. The area around the river bridge at the nearby Medovo village is at risk of flooding, as is the territory at the Aheloy river mouth. Such risks are aggravated by the torrential character of the river and the heavy concentration of tourists in the summer.

Studies conducted by Russe University in 2014 explain furthermore that floods along the Black Sea coast are a threat to tourism of a higher magnitude. The paper in question asserts that floods are (statistically) the most significant natural disasters in Bulgaria and especially along the Black Sea Coast. Summarized data confirm that river floods have the largest share, followed by infrastructural and sea floods. Main flood causes are also confirmed, as per our account above – downpours, rising sea levels and human negligence. An extensive study of past major floods provides sufficient information about the potential risk that these floods happen again with serious consequences, above all for the local population but also for marine tourism which defines economic structure in most of the Black Sea coastal areas.

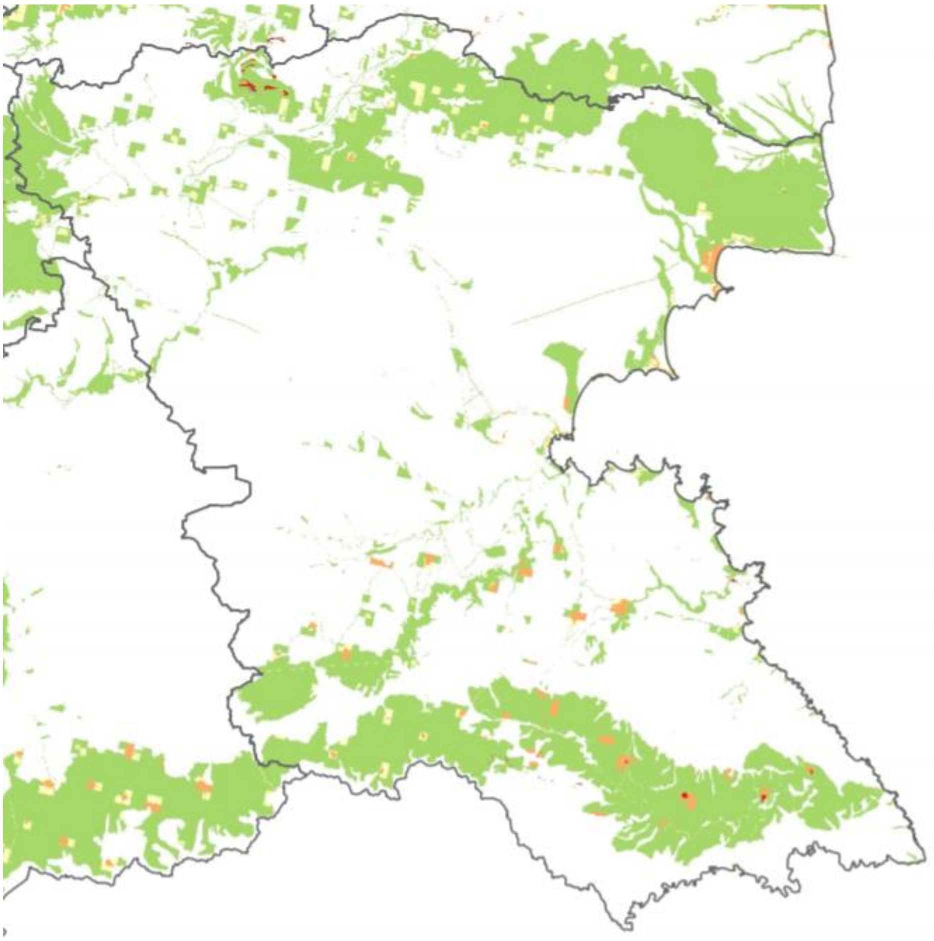
Crucially, studies like this one, as well as water management experts quoted in the media, emphasise the fact that Burgas District (as is the case for most of the Black Sea coast) has an entirely outdated concept for its extended coastal area protection.

In its extended jurisdiction area Burgas Municipality includes a total of **27** dams and open-air **reservoirs** (in 11 sub-municipal settlement zones). They all represent sites of manifold local importance and, as such, all dams need to be monitored by the Mayor of the specific settlement. However, there are objective difficulties for optimal exploitation of many of the dams. They frequently have their bottoms and inside walls partially or completely covered in sediment, while some dam walls are poorly supported of have had inadequate maintenance of their water slopes through the years.

Burgas, as a city, is literally **confined on all sides by lakes**, with many of the dams lying higher and presenting a further risk factor for potential floods. One such dam which requires practically constant monitoring on its wall and relief facilities is the Mandra Dam. Notably, it is used for industrial water supply and is owned by "Lukoil-Neftochim-Burgas". And while the management and professional services at the disposal of a large petroleum refinery are more than sufficient for monitoring and maintaining one such water reservoir, most smaller settlements and their mayors tend to lack resources and suitable personnel to exercise directly or delegate such responsibilities.

As for **landslide** activity, Burgas district and most of the South East is not particularly affected by them. Below is a map showing the strictly local and limited impact of land erosion risks such as landslides and rockfalls.

*Figure 8. A colour coded Land erosion risk mapping in South-East Bulgaria.*



## Fires – a Category Apart

Our study considers fire risks as a specific and separate category, not because of its inherent characteristics as a process but because of its **complex causal factors**. There are both anthropic and natural causes. And despite the fact that the majority of recorded instances have been started by human activity, natural factors exasperate fire risks, while – vice versa – human negligence aggravates natural predisposition to fires of many areas.

There are several main types of fires which can happen in nature, according to their localisation and development. **Crawling** or **surface fires** are the predominant type of forest fires, both nationally and in the areas close to the Black Sea coast. They develop among combustible vegetation and matter lying close to the ground (fallen leaves and branches, dead matter, undergrowth, timber waste, etc). Although these fires tend to burn at relatively lower temperatures (below 400°C), in areas with horizontal and vertical continuity of combustible matter – especially with relative low humidity and wind – intense surface fires can turn into crown fires.

**Crown** fires (also known as **canopy** or **aerial**) burn suspended material at the level of the tree crowns – taller trees, moss, etc. Despite the relatively higher humidity along the Black Sea coast, the sheer vegetation density in some old growth forests presents a higher fire hazard and elevated difficulty of control and extinguishment. Notable examples include the zones around the rivers Kamchia and Ropotamo, with rare combinations of coexisting high tree types, with lianas among their branches, which together create the impression of a tropical forest. Those forests rarely border agricultural or industrial sites but many other forests in the coastal region do. And the ignition of a crown fire is a short step away from a field fire and a crawling fire, especially in the hot and dry summer months.

The below data is obtained on the basis of annual reports submitted to the NSI by the municipal administrations.

*Table 15. Fires – total for the country and the analysed districts*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Country Total | 1630 | 2185 | 3010 | 764 | 2245 | 2474 | 2448 | 741 | 480 | 521 |
| **Burgas** | **34** | **659** | **786** | - | - | - | **6** | - | - | - |
| **Varna** | **5** | **174** | **333** | **25** | **67** | **57** | **109** | **7** | **4** | **3** |
| **Dobrich** | **194** | **475** | **348** | - | **212** | **291** | **332** | - | - | - |

*Table 16. Economic Losses caused by Fires – total for the country and the analysed districts (in BGN Thousands).*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Country Total | 2239 | 2186 | 1437 | 2013 | 729 | 1795 | 1061 | 1250 | 1703 | 194 |
| **Burgas** | **50** | **250** | **19** | - | - | - | **20** | - | - | - |
| **Varna** | **.** | **200** | **3** | **1000** | **1** | - | - | - | - | - |
| **Dobrich** | **220** | **72** | **2** | - | **20** | **42** | - | - | - | - |

We can see that reported numbers decrease over the past decade, while their number is not directly proportional to damages and significance. A particular example is provided by the “only”

25 fires in Varna District in 2013 have caused more damage for the entire Black Sea coastal region as the rest of the years and areas put together. Those fires account for half of the nationally reported damages in the same year).

Separate types of reasons for fire ignition is rarely reported diligently throughout the years. We have at our disposal, however, some data from before the current decade. 2008 is recorded in detail both for specific fire causes, as well as the usual fire counts.

*Table 17. Causes for fires throughout the country, 2008.*

| **Cause** | **Manifestations of the cause** | |
|---|---|---|
| | **Number** | **Relative share - %** |
| “Other” natural causes | 741 | 5.4 |
| “Other” physical-geographical causes | 637 | 4.6 |
| Intentional actions | 951 | 6.9 |
| Personal interests | 223 | 1.6 |
| Technical causes: malfunction, low illumination, etc | 3315 | 24.1 |
| Social causes | 150 | 1.1 |
| Economic causes | 7 | 0.1 |
| Other man-made causes | 7750 | 56.3 |
| Total specified reasons: | **13774** | 100.0 |
| Unspecified causes of fire crises | 2776 | |

For the same earlier period ending in 2008, we have the total count for the total number of natural disasters since 2004 – without counting in forest fires which are further inland. Burgas district still comes high up in the list with 388 instances (after Sofia with 565, Smolyan 543, Kardzhali 434, Vratsa 414 and Plovdiv 410). Varna District is much further down that list with 235 fires between 2004 and 2008. But we repeat an earlier observation: reporting mechanisms have been changed since the turn of 2009/2010, thus a comparison is more relevant within a series of annual reports before that limit, as well as after it, made separately.

Having separated significant forest fires for 2004-2008, we have the data for those as well: the number of forest fires within Burgas Regional Forestry Board jurisdiction for the period amounts to 130, with an affected surface of 20539 decares. Varna RFB, in comparison, has reported 201 forest fires, with 9785 decares of burnt surface areas.

The causes, nationally, on the other hand, are much less segmented than for year 2008 alone, but still quite relevant:

- cause unknown – 883 cases;
- human negligence – 1883;
- intentional – 185;
- natural causes – 44. For a total count of 2995 fires (2004-2008).

