Floods

EVANDE project, Technical report

European Civil Protection

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EVANDE

www.evande.eu

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Preface

The technical booklet on floods was produced by the European civil protection project EVANDE (Enhancing Volunteer Awareness and education against Natural Disasters through E-learning).

The EVANDE project was implemented the period 2015-2016 and was co-funded by the Union Civil Protection Mechanism (Grant Agreement No. ECHO/SUB/2014/693261). It was coordinated by the Natural History Museum of Crete-University of Crete, in Greece and involved also the following partners:

- Technical University of Crete -Laboratory of Distributed Multimedia Information Systems and Applications, GREECE
- Consorci De La Ribera, SPAIN
- Beigua European & Global Geopark, ITALY
- Earthquake Planning & Protection Organisation, GREECE
- Fondazione Hallgarten - Franchetti Centro Studi Villa Montesca, ITALY
- Centre for Educational Initiatives, BULGARIA.

The present booklet is a synthesis of selected civil protection knowledge and experiences in Greece, Spain, Italy, Bulgaria and globally. It aims to present basic knowledge and information on civil protection against floods and focuses in all aspects of civil protection including prevention, response, recovery and covers institutional, economical, social and educational issues.

The booklet is targeting to local authorities' staff and civil protection volunteers and aims to offer insights on how civil protection policies and initiatives could be improved. The contributors were both staff member of the EVANDE partner organizations as well as experts and external collaborators. The synthesis of these experiences indicates the diversity of approaches per country as well as the importance of prevention and awareness-raising on natural disaster risks.

Further information about the EVANDE project:

EVANDE website: www.evande.eu

EVANDE e-learning platform: http://evande.coursevo.com

EVANDE Facebook Group: https://www.facebook.com/evandeproject

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1. Hazard description

1.1 General Aspects

A “flood” usually means the temporary flooding of territories with vast quantities of water. Under DIRECTIVE 2007/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL - *“Floods have the potential to cause fatalities, displacement of people and damage to the environment, to severely compromise economic development and to undermine the economic activities of the community. Floods are natural phenomena which cannot be prevented. However, some human activities (such as increasing human settlements and economic assets in floodplains and the reduction of the natural water retention by land use) and climate change contribute to an increase in the likelihood and adverse impacts of flood events.”*

As water falls to the Earth in the form of rain or snow, it seeps into the ground. But if the ground is frozen or the surface impervious (asphalt or concrete are two contenders) or the soil is already saturated and cannot absorb the water faster than it falls from the sky, problems arise.

Water running downhill into channels and streams begins to "pile up", eventually overrunning the sides of those channels. How quickly this happens depends on the strength of the precipitation and the slope of the land. Sometimes flooding causes deep water to move quickly, while other times, shallow water may linger, taking days to dissipate.

Floods differ by:

- Origin;
- Duration, damage;
- Number of victims.

1.2 Types of floods

The experts classify floods depending on their origin as follows:

- **River floods** - inundation of land by water emerging from natural or modified drainage systems. This type of flooding is caused by rivers, drains, mountain streams, short one-off and/or periodical watercourses (eg. In the valleys), etc.
- **Flooding caused by heavy rainfall** – as a result of intense rainfall, drainage infrastructures in the settlements or the natural capacity of the soil outside the settlements to absorb rainwater is over fraught with the large amounts of water;
- **Flooding from groundwater** – emerging groundwater. This process may be due to a sudden increase in groundwater, which is often associated with high levels of surface waters;
- **Sea floods** - floods of seawater in estuaries and coastal lakes. Such flooding may be due to the extreme level of tides, continuous strong winds and high waves, such as coastal tsunami and others;
- **Infrastructure floods** - they come from artificial water-retention or water-drainage facilities. It may be due to accident or insufficient capacity of dams, waste water treatment plants (WWTP), water supply and sewerage facilities;
- **Flooding from snowmelt** - possibly in combination with rainfall or obstruction/siltation with ice.