What all of the above numbers reaffirm, without any doubt, is that different natural habitats and area types may be predisposed to different fire risk levels, even comparable between one another. Different years may aggravate such risky conditions to a certain extent (a dry and hot year vs. wet and stormy). However, the first and foremost risk factor and cause of fires and fire-related critical events throughout the years remains human activity in all of its manifestations – intentional, negligent or a combination of the two.

### Burgas District Fire Risk Specifics

Having established the above leading cause of fires, nevertheless, we need to consider particular natural factors that characterize the Black Sea coastal regions.

Burgas District and the entire South-East is under the influence of a climate predominantly defined as Mediterranean to subtropical. Typically, precipitation levels have an even distribution. The average annual temperature is above the national average and is around 13-14 ° C.

Burgas District has a forest covered area of 341 552 ha – 8.13% of the total forest territory of the country (Somewhat surprisingly, it is the district with the second most forest covered areas in the country). The forest territories have 41.01% forest cover, important to evaluate density and extended risk. Forest territories which are considered to belong to "**I class of fire risk**" (high), are **22.0%** of the total forest territory of the district.

For the period between 2006 and 2015, there have been 314 forest fires reported in Burgas district, which represent a 5.71% of the total number of fires in the country. Thus, the **average annual** number of fires for Burgas is **31**.

The total area burned for the same period is 5,671 ha or an annual average of **567.1 ha**. The burned forest areas in the district occupy 6.39% of the total burned area for the country. Hence, forest fires burn an average of 0.17% of the forest territory of Burgas District each year. Furthermore, the average "**size**" of a single fire is 18.1 ha which exceeds the average fire impacted area in the country 1.12 times.

Fire occurrence in Burgas District forest territories is traditionally extremely dynamic, with **peaks in 2012** and **2007**, when the number of fires exceeds the average for the indicated period by 1.9

and 1.77 times, respectively. The areas burned areas for 2012 and 2007 exceed the average for the indicated period by 3.87 and 2.29 times, respectively.

And finally, forest fires around Burgas during the analysed period have been mostly crawling/surface fires (84.88%), while those which have developed into crown fires are roughly 1 in 6 (15.12%).

A couple of other important indicators of fire hazards and vulnerability include the fact that Burgas District forest territories have experienced an average of 0.09 fires per year for every 1000 ha of ground surface area; as well as the statistic which sees an average of 1.66 ha per every 1000 ha of forest territory being burned annually.

The last two measurements help us calculate the **magnitude of fire risk for Burgas District**. Said risk is determined by a Methodology based precisely on the values of fire density and actual flammability

0.09 × 1.66 = **0.149**

According to a scientifically agreed methodology for determining the risk factor scale, we can substantiate a claim that the **forest fire risk** for Burgas district is **average**.

### Varna District Fire Risk Specifics

Varna, on the other hand, has a total territory of 3 818 km$^2$, which is 3.45% of the National territory. In terms of its climate, Varna district belongs to the temperate continental belt, although it shares many similarities with Burgas District. A pronounced influence of the Black Sea makes winters and summers milder. The area relief is mostly flat in the Northern part, while in the South it turns into a plateau-hilly to mountainous one.

There, we see the total forest coverage of the district at 121,950 ha, which is 2.9% of the total forest territory of the country. The forested area is 115 146 ha, which sets the **forest cover** of the district at **30.16%**.

Much like in Burgas, the forest territories in the district are divided into coniferous - 6.19%, **deciduous** - 88.23% and unforested - 5.58%.

For the same period we last examined (2006 – 2015), Varna district forest areas have been affected by a total of 267 fires, or 4.85% of the total number of fires for the country for the same period. Burned territory amounts to 1,338.7 ha – that is, 1.51% of the total area burned in Bulgaria.

The average annual percentage of fire damage in the District forests stands at 0.17%, roughly the same as in Burgas District. The average annual **size** of a fire for the period is 5.01 ha, or 3.2 times smaller than the national average. Again, due to a combination of natural factors (and reporting procedures, most likely), the maximum amount of critical fire events reached peak levels in 2007 and 2012, supporting the previously established cycle of 5 years.

On average, there are 0.22 fires per 1000 ha of Varna District area each year. The standard size of forest burned per 1000 ha in Varna is 1.1 ha for all encompassed forests.

Once again, the fire risk magnitude is determined as

0.22 × 1.1 = 0.242

According to comparisons with the risk factor scale, forest fires risks in and around Varna forests are determined as average.

Last but not least, on average, 1.1 ha per 1000 ha of Varna forest territory are burned. Considering the above risk scale (0.242) and the data substantiating such a numerical risk scale level, the **risk of natural (forest) fires** within Varna district is considered **average**.

### Dobrich District Fire Risk Specifics

The most important settlements which lie in Dobrich district and are situated along the Black Sea coast are **Balchik**, **Shabla** and **Kavarna**.

*The district occupies the North-eastern part of the country and covers an area of 4,720 km$^2$, which is 4.26% of the national territory. The Dobrich district population is 189,677, and the density 40.19 inhabitants/km$^2$. There are 215 settlements under 8 municipalities.*

The relief of the area is mostly a hilly plateau and valleys. Climatically, the area is characterized by hot summers with characteristic drought, especially towards the end of the season. The area also has characteristic strong north and northeast winds.

The forests on the territory of Dobrich district occupy 65 782 ha – 1.56% of the total forests in Bulgaria. The forest cover of the district is 12.77% – one of the lowest in the country. Forests and trees in Dobrich district are predominantly deciduous. Those territories around Dobrich which fall into “I class of fire risk” (high), are 18.2% of the total forest territory of the district.

For the analysed period, 2006–2015, there have been 165 fires registered in the forest territories of Dobrich District. They have incinerated a total of 421.8 ha, or 0.48% of the total area burned in Bulgaria the country. The average rate of annual fire damage is 0.06% – 3.5 times lower the national average. Statistically, again, there has been peak fire activity in Dobrich district in 2007 and 2012.

Further calculations indicate that in the forest territories of Dobrich district an average of 0.25 fires occur annually on its forest territory of 1000 ha. The actual flammability of its forest territories per 1000 ha corresponds to 0.64 ha burned. This gives us a coefficient of 0.16 on the above fire risk scale classifying **forest fire risks** for **Dobrich** district as **average**

Ultimately, we always have certain human factors which add to natural disaster risk predisposition of any kind. We must keep in mind, however, that natural conditions are what we describe them at any given time, while certain processes take place and change circumstances which may seem static.

According to one preliminary (flood) risk assessment in the Black Sea region, the **weather in Bulgaria is becoming more extreme**. There are more (and longer) droughts; more severe storms and severe floods which bring destruction and casualties. Bulgarian meteorologists warn that **climate change** is reducing crop yields and affecting tourism profits. Research on climatic fluctuations nationally shows that certain trends can be linked to flood dynamics. Crucially, however, ever since the 1980s there has been a measurable trend for slow but steady rise in average temperatures in Bulgaria. The amplitude between maximum and minimum atmospheric temperature also tends to decrease, with the minimum temperature rising faster than the maximum.

Extreme precipitation, mostly rains, has also increased significantly. The average number of days with daily amounts over 100 mm has risen by about 30% in the period which goes between 1991 and 2007, compared to the norms of 1961-1990. Moreover, in the period 1991-2007 there is an upward trend in the annual number of days with catastrophic rainfall.

Statistical data presented in the National Disaster Protection Program 2009-2013 confirmed that Bulgaria floods have the largest relative share of natural disasters (54.2%), followed by landslides (22%), storms and tornadoes (18.2%). A wide range UN study on disaster risk reduction in Southeast Europe for the period 1974-2006 also has shown that floods are most relevant, followed by wind storms, earthquakes and extreme temperatures, drought and fires.

This leads us to consider a major category of determinant factors in our analysis.

## Climate Change. Incidence on Risk Profile Definition.

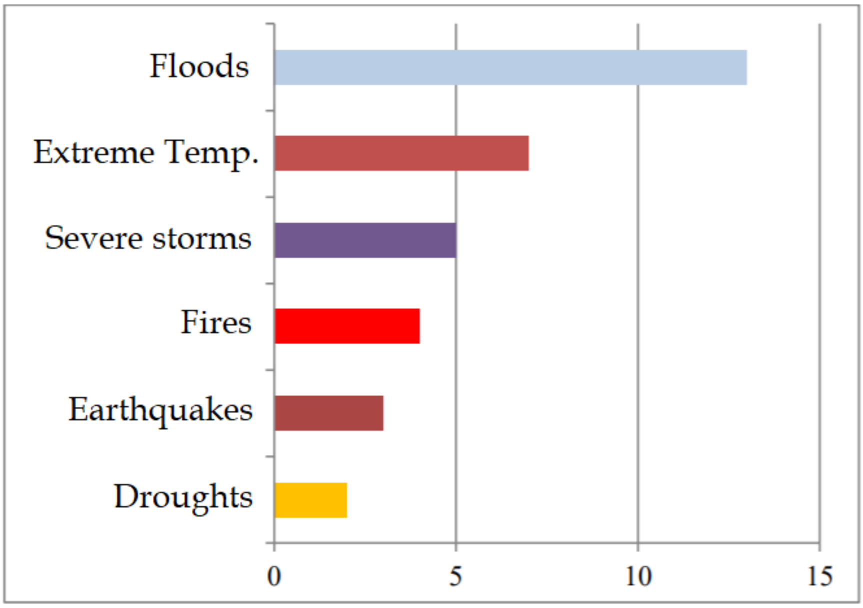
Inevitably at this point (in history), we must substantiate climate change as an aggravating macro risk factor, providing considerations for its effects on separate risk factors causing or increasing the likelihood of disasters.

Natural disasters related to hydro-climatic and meteorological conditions in Bulgaria are especially influenced by climatic changes. Floods, fires, storms and their effects on the geological stability and resilience of urban and suburban environmental settings are critical in measuring historical climatic trends. As we already saw, this main groups of climatic disasters, as much as earthquakes, can further activate many of the dangerous phenomena in the lithosphere, such as erosion, landslides, landslides, muddy-stone streams and others.

The Black Sea coast is particularly sensitive to climate changes, bordering on one side exclusively on Nature and its phenomena. With a clear global upward trend in both number and damage caused by natural disasters, we can follow this trend as being particularly pronounced in the group of climate, hydrological and meteorological disasters.

If we go 40 years back, according to criteria adopted by EM-DAT, in the period between1980 and 2010 Bulgaria has been affected by 13 floods, 7 cases of heat waves, 5 storms, 4 fires, 3 earthquakes and 2 droughts (see below figure). This also comes to show that Bulgaria is mostly affected by floods, as well as extreme temperatures, storms, fires and droughts. Of the group of geophysical disasters, only earthquakes have found a place in this list.

*Figure 9. Natural disaster distribution in Bulgaria by type, 1980-2010. (EMDAT, 2014)*



What is crucial, however, is that the most severe disasters observed during this period have been registered in the **last 10 years**. Five of the ten disasters with the highest number of people affected occurred during the last decade, as well as nine of the ten years in which disasters claimed the most lives and seven of the ten years with disasters causing the greatest material damage.

This ranking leaves floods are at the top of damage impact and affected population. However, the most **victims** (18) have been caused by extremely low temperatures (cold waves) in 2006, followed by floods in 2005 (17) and extremely high temperatures (heat waves) in 2008.

Some of the criteria according to which these statistics are maintained inevitably has a conditional and discretionary character. We take it into account as a guideline of the most general nature, considering also the fact that national and regional statistics have been gathered using separate methodologies, as well as changed in the last decade.

An important evaluation parameter in tracking climate change and its impact on regional disaster risk profiles is provided by the so-called **Climate Risk Index** (**CRI**). It is compiled annually by the Bonn-based non-profit NGO Germanwatch. In their own definition, they seek to "influence public policy on trade, the environment, and relations". If nothing else, the CRI indexation has undoubtedly been established as an influential tool in evaluating integrated climate risk.

CRI shows the degree of **exposure** and **vulnerability** of countries to **extreme weather** (tropical and winter storms, local storms, hail, tornadoes), climatic (freezing, fires, droughts) and hydrological events (sea storms, floods, landslides, etc.).

The CRI is calculated by taking the average value of the country's rank on the following 4 indicators, with respective weight parts:

1. number of deaths (1/6 weight);
2. number of deaths per 100,000 inhabitants (1/3);
3. damages expressed in purchasing power in US $ (1/6);
4. losses to gross domestic product (1/3).

This integrated tool facilitates considerations such as which country and region has suffered the most from extreme weather events; where do we observe significant weather-related losses; and essentially – how do these statistics **change over the years**?

*Table 18. CRI and Weather-related Loss Events in Bulgaria in recent years and over a period of 20 years.*

| | CRI Rank | RI Score | Fatalities | | Fatalities per 100 000 inhabitants | | Losses in US$ million (PPP) | | Losses per unit GDP in % | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Annually | Rank | Annually | Rank | Annually | Rank | Annually | Rank |
| 2017 | 53 | 8.17 | 13 | 54 | 0.184 | 32 | 29.70 | 75 | 0.019 | 78 |
| 2016 | 120 | 09.50 | No Data (fatalities and losses given as 0) | | | | | | | |
| 2015 | 27 | 42.50 | 7 | 74 | 0.10 | 57 | 756.356 | 27 | 0.5515 | 20 |
| 2014 | 6 | 13.83 | 31 | 36 | 0.430 | 12 | 2383.60 | 13 | 1.8463 | 15 |
| 2012 | 31 | 39.00 | 44 | 29 | 0.6042 | 12 | 29.23 | 55 | 0.0285 | 63 |
| **Ave. for 1998-2017** | 66 | 70.33 | 9.700 | 86 | 0.128 | 87 | 330.074 | 48 | 0.282 | 57 |
| **Ave. for 1990-2008** | 86 | 82.83 | 4.53 | 100 | 0.06 | 116 | 123.0 | 55 | 0.21 | 59 |

We can observe several trends and notable facts for the period for which the above table cites data:

- In **2014** Bulgaria is ranked at **#6 globally** with its CRI score (*Higher ranking means more vulnerability and more climate risk*);
- The same year sees Bulgaria among the **10 most affected countries –** 3rd in Europe and **1st in the EU**.

Calculations and statistical indexation takes account of events already occurred as well as the evolution of certain conditions. But with weather related losses of human life and resources, we can safely claim that the high 2014 ranking is due to a series of critical events in 2012 and 2013 that cannot be ignored. Heavy floods occurred in Eastern Bulgaria precisely in June 2014, killing at least a dozen people and badly affecting agriculture and the tourism sector, as accounted for above in our study.

- For **2012**, Bulgaria is among the **15 most affected** Eastern European countries;
- For the entire period between 1993 and 2012 Bulgaria is also quoted among the 15 most affected Eastern European countries, as well as **8th in the EU**.

Even if we consider certain incompatibility between PPP estimates in USD and its exchange rate to BGN throughout the years, there is a clear movement **up the CRI scale** for the past 30 years, as well as an aggravation of indicators in terms of total and average fatalities, damages and integrated risk.

## Climate Change Impact on Flooding

Flood risks in Bulgaria have been studied by many scholars and sector experts, with interest in the topic increasing significantly since the disastrous year of 2005. The significant incompatibility of different databases and collection mechanisms for natural disasters reporting is quite the obstacle to their work. As is the insufficiently long database period for crisis events, going back, which is available at the National Statistical Institute (NSI), where most reliable information about precisely segmented critical events refers to the period 2004-2008, as well as after the 2010 change in methodology. Today, this information is provided by municipal administrations on the basis of the damages established by the permanent municipal commissions for protection of the population in case of disasters, accidents and catastrophes. While in the recent past it was collected and reported by various regional and national prevention and recovery agencies and the Ministry of Interior.

That is exactly why the data provided by the former State Agency “Civil Protection” (nowadays Fire Safety and Civil Protection at the MoI) is probably the most relevant one for the period going back. As an example, between **1990** and **2001** it reports 440 “severe floods” in 92 medium and large river valleys.

Out of those, 19 rivers flowing into the Black Sea have caused 84 floods, with a million BGN in damage, 1492 buildings affected and 4 victims.

However, that is in a period of more than 10 years. If we compare it only to **2005**, there has been several devastating floods which have no analogue in the last 56 years at least. The annual amount of precipitation in 2005 is reported as **924 mm**. For a period of 104 years (1904-2007) in Bulgaria there are only 9 years with an annual rainfall over 800 mm, 5 of which have been registered in the **last two decades** of the period. The calamitous year 2005, in particular, has seen reported the extreme daily precipitation of **353 mm**. Normally unthinkable for Bulgarian climatic standards, it was been registered at the **Shabla** meteorological station, namely along the Northern Bulgarian Black Sea Coast.

We can also compare these reports to EM-DAT statistics going back over a century: **Out of 13** really big flooding instances reported between 1900 and 2011, **eleven** have occurred **between 2000 and 2009**. Rain and storm intensification cannot seem to be put for questioning at this point.

## Climate Change Impact on Landmass Instability

**Rockfalls** are a sudden process of gravitational collapse or detachment of different volumes of rock masses from a slope. They are activated under the influence of weather phenomena (e.g. heavy rainfall), abrasion or earthquakes. These trigger factors bring up the appearance of cracks in the upper parts of the slopes, which then break away entire blocks and earth volumes which collapse at the foot of said slopes.

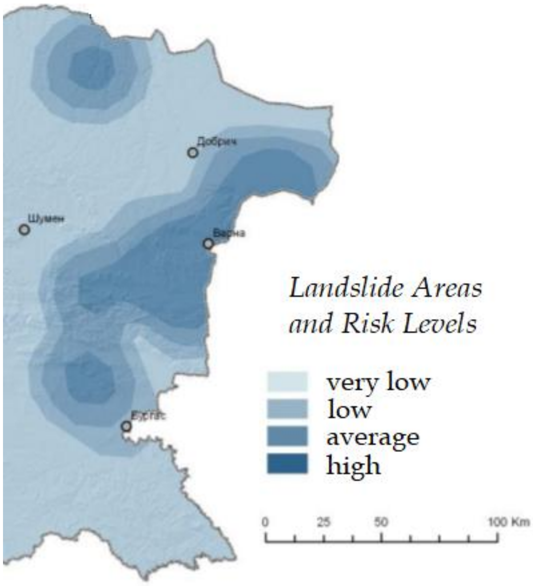
Quite relevantly, prolonged or intense rainfall contributes significantly to their activation, and we have seen the influence of climate change on the intensity and magnitude of recent torrential precipitations. Those are likely to exert above average impact on the peripheral areas of plateaus, especially in North-eastern Bulgaria, along the Black Sea coast.

The same changing risk factors exist for **landslides**, naturally. Prerequisites for their manifestation, as we saw in detail, include the presence of slopes with a lithological-facial and lithological-stratigraphic structure, the presence of a so-called watertight “horizon” within the ground layers, as well as underground water flows and other peripheral processes.

Landslides are more relevant for Varna and Dobrich, provided how pronounced their districts’ coastal slopes are. With all the rest of the conditions present, landslide activity there is essentially determined by precipitation regimes and the directly related groundwater, the accumulated energy in sea waves, as well as any increased river flows which contribute to increased erosion. Tectonic movements are also quite relevant but they are not influenced by climate change and weather dynamics.

Given the above considerations, this Black Sea coastal area is becoming increasingly vulnerable, especially in the 30 km strip between Varna, Kavarna, Balchik and Kranevo. The figure below shows the areas which have been put under increasing landslide risk due to intensifying water and weather-related phenomena.

*Figure 10. Landslide areas along the Black Sea coast with their risk levels*




*Source: BAS.*

Climate change also affects natural **abrasion** processes. This incrementally dangerous phenomenon is provoked by the destructive force of sea waves, hence also typical for the Black Sea coast. With storms increasing in frequency and intensity due to altering climate dynamics, the speed of the abrasion processes tends to increase as well. Abrasion affects about **70%** of the entire coastline, with the North particularly presenting long abrasive cliffs. Although mechanical abrasion is predominant, it is still affected by weather phenomena greatly, thus climate change aggravates the overall status of the shores.

Abrasion affects predominantly the Dobrudzha and Strandzha coasts (North East and South East respectively), with up to 80% of the coastal length there affected.  The process is particularly easily noticeable in Kranevo, Ravda, Sarafovo, as well as between Cape Emine and Batova river.

State registers maintain statistics of current abrasion speeds, with the rate of meter per year as an indicative unit. While these registers are kept for much of the shoreline, notorious cases (with at least 1 meter each year) include the strip between Sivriburun village and Shabla village, with a total linear length of 12 500 m; the strip between Galata village and Kamchia resort, 18 000 m; and the shore between Pomorie and Lake Atanasovsko, 14 000 m.

The accelerating abrasion processes is under the influence of observable changes in the frequency and intensity of sea storms along the Black Sea shores. Coastal waves often reach a height of 2 metres and above and exert their destructive effect on the coastal zones in and around Varna, Shabla (North), Primorsko and Sarafovo (South). Near Burgas, experts have recorded certain salinization of soils, still over limited areas. However, should expected climate change scenarios be confirmed, the Black Sea level may rise (moderately) and affect up to 10 km of the coastline which is currently located under 5 metres amsl.

Other types of land instability include **erosion** which is even more straightforward in being affected by climate change. Soil erosion assessment has been conducted in direct correlation with rain intensity and frequency. Intense precipitation forms a larger surface outflow, which in turn leads to an accelerated erosion process. About 14% of all heavy rains in the country are estimated to be heavily erosive.

The Black Sea coast increasingly presents conditions for **water tornadoes**. Between July and September, recent years have put on record several cases. Burgas District alone has had 3 of note (in 1993, 1999 and 2005), while in Varna most significant cases have been registered in the earlier part of the 20$^{th}$ century, as well as one in 1998. With heavy rainfall cases increasing, the strength and frequency of **thunderstorms**, storm surges and floods are all likely to increase as well, due to a changing climate.

Naturally, it is very difficult to determine the precise parameters of these changes in relation to natural disaster risk profiles but we must be prepared to deal with certain complex consequences of extreme events related to climate change.

Rising global temperatures – both in the oceans and on land – lead to an increase in the amount of water vapour in the atmosphere, which in turn could lead to additional radiant warming, as they are a greenhouse gas. It is known that humid and warm air masses are also more unstable and create conditions for the formation of convective clouds and intense rainfall.

According to some simulation and **prediction models**, when the concentrations of greenhouse gases doubles in the atmosphere (compared do 1990), the amount of **precipitation** on the planet will increase by between **1-3% for every 1°C increase** in the average global temperature. Of course, this process would be accompanied by ample regional variations in precipitation and temperature changes.

Other simulations that do not base final estimates on an alteration in relative air humidity show that the current water content in the atmosphere would increase by 6% for each degree that the average global temperature rises. This would lead to changes in hydrological cycle dynamics, and again, an increase in extreme rainfall and a decrease in moderate and low rainfall.

The Ministry of Environment and Waters has reported in 2014 that for the **40 years** between 1971 and 2011 the average ground air temperature in Bulgaria has risen **by 1.5°C**. Notably, the years **1994**, **2000** and **2007** have had the largest median deviations in average temperatures, about 2 ˚C. A **direct correlation** has been established that the same years were the ones which saw **droughts** and **heat waves** sweep the country, leading to severe economic and health consequences for many.

The same MoEW report shows that annual precipitations for the period 1988-2011 were measured at an average 604mm per sq.m. We already pointed out some years which had brought precipitations of 100 mm or even 180 mm overnight, 2005 most notoriously, as well as 2014. While that may not be considered a trend in itself, significant changes are also found in the **number of days** with maximum daily precipitation of **over 100-200 mm/24h**. Those show a marked tendency to increase in recent years, and present a clear case for evolving risks of flooding and related landmass instability, with torrents and storms being a major factor in both disaster types.

Additionally, the MoEW declares a statistically traceable and increased risk of heat waves, droughts, prolonged periods with "hot days and tropical nights". All of those lead to an increased vulnerability and risk of **fires**, anthropic factors aside.

Despite the fact that a combination of factors determine whether an extreme event will lead to a disaster or not, are many causal relations of different nature (natural, anthropogenic, social, managerial, etc.) which need to be monitored and taken into consideration. In the context of climate change, particularly, **regional characteristics** of hazardous phenomena influence the levels of risk exposure to natural disasters but they are also directly or indirectly an expression of certain **global processes**.

Hydro-climatic disasters endanger people's lives and cause great economic damage to industrial, transport and social infrastructure in towns and natural/agricultural areas. Their adverse effects is also transferrable into indirect and prolonged losses: disrupted communications and energy supply, epidemics, loss of agricultural and industrial products and deterioration of fields, to name a few. Damages depend both on the disaster scale and on the population and material goods exposed to it.

We need to be explicit with such causal relations when analysing integrated risk. Climate change is namely a pertinent link to another macro group of risk factors and potential scenario types. Those involve mostly **anthropogenic**, **socio-economic** and **governance** determinants which shape further the overall risk profile of the Bulgarian Black Sea coastal area.

## Socio-Economic Factors and Regional Anthropic Risk Profiles

The object of this part of our study is the influence of urban and industrial technological systems and facilities in the analysed Black Sea region. **Anthropic risk sources** are mostly determined by technological causes leading to system failures, and the adverse events they generate are directly manifestable into accidents, catastrophes, toxic discharges, radiation pollution, fires and explosion and other.

The classic understanding of a disaster sees it as an event (or series of events) caused by one or a combination of the following – "natural phenomena, incidents, accidents or other extraordinary circumstances which affect or endanger the life or health of the population, property or the environment to an extent requiring the taking of measures or the participation of special forces and the use of special resources". Human factors end up both on the causal and the receiving ends of the formula.

**Anthropogenic factors** depend on (and are a reflection of) the economic development of any given territory:

- the availability of critical infrastructure of local, national or EU importance;
- the demographic profile of the population;
- management systems;
- early warning and prevention systems;
- additional cultural characteristics and risk attitudes of the population.

A combination of the above factors can significantly influence and largely determine the vulnerability to and risk of natural disasters.

Critical events and disasters typically affect the population over extended areas and frequently for prolonged time periods. Said population may be located in greater or lesser proximity to the accident site and this will merely determine the scale of material damage and health impact of such events.

Potential negative consequences of an accumulation of hazardous factors in **production** and **industrial facilities** may end up in a general technological system failure; an interruption of risky specific technological processes; or simply errors by service personnel. Any of the above (or a combination) may exert certain negative impacts on the nearby population and the environment – even provided a relatively accident-free operation. A release of harmful emissions or hazardous substances into the environment is a perfect example of the latter.

Then again, industrial accidents are often followed or accompanied by explosions, the destruction of facilities and, frequently, fires. Statistically, the number of fire victims in chemical facilities is three times higher than those who succumb to chemical exposure. Poisonous substances, on the other hand, are almost always suffocating besides being generally toxic. They enter the body quickly through the respiratory system or, at times, through the skin and mucous membranes. The simultaneous action of two or more toxic substances leads to a multiple increase in damage effects and impact.

Natural disasters do not affect the territory evenly, because of their inherent character and prerequisite conditions. On the other hand, many settlements and areas of socio-economic importance are subjected to disasters which are a result of anthropogenic causes of such calamitous events. These risks follow the distribution logic of **industrial saturation**, **urbanisation levels** and **infrastructural specifics**.

Integrated risk assessment plans need to focus on its precise evaluation, as well as a prevention and mitigation strategy. Any existing or upcoming residential or industrial object comes with its own risk factors and collateral effects. Local authorities need to be demanding in their evaluation and control of the probability and severity of potentially undesirable effects of organised anthropic action.

One highly visible scenario and a particularly notorious issue is a potential incident involving radioactive emissions. That, particularly, is seen as directly related to the Kozloduy NPP. However, according to the Bulgarian Nuclear Regulatory Agency (NRA), an accident there is very improbable. The 2010-2016 statistics are considered sufficient as a recently recorded proof of such claims, since the few operational events which were reported as potentially problematic, resulted in their categorization as "**under scale-Level 0**”. These evaluations are carried out in accordance with the requirements of the Ordinance on the notification of events in nuclear facilities and sites with sources of ionizing radiation.

The NRA maintains a database of events registered as relevant in relation to radioactive sources, and it regularly publishes such information on its website. Since 2000, about **80%** of the cases (244) are related to **scrap metal** which seems to maintain certain **elevated radioactivity**. Out of these, again a majority of cases (176) regards devices or parts with a luminous coating containing 226Ra. Typically, other reported risk sources include abandoned material, radioactive substance theft; illegal trafficking; accidents at work and more.

Quite relevantly, the "**Second Line of Defence**" Programme is targeting the protection of external EU borders against import and general trafficking of radioactive substances. For Bulgaria these include a large portion of its land borders (with Turkey) and its entire Black Sea border. To that end, border checkpoint areas have been supplied with stationary and portable devices for detecting radiation sources, as well as mobile detection systems. Those entry points include the **Airports** and the **Ports** of Varna and Burgas.

## Varna District:

## Anthropogenic Specifics and Socio-economic Disaster Risk Factors

The entire District of Varna includes many settlements with their own particular specifics – all especially relevant to man-made risks and potential industrial hazards.

Aksakovo, Avren, Dolni Chiflik and Byala have direct access to the Sea, with infrastructural and general societal risks being integrated into overall coastal safety planning.

More importantly, **Devnya**, **Suvorovo**, **Beloslav**, **Provadia**, **Vetrino**, **Valchi Dol** and **Dalgopol** all contain **important industrial sites**, production areas and logistics centres that serve the extended Varna District area, greatly influencing the economy throughout the Northeast region. Most of these townships have had this crucial importance for half a century, while almost all host local critical infrastructure.

In such a context, a number of companies, some NGOs and even citizens (are allowed to) use and **store substances such as dyes, fuels, lubricants and other synthetic matter** – most of which toxic – as well as artificial fertilizers and chemicals which are highly **flammable**. Varna Municipality and District Governor have taken these operations in consideration when designing the Municipal and District Disaster Protection Plans. Said Plans contain detailed measures on impose monitoring requirements and establish prevention and protection measures, if and when a higher order government Agency or Ministry does not supervise that particular type of activity.

There are, additionally, many structurally important economic and socially relevant operators in Varna Municipality alone possess or operate risky facilities and substances. Those include "Varna Storage" (petroleum); the Ports "Odessos", "Varna East" and "Lesport"; the shipyards

“Bulyard Ship Industry” and “Odessos”; the Naval Forces Headquarters (with a Naval Base); Varna Airport. Most of those have elevated **risk factors inherent** to their main (economic) activity**.**

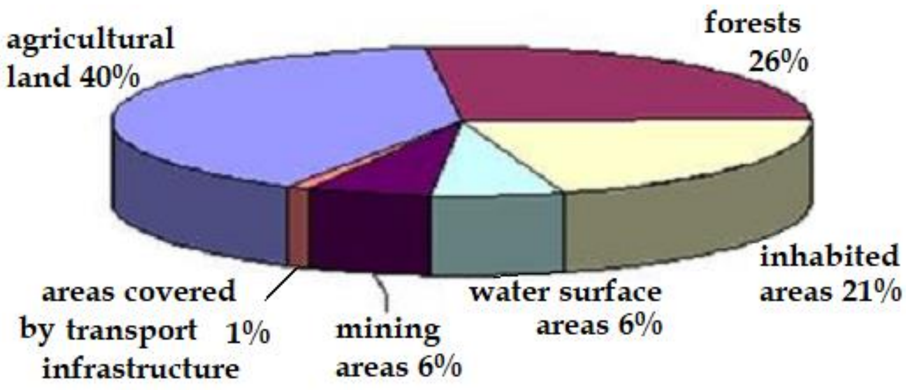
Moreover, significant cultural, sports and healthcare facilities with considerable capacity – e.g. the Palace of Culture and Sports, the Festival complex, hospitals, educational and social service buildings – frequently host mass gatherings of citizens, potentially placing them at risk.

Last but not least, more than 30% of Varna municipal territory is occupied by forests, parks and vegetation areas where summer droughts and high temperatures create higher risks for human activity, unintentional or deliberate it may be.

There are **17** registered **companies** on the territory of Varna District which operate or store potentially dangerous substances such as chlorine and chlorine compounds, soda ash, nitrogen and phosphorus fertilizers, cement and others.

Several types of production accidents in Devnya, Beloslav or Provadia could lead to the creation of a so-called “Outbreak of chemical contamination”. Should there be particular air current types, large parts of the population of Varna District could be gassed. Possible ecological risks include the gassing of territories with an area of 2-3 sq. km in the Western parts of Varna which include, in addition to industrial sites, most parts of the residential neighbourhoods of “Vladislav Varnenchik”, “Vazrazhdane”, “Mladost” and the area of Varna Airport. Such chemical substances are located mainly on the territory of the town of Devnya.

*Figure 11. Structural Distribution of Land Use in Varna District*




**Beyond the obvious significance of many industrial processes and economic operations which may be potentially hazardous to the population of Varna District, we must consider**

**a wider range of land, coastal and marine uses of the regional resources. This includes residential use, ports and marinas and tourism, besides industrial and natural risk factors.**

Residential and urbanised areas represent the main use of land in the District. Approximately 400.000 inhabitants live in the city of Varna alone but during the summer tourism and related activities bring this number up to anywhere between 800.000 and **1 million** (temporary) residents.

A characteristic sandy spit stands at the mouth of the two navigable canals connecting Varna Lake to the Black Sea. There is also an artificial between them, as the area is mostly occupied by the **"Varna-East" Port** complex (for total 110ha), as well as numerous industrial and storage facilities (total of 335ha).

Furthermore, the North-western shores of Varna Lake accommodate industrial and transport facilities like a power plant, dredging and timber terminals. The western shore of Beloslav Lake houses the "Varna-West" Port and Ferry terminals, as well as several chemical plants.

While urban planning and development efforts may not always have been consistent in their approach, most of the above industrial activities have been located on one side of the urban centre, towards the western end of the city, reaching towards Devnya. On the other hand, the coastal area is predominantly occupied by light urban economic activity, surrounding beaches and cliff or landslide stretches. Many of the beaches are located within the borders of Varna itselt, while those outside it are administratively a part of **sea and spa resorts**. Several marinas are also located along the coastline, dedicated to leisure or fishery purposes.

### Socio-Economic Disaster Risks & Environmental Impacts of Human Activity

Public records show significant transport and industrial accidents that have been registered both nationally and near the Black Sea coast, claiming often lives and causing substantial damage. Although some data is incomplete, one easily notes that some of the worst disasters and incidents have been registered in the last 15 years.

Everyday human activity in Varna and the surrounding district usually contributes fo some beach loss (e.g. due to unregulated building practices), infrastructure or property damage. Those might have an important impact on tourism and the loss of natural habitat but they are **not disasters** or severely critical events in the short run.

Industrial production is the one which has the potential to negatively affect the regional safety. As mentioned above, there are 17 important companies (out of a national count of around 350) which can bring about an **industrial incident**.

Accidents at sites operating with oil, related products and natural gas pose a great danger to the population and the environment. The production of ammonia, chlorine, cellulose, as well as the storage facilities for liquid and gaseous fuels are all highly flammable. Large industrial sites have designated tailings ponds, ash dumps and embankments where industrial waters containing hazardous substances are stored and left to precipitate. Any breakages or malfunctions in their walls may cause catastrophic chemical flooding of settlements, pollution of water sources and the environment.

The principal **substances** that can cause mass intoxication among workers and the population of Varna District are chlorine, ammonia, dichloroethane and trichloroethane. Storage and transportation hazards are presented by ammonia, dichloroethane, trichloroethane (potential danger of explosion and fire) and phosphoorgans. The dichloroethane and trichloroethane (halogenated ethane derivatives) particularly have been stored for a few years in a non-operational chemical plant in the town of Devnya (the former enterprise Polymeri AD). Large quantities are stored directly in outdoor tanks and, unfortunately, there have been several leakages ever since the company went bankrupt in 2012. While leakages were never substantial and always repaired, they pose a great threat to the health of the population in the region and the environment. Slowly but surely, since 2018, a procedure has been put in motion for their transportation initially to Romania and then to France for recycling.

There is a clear and present industrial accident risk which may lead to a disastrous scenario during improper storage, use or transportation of hazardous substances, materials and waste. There are certain companies and economic operators on the territory of Varna Municipality which have been classified and registered as "enterprises with high risk potential" (e.g. Petroleum terminal operator "Varna Storage") or "enterprises with low risk potential" (e.g. "Enterprise for maintaining the purity of sea water" AD).

Statistical levels of risk aside, industrial accidents with any of these operators often have severe consequences for the population and the environment, impacting areas way outside the industrial sites. This emphasizes the need to improve existing risk controls as a prevention for industrial accidents involving hazardous substances.

The following **list** of potentially **hazardous sites and operations** may not be exhaustive but contains the main storage and industrial activities with hazardous substances in the **city of Varna** (alone):

- "Varna Storage" – stores and moves oil products. The site is located within the Southern Industrial Zone complex, at the eastern end of the island between the two navigable canals. The site also includes a quay with three ship berths for unloading petroleum products. Classified as a high-risk Fire Hazard Site according to the Environment Protection Act;

- “Nestle Bulgaria**”** – stores an average of 15 tons of ammonia which the it uses for its cooling systems. The company is located on the main road I-2 Ruse - Varna in the Western Industrial Zone;

- “Primagaz” – distributes and supplies natural gas;

- “Overgas Networks” – distributes and supplies natural gas;

- “Melrose Resources” Gas Terminal – Borovets area;

- "Geology, Research and Design" company explosives warehouse in Borovets area – stores explosives used in exploration.

The Municipal Disaster Protection Plan (MDPP) specifies explicitly that local authorities and the Unified Rescue System consider facilities which can accommodate a mass presence of the local population as vulnerable elements of the Critical Infrastructure (CI). The ones which are more visible and topically related to mass-gatherings and high profile events include the Palace of Sports and Culture and the two actively functioning Stadiums in the City. However, the majority of CI objects are transportation, energy and multi-purpose infrastructural facilities.

The following list presents the main CI locations and facilities which constitute vulnerable points and **urban disaster risk sites** in Varna:

- Asparuhov bridge – a crucial crossing point to the South, it has a reinforced concrete supporting structure, a length of 2,054 m, width of 16 m and a maximum height above the water of 45.50 m. Its load capacity is 80 tons.

- the bridge leading to the Southern Industrial Zone – its metal supporting structure holds railway tracks and a roadway. 55 metres in length, 16 in width, height above water of 5.50 m. Similar load capacity – 80 tons.

- all overpasses and underpasses large enough for vehicle traffic.

- the three railway stations: main Varna Station with 8 railway tracks; the freight station of Varna with 10 tracks; the station in Topoli village, with 4 railway tracks.

- certain essential Power supply facilities: the substations "Trakata", "East", "Chaika", "Centre", "South", "Asparuhovo", "Maksuda" and "Devnya-2"; the High-Power line 110 kV "Zvezditsa"; the Power Lines 110 kV "Perla" and "Brilliant".

- the CI upholding the water supply network: the water main linking Kamchia Dam to Varna ("Kitka–Varna"); the water main "Devnya springs"; the water supply systems Batova–Varna and Pasha Dere–Galata; the water main Varna–Asparuhovo.

- the gas pipelines and gas distribution points of Overgas Networks and Primagaz.

The above CI facilities have been categorized by their degrees of vulnerability, local importance and integrated risk for the population, and are monitored in coordination with state bodies and URS units.

Economic development for the Black Sea coast often means more extensive tourism, as much as industrial and commercial activity. Besides land use and natural management (i.e. flood-prone and landslide areas), industrial and CI sites need careful monitoring and maintenance to avoid significant disaster risk increases.

### Specific Radiation Risk Profile of Varna

As mentioned above, Bulgaria has a Nuclear Power Plant (NPP) located in Kozloduy. The NPP site is at a direct air distance of 330 km to Varna (and 325 to Burgas) and bordering Romania which has its own NPP located in Cernavoda (120 km from Varna and 200 km from Burgas). Naturally, other industrial, military and medical installations, devices and processes may emit nuclear or other perilous radiation, although such activities are more easily controlled by the authorities and with infinitely less potential of exposing large groups of the population to direct danger.

Large scale radioactive pollution may occur when there is an incident at NPP "Kozloduy" or there is a trans-border transfer or radioactive substances from NPP "Cernavoda" or other similar CI. Additionally, according to Varna MDPP, there are risks associated with:

- incidents involving land vehicles, water- and air-craft carrying radioactive materials;
- discovery of an abandoned Source of Ionizing Radiation (SIR);
- transportation of radioactive waste or SIR;
- the use of nuclear or radioactive materials for terroristic aims, sabotages, etc.;

- deliberate radioactive contamination of public spaces, drinking water sources, food or consumer products
- the crash of a nuclear-powered or SIR satellite;
- a fire at a SIR facility.

And although Varna is outside the "strict control zone" of NPP "Kozloduy", potential threats arrive mostly from meteorological conditions and the extent of emitted radiation. The time it takes for a radioactive cloud to reach Varna depends on average wind speed in its direction, with estimates ranging between 9 and 32 hours, if and when such wind occurs. Expected intensity of radioactive exposure is measured at 7 mGy/h or 0.7 mR/h, Total dosage of median expected exposure ranges from 0.5 cGy (within a day) to up to 5 cGy (over a period of a year), if conditions persist. These probability scenarios have lead the authorities to the conclusion that no immediate loss of life is to be expected.

Similar analyses related to possible incidents with NPP "Cernavoda" consider accidents and meteorological conditions. And with Varna much closer to that Plant authorities have to also take into account possible collateral contamination with tritium (a radioactive isotope of hydrogen).

Considering all of the above factors, we are led to affirm that **radiation disaster risks** and any related critical events are **not typical** of distinctive for Varna District, as well as Dobrich District for that matter.

### Burgas District:

### Anthropogenic Specifics and Socio-economic Disaster Risk Factors

With a total territory of 7,748 km$^2$, Burgas District occupies 6.99% of the country's territory. By area, Burgas district is the **largest district** in the country. The population of the district is 415 817 people at a density of 53.67 people / km2 – less than the national average.

To the East the district has a wide outlet to the Black Sea – 224 km out of the total 378 km of Bulgarian coastline. Burgas District includes the municipalities of Aytos, Burgas, Kameno, Karnobat, Malko Tarnovo, Sredets, Sungurlare, Ruen, Nessebar, Pomorie, Primorsko, Sozopol and Tsarevo. Six of those – the last five plus Burgas itself – border on the Black Sea. The main economic activities in the district are tourism, chemical industry, agriculture and food industry.

A major chemical industry operator of national significance for the Bulgarian economy is located within Burgas municipal territory: "**Lukoil-Neftochim-Burgas**" AD (**LNB**). This major chemical operator is characterized by a certain high level of risk for its workers and employees, as well as for the entire district population located in nearby settlements and sites, and ultimately for the environment.

LNB's production, operation, storage and transportation practices include highly poisonous, flammable, explosive and toxic chemical products. With the refinery a settlement in its own right (with a separate power supply and train station), storage facilities, warehouses and tanks are located in close proximity to other District settlements. It is relatively close to Burgas as well, hence any critical events or industrial accidents of a larger scale may be expected to involve the urban centre under certain conditions. Outbreaks of extended chemical contamination would have a significant impact and damage on the regional wellbeing, natural balance and economic stability.

Any possible chemical contamination can also be expected in the event of industrial accidents in ammonia refrigeration installations at the sites or warehouses of the food industry, which can affect both workers and the population of the surrounding areas. Such potential accident risk is also present in companies that work with highly flammable liquids, synthetic and wood matter.

Even apparently non-hazardous substances can be dangerous when being handled in excessive amounts or an unsafe manner (e.g. sulphur dust, ammonium nitrate, superphosphate, ferrosilicon, etc.). Port-Burgas EAD performs loading and unloading activities of various types of products and bulk cargo – liquid, solid, powdered – the quantities of which often exceed the limits set by a specific Ordinance №2/1990. Disaster or emergency situation at the Port may be expected to produce large-scale consequences and damages – material, ecological and loss of people, given the location of the site in the central part of the regional hub. Tankers with chemical products and hazardous shipments also transit or reload in "Port-Burgas" or at the warehouse facility "Rosenets National Park".

Local authorities and national regulators have established a special mandatory route to and from LukoilNeftochim-Burgas, in order to reduce significantly the preconditions for accidents or catastrophes during the transportation of dangerous goods by tankers and tank trucks. A main pipeline for liquid fuels has been built from the 20-A ship berth leading to neighbouring storage facilities. Moreover, most chemical and hazardous cargo is distributed in the area of railway station "Druzhba" among railway and auto tanks. Authorities have imposed an mechanism for "Automatic regulation of train traffic" which is to be maintained and operated by LNB. Specific area conditions and the proximity of the railway line between Burgas and Sofia (between the stations "Dolno Ezerovo" and "Druzhba") have allowed both the operator and the authorities to manage and decrease logistic risks related to hazardous cargo and any potentially risky manoeuvres.

Other significant CI and industrially relevant sites with potentially hazardous operations or cargo include:

- “Rosenets” Cargo Port (owned by LNB);
- the operation site of “Toplofikatsiya-Burgas” EAD, a district Central (Thermal) Heating company;
- the ports of “BMF Port Burgas” EAD, “Burgas East-2” Port Terminal and the liquid fuel “Buffer storage” facility;
- “Andesit” Ltd. (industrial-purpose explosives storage facility);
- the fuels and lubricants warehouse, as well as the steam power plant located at Burgas Airport
- the “Despred” AD-Sofia warehouse facility in the Dolno Ezerovo quarter of Burgas – it stores packaged ammunition and pyrotechnic articles;
- another warehouse facility storing explosive materials, 3 km southwest of Gorno Ezerovo quarter.

The **release of industrial toxic substances** as a result of production and economic activity might include Sulphur dioxide (SO2), Nitrogen oxides (NOx) and Nitrogen dioxide (NO2). These gases are normally a by-product of industrial activity of some of the enterprises on the territory of Burgas District, among which is the LNB refinery.

Examples of catastrophic events related to contamination with industrial toxic substances include the hydrogen sulphide pollution of 31.03.2016. On that day, the maximum permissible concentration of hydrogen sulphide (0.0050 mg/m$^3$) was exceeded 36 times, as per measurements at 02:00 and 05:00 a.m. from the automatic measuring station "Dolno Ezerovo" in Burgas. The highly dangerous concentration dropped below the necessary limit about 30 hours later.

Unusable pesticides have gradually been resolved as a problem in Burgas. Their disposal and storage is managed by applying the technology of "BalBok Engineering" – disposal in BB-cubes-reinforced concrete containers – or by collecting, repackaging and storage in secure and guarded storage premises. In a warehouse of the Agricultural Cooperative of the village of Bryastovets for temporary storage are packed and guarded about 130 cubic meters. Expired pesticides from the municipalities of Burgas, Pomorie, Nessebar and Kameno are kept in the above way at the Tsarevo storage base. Pesticides are as much of a hazard as many other chemical byproducts which are difficult to dispose of or recycle.

The dry port - mainly a warehouse complex, has a furnace for incineration of solid waste. In the event of a potential disaster or emergency situation, air pollution, including **fine dust particles**, is likely to occur. It would affect a large number of people due to the location of the site. "Kronospan Bulgaria" EOOD is located in the Industrial Zone "North", at the exit of the city of Burgas to Dolno Ezerovo and is engaged in the production of wood panels and laminated boards, with a continuous technological process, also at risk of releasing excess fine dust particles.

**Explosions** present a relative risk for most large cities and Burgas is not an exception. Most of these instances are grouped together with fires in an urban context, as we mentioned above – caused by technical malfunctioning of human negligence in most of the cases. Still, some explosions and fires have to be directly attributed and accounted for in the context of industrial production activities and facilities.

The heating power plant of Toplofikacia is located in close proximity to the road Burgas - Dolno Ezerovo. Standing at 700 m from the village of Lozovo (and 2500 m from Dolno Ezerovo), the facility produces heat, mainly by burning natural gas or other fuels. Its potential explosion risk is among the highest.

EMCO EOOD (located in Karnobat) is a warehouse for finished products: ammunition and explosives, with a capacity of 310 tons. The company also has its production facility in Karnobat. Likewise, prevention and monitoring protocols need to be of the highest order at these facilities.

Notable recent cases of explosions and industrial fires in Burgas District include the fire at LNB on 16 July 2013. At 10.15 am in Lukoil Neftochim Burgas, an ignition occurred in the Xyloli Hydro Cleaning installation. During the repair works, a spark was produced, which ignited low-octane gasoline. The fire was controlled and soon extinguished by the emergency rescue services of LNB.

Another notorious case is the fire at the gendarmerie warehouse: A large fire broke out in the Burgas district "Izgrev" on December 9, 2017. At 15.25 the FSCP in Burgas received a signal for a fire that broke out in the premises on "Stefan Stambolov" Blvd. The total area of the warehouse is 700 sq.m., with ammunition and other flammable and explosive substances inside. Luckily, the facility was quickly extinguished.

There is a **list of companies** which, according to the Municipality of Burgas, produce, use, store or transport dangerous goods – flammable liquids, liquefied gases and other toxic, explosive and flammable substances (plastics, synthetic fibres, chemical adhesives, fertilizers, etc.). These companies currently are:

"Bules - Kronospan Bulgaria", "Tekom-Unimat" – based in the village of Cherno More, "Airport-Burgas", "Naftex Petrol" Oil base, "Toplivo" AD Sofia (Burgas base), PSB - Karnobat, "Koh-i-Noor Hemus-Mark", "Transvagon Holding", "Pirgosplod", "Buldjac", "Black Sea Gold" Pomorie, "Vinsindustrijs" in Venets village (Karnobat Municipality), "Plastic Products" (Sredets), Fuel production base "H-77" in Dolno Ezerovo, "Komplektstroy" Construction base and Concrete unit, Quarry "Varli Bryag", along with various smaller gas stations.

Clearly, all of the above companies and operations have their internal safety procedures and monitoring mechanisms. They do not represent a standard case for a disaster scenario. However, the sheer number of industrial operations with inherent potential accident risks in Burgas makes them a relevant factor in preventing, planning and mitigating disaster risks which might impact large portions of the District.

### Specific Radiation Risk Profile of Burgas

Increased radioactivity in the bay of "Vromos" (13 km south of Burgas in the area of Chernomorets) was detected in the early 2000s. The nearby copper mine "Rosen" was exploited in the period between 1945 – 1995, after which it was closed due to inefficiency of extraction and depletion of reserves. Discharges of radioactive waste and sludge from the tailings of the mine were found to be released and accumulated as a thick layer of radioactive sludge near the shore. In 1998, the PHARE program rehabilitated the contaminated areas, scraping part of the sand of Vromos and filling the shore with a clean sand fraction. However, over the years, sea waves have continued to carry heavy minerals back to the land from the bottom of the bay, and the beach has to be reclaimed periodically.

There have also been cases of established sources of ionizing radiation at the Port of Burgas. On August 27, 2013 at the Port of Burgas border checkpoint, a truck loaded with scrap metal was identified as emitting caesium Cs-137 radiation. The ionizing radiation was measured at 500 µSv/h (nearly 1000 times above the permissible 0.08-0.40 µSv/h).

Besides the efficiency of the border control mechanisms and the measuring apparatus, this comes to show what we analysed above – most radiation risks are related to smaller emission sources and depreciated technical equipment.

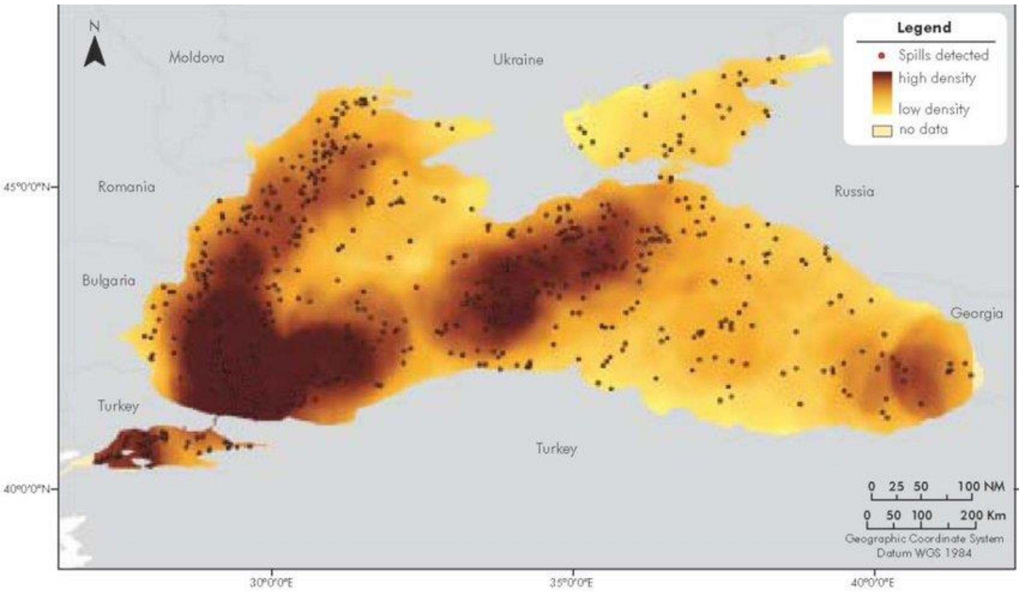
### Oil Spills and Port Activity

Large ports have a significant impact on the environment. They affect the occurrence of environmental problems as a result of intentional or accidental dumping of waste, spillage of bilge water, etc. The Black Sea region is extremely vulnerable in terms of chemical pollution due to the existing **intensive maritime traffic in the coastal zone**. In recent years, the risk of contamination with petroleum products has increased as a consequence of oil and gas exploration activities with view of potential production in the region.

Any pollution of marine waters disrupts the ecosystem. However, oil spills are particularly dangerous, albeit incidental. They lead to losses for the fishing industry, tourism and significant environmental damage.

Statistically, the number of oil and by-product spills after 2000 has decreased worldwide. Varna and Burgas are no exception, in principle. Perceivable improvement was observed as a result of adopted international conventions, the Strategic Plans for the protection of the Black Sea, the Istanbul Strategic Plan and MARPOL 73/78.

*Figure 12. Mapping the oil spills in the Black Sea since 2000.*



As we can clearly see, the majority of oil spills and waste by-product release is coming from the Bosphorus, directed to Burgas, Varna and Constanta (Romania). The sea traffic leaves its mark towards Crimea and Georgia as well.

There is a high risk for mammals, fish, seabirds and their young. Petroleum products trapped in water bodies have a negative impact on marine vegetation, which also reflects on the related human economic activity. Phytoplankton is at risk first (the process of photosynthesis is suppressed). Fish, due to their greater mobility, can survive longer after oil enters the water. In addition to toxic effects however, contaminants can have other harmful effects, such as suffocation or direct contamination of the body by spilled oil.

**Local surface oil spills** have been detected in and around Lukoil Neftochim Burgas (Dolno Ezerovo) and its Rosenets port south of Burgas. On June 17, 2015, tens of tons of gasoline leaked from the refinery pipeline. No danger to the population has been identified, nor was there a danger of the spill contaminating drinking water or the sea. Lukoil Neftochim supplied absorbent materials to clean up, as well as to build an additional layer to prevent the spill from entering the protected area. Vouchers and absorbents were placed to localize the gasoline spill, while the surface water layer was pumped with tanks.

## Biological Contamination Risks

Given the existing production and economic conditions and the structure of national agriculture, the Port of Varna is a natural “entrance point” of Bulgaria. The deteriorating epizootic and epiphytic situation, trade, import and export of live animals, products of animal and plant origin present sufficient risks and conditions for outbreaks of biological infection. The boundaries of any biological outbreaks are determined by specialized anti-epidemic and anti-epizootic teams of the competent veterinary authorities. They usually coordinate their actions with phytosanitary inspectors of the Bulgarian Food Safety Agency. Consequently, they inform affected operators, sector professionals and the public at large.

## Preliminary Conclusions

One of the definitions of a **crisis** or a critical event is the change in an established state of life. It covers territories, objects, sectors and spheres of the economy and public life or the environment, caused by human activity or natural phenomena, as a result of which the **conditions** for existence and activity in the changed environment are **severely disturbed**.

Disaster scenarios along the Black Sea coast have complex traits, albeit certain cornerstone specific. The integrated risk profile of the urban and rural areas of East Bulgaria includes mostly natural phenomena as a background determinant. However, they are frequently aggravated, triggered or made possible by anthropic actions or inactions.

In each of the analysed territorial Districts there are several sites with high disaster risk potential, those which can conjure up events with the highest degree of risk and destructive impact. They are and always have to be assessed with a maximum commitment and meticulousness, especially provided that there are large material losses and human health or lives at stake.

## Summary Recommendations on Prevention and Response Approaches

The above analysis brings up several critical organisational milestones to mind which could improve national and regional efficiency in the prevention, protection, mitigation and response mechanisms to disasters and incidents in the Black Sea coastal region of Bulgaria.

Since the focus of our study is mostly on recognizing and describing the typical disaster scenarios and risk factors, we will limit our recommendations to topical interventions related mostly to such activities in the first place.

The following recommendations are also a synthetic reference to **good governance practices and systemic improvements** which have been recognised as necessary for the entire Bulgarian civil protection system:

- Develop and implement standard disaster response forms to be completed by individual operators, citizens or public officials. This is especially relevant precisely for typical and widespread disasters – both on a national and regional scale. Such an act would facilitate the collection and processing of information as well;
- Create an information system for natural disasters and risk profiles including: primary data, descriptions of events, catalogues, albums, hazard and risk maps, zonings, forecasts;
- To create an effective public system for wide dissemination of popular and necessary disaster prevention and risk mitigation knowledge. This should be done through electronic mass media and printed publications, in order to increase the level of awareness and preparedness to respond to natural disasters.

Many of the response system's perceived shortcomings are due to the inability to fully anticipate and take into account the possible causes for disasters and critical events, hence the ability for prevention and reaction. Authorities should move towards a policy of comprehensive risk management, building up universal prevention and response mechanisms in the context of coexisting with the specifics of the land.

Responsible public units need to be aware of the fact that acting after the event is always more costly and less effective, with some exorbitant losses and casualties at times.

Another important aspect was highlighted in a 2014 Deutsche Welle article about Bulgarian disaster response mechanisms. Due to **climate change**, disasters have recently become more frequent and intense. "In order to avoid such tragedies in the future, preventive action must be taken, focusing mainly on the cleaning of riverbeds, reservoir walls and sewers," when specifically considering flooding scenarios. One cannot expect to avoid having to deal with extreme weather phenomena, instead they must be **anticipated**.

In 2018, the Mayor of Varna noted that a total of more than BGN 100 million would be needed for Varna to fix its drainage system in the long term and not get flooded after heavy rains. It is also true that the problem has existed for decades and one of the more pragmatic solutions is to separate domestic and rain sewerage systems in most (lower) parts of the city.

As one of the most relevant disaster risks – as well as in light of climate change forecasts – flooding needs to have an increasingly considered disaster scenario. A positive move in that direction is the topical Flood Risk Management Plans (FRMPs) for the period 2022-2027.

Being an update of the first FRMP (2016-2021), they need to seriously take into account the conclusions and recommendations of the European Commission with regards to the Floods Directive. This would mean to concentrate on the measures that help **prevent and reduce** the flood risks rather than combat them afterwards. And this can only be an effective approach if the MoEW considers a **climate change** a cornerstone determinant.

Similar considerations need to shape policy and practice in the other segments of disaster preparedness – landslides and earthquakes, fires and human activity. An integrated strategy is merely the basis of a comprehensive risk reduction action plan. High-risk structures and networks need to be supported with monitoring, early warning and prevention mechanisms, while high-probability risk factors and critical events need to be met with preparedness and collateral facilitation of mitigation actions.

Last but not least, the more segmented and targeted the planning and interventions processes, the better need to be the **feedback** and **standard response** algorithms. Disaster reports and related information needs to be systematically integrated into urban and urban development plans in a way that listens citizens and channels practical measures which help the businesses,

## Recommendations for Necessary Investments in Human and Material Resources

Reducing any kind of integrated risk requires good spatial planning and some quality infrastructural facilities, that much is true. However, much depends on the overall territorial preparedness to prevent or mitigate the negative effects upcoming disasters. Preventive measures include the training of the population and adequate planning of response activities. Often, even simple acts like regularly cleaning the river beds and canals can maintain territorial preparedness.

Despite a growing awareness of the benefits of disaster risk prevention, the prevailing institutional knowledge and expert capacity reflects policies and practices related to emergency response as a main form of preparedness. Consistent steps are needed to even pragmatically set a **financial management framework** for general preparedness. Such an approach will for more frequent and typical disasters – as the ones described above – to receive priority in prevention and early planning as opposed to damage liquidation and emergency response. Without even considering mid- to long-term effects on the economy and societal processes, anticipating what one knows will come is always more cost effective.

Although Varna and Burgas are quite important Bulgarian realities in terms of size and economic influence, the two Districts – as well as Dobrich – are not suffering from over-concentration of their population in the few urban neighbourhoods or industrial production zones. Instead, infrastructural vulnerability stems from insufficient facility maintenance in some cases and underinvestment in others (e.g. sewage, dams, roads, industrial cleaning). Therefore, national and regional authorities need to re-evaluate certain crucial concepts of disaster prevention financing, as part of a larger discourse on an infrastructural upgrade. Some measures which could help include:

**1.** Involving civil society, the public sector and finance/insurance agents in a wider discussion on **flexible and targeted financing** through public-private **partnerships and ownerships**; as well as on **insurance** coverage as a form of preparedness which is currently underexploited;

**2.** A re-calculation of some financing paradigms (we mentioned above) – **before vs. after financing** matched against **probability**, **frequency** of occurrence and the extent of post-disaster recovery efforts;

**3.** Launching a campaign – if necessary, with initial public co-financing – to stimulate public and private **insurance against disasters**, including via **legislative** and **procedural facilitations**.

## Recommendations for the development of voluntary networks

An entirely renewed strategic planning approach is probably needed to reposition the status of volunteer services and civil duty in the eyes of many Bulgarians. Some of its objectives would not be strictly related to risk reduction but rather to the creation of an effective mechanism for communication and involvement between institutional entities and third-party interest groups, i.e. NGOs and the general public.

Being able to maintain an Early Warning System relies to a large extent on the efficient functioning of a voluntary formation as part of the URS. However, training existing volunteers does not seem to be enough to increase the desired involvement. A range of stimuli, campaigns and the creation of a sense of common ownership and socio-economic returns is needed to be able to count on wider participation and a more positive attitude.

## Conclusions and Institutional Perspectives

Prevention and mitigation activities have been a leading topic in the social discourse – after some serious consequences of floods and transportation disasters in recent years, new laws and instructions have been adopted, the role of the Unified Rescue System has been boosted and its organisational structure is now flatter. Communication and information centres are up and running in each district. However, more measures are needed to prevent, control and scientifically anticipate possible disasters related to the typical disasters for each region.

Climate change is predicted and widely expected to overwhelm many of our certainties and much of existing biodiversity, terrestrial, aquatic ecosystems, water resources, agriculture and the forestry sector. These changes will have an important impact on society as well, its citizens will have to adapt to a new global paradigms, much more “green” and sustainable. And while climate change would not affect all regions equally – due to differences in exposure and local factors – territorial vulnerability and adaptive capacity depends much on the ability to plan ahead. Anticipating these processes is not a luxury anymore, it is a must for those who want to build up local resilience.

Many of the national trends regarding disaster risks are perfectly valid for the Black Sea coastal areas. We need to keep in mind that **floods** and **landmass instability disasters** have the **highest probability of occurrence** among all natural disasters. And both are very often related functionally and temporally. Then again, separate **weather** related disasters could stimulate either of the two. **Fires** may have a relation to another disaster (preceding of succeeding) but are mostly of **anthropic origin**.

The inherent inevitability of most natural disasters leads societies to set up prevention and preparedness systems. The Bulgarian modular URS is replicated on a local and regional scale for Varna, Burgas and Dobrich Districts, with the three sharing some of the resources and coordination systems. In any case, territorial response units are prepared to act in cases of most of the typical natural disasters or man-made incidents with certain gravity and scale.

There is sufficient consensus in the scientific end expert community that **climate change will increase the frequency of most extreme natural events**. Thus the challenge for today’s society is twofold – be prepared for sudden critical events with different characteristics, damage type and required response mechanisms; and, on the other hand, get used to gradual change and adapt daily and long-term activities and existing prevention algorithms. However, as **most statistically relevant disasters are of natural origin**, the Bulgarian Black Sea coastal areas and its inhabitants need to be prepared for planning and management strategies which focus on prevention and risk reduction, rather than on response mechanisms and preparedness for multiple disaster types.

Reports have shown that since the turn of the century the frequency of important natural disasters in Bulgaria and along the coast has increased significantly. Ten catastrophic events have only been registered between 2004 and 2006. The number of people killed and injured as a result of natural disasters is also on the rise, indicating **increasing vulnerability**. The most common **hydro meteorological** and **geophysical natural hazards** are **floods, extreme temperatures**, **storms**, **forest fires**, **earthquakes**, **landslides** and **droughts**.

For the Bulgarian sea coast, in particular, hail, snowstorms and icings are somewhat less relevant, although they come back occasionally without any cyclical frequency. National Statistical Institute data indicates earthquakes as an almost negligible disaster type, yet we must remember that Bulgaria has experienced serious earthquakes in the past and, crucially, Bulgaria is located in a highly seismic region. The North-East specifically presents several faults (Shabla and Dobrich) and such disasters can never be overlooked.

In the present paper needs to come **back to one particular leading type of disaster** for the entire Black Sea coast, it has proven to be **floods**. Various types and causes make it the most significant natural disaster – both nationally and especially for the Black Sea region. Statistical orders have proven that the South Black Sea region (centred around Burgas and its district) is the most affected by this type of natural disasters.

We have also analysed the principal causal factors for such floods. The ever more frequent and intense torrential rains are the main causes of floods of any type, "aided" by rising sea levels and occasional storms, followed by human negligence. An analysis of important past floods has provided us with the certainty that floods and rains possess the regular potential and risk factor needed to declare them main critical events with an impact which extends beyond immediate damage, hampering maritime tourism, which is a major industry for the entire region.

With torrential rains becoming more important in determining severe weather, they tend to unlock other disastrous phenomena and critical events – floods, landslides, storms, rockfall.

In a way climate change is also of anthropogenic origin, thus contributing to the intensification and severity of most of these processes and disaster risk factors. And with human activity definitely the number one cause of fires – both in cities and amongst nature; intentional or because of technical malfunction – there is definitely more than something that we can do to prevent and mitigate such catastrophes.

NSI data also shows that nearly two thirds of all settlements and local realities have been hit by at least one form of disaster going a few years back. This brings enormous losses to the entire coast, its inhabitants and its economy, largely based on tourism and other services. If nothing else, this confirms the need to build adequate prevention systems in settlements.

The findings in this study suggest that a comprehensive management approach to natural disasters is needed, since risks and vulnerabilities are integrated, connected and accumulated. An effective (and financially efficient) approach must pay its due attention to the overall vulnerability, potential impact and extent of damage. But think about the interrelationship between various disaster types, as well as their impact on regional socio-economic development.

Contemporary methodology of risk assessment and planning includes **prevention measures in the first place**. Local infrastructural preparedness adds up to population and personnel **training**, while **investing ahead** in monitoring, early warning systems and **flexible financial coverage** (e.g. insurance and co-ownership) saves on later recovery efforts and rebuilding campaigns.

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