According to the mechanism of occurrence of floods are divided into:

- **Natural overflow** - flood waters exceed the capacity of the drainage channel, riverbed or the level of river banks;
- **Spill over protective structures** – e.g. dams or dikes;
- **Failure of protective equipment or infrastructure** – e.g. dam break or destruction of the dam wall or damage to pumping equipment;
- **Blockage or water retention** - due to blocking the natural path of drainage, such as natural deposits or household waste under bridges;

According to the rate of occurrence of floods could be divided into:

- **Sudden flood** - occurs quickly and without the opportunity to be foreseen. Usually due to intense rainfall on a relatively small territory;
- **Semi-sudden flood** - occurs more slowly than the sudden flood and can be predicted under certain circumstances;
- **Slow start flood** - develops even slower. It can be foreseen relatively early.

Type of flooding	Causes of flooding	Effect of flooding	Relevant parameters
River flooding in flood plains	Intensive rainfall and/or snowmelt; Ice jam, clogging; Collapse of dikes or other protective structure	Stagnant or flowing water outside the channel	Extent (according to probability) Water depth Water velocity Propagation of flood
Sea water flooding	Storm surge Tsunami High tide	Stagnant or flowing water behind the shore line Salinization of agricultural land	Same as above
Mountain torrent activity or rapid run-off from hills	Cloud burst Lake outburst Slope instability in watershed Debris flow	Water and sediments outside the channel on alluvial fan; erosion along channel	Same as above; Sediment deposition
Flash floods in Mediterranean ephemeral water courses	Cloud burst	Water and sediments outside the channel on alluvial fan Erosion along channel	Same as above
Groundwater flooding	High water level in adjacent water bodies	Stagnant water in flood plain (long period of flooding)	Extent (according to probability) water depth
Lake flooding	Water level rise trough inflow or wind induced set up	Stagnant water behind the shore line	Same as above

Table 1.1 *Relationships between Types of flooding – Causes – Effect - Relevant parameters*

The most common classifications of flooding according the experts is:

- **River overflow** - these floods occur when rivers flow out of their beds and incoming high waters spill out into the fluvial terraces. This is due to a drastic increase in river flow (due to accidental heavy rains and snowmelt), and backing up, caused by different factors (overgrown watercourse, culverts clogged by sediments, dragged wood material, etc.)
- **Torrential floods** - torrential floods are due to accumulation of water on the ground during intense rainfall. When the intensity of water accumulation exceeds the drainage capacity of the ground (either natural or sewerage capacity), large volumes of water accumulate on the surface, which flow into the lowlands and fill them up. Torrential floods cover limited areas and are not necessarily related to the presence of a river network.
- **Flooding caused by accidents and/or improper management of hydraulic structures** - this type of flooding is due mainly due to two reasons - accidents at large hydraulic structures (dams, equalizers, tanks, large penstocks, large diversion channels, etc.) or mismanagement of dams, mainly with large hydraulic capacity of the facilities (main outlets and spillways with controlled water retention valves).
- **Flooding caused by deliberate harmful actions** - this is artificially induced flooding as a result of deliberate actions directed against the security of the country. Possible reasons for the occurrence of this type of disaster can be acts of terrorism, subversive activities, acts of organized crime, war and

others. The first three reasons are especially dangerous because they are characterized by their difficult predictability under peaceful conditions and the possibility of sudden extensive damage. Objects of deliberate action to cause flooding can be large hydraulic structures such as dams, equalization basins, tanks, large penstocks, large diversion channels, etc.

1.3 Criteria for assessing the scale of the flooding

Under Directive 2007/60 / EC of the European Parliament and of the European Council of 23 October 2007 on the assessment and management of flood risks can be made. In the table below show **an example how** this is transferred into Bulgarian legislation through the Water Act, and flood can be labelled *significant* or *insignificant*, concerning categories such as "Human health" "Economic activity", "Environment" and "Cultural Heritage". The values that define a flood as being *significant* in terms of size and damage, consistent with Bulgarian socio-economic status, are listed below:

Category	***Criteria***	***Minimum value***
HUMAN HEALTH	***Affected people***	***15 people***
	Deaths	***1 person***
	Affected elements of the critical infrastructure for public use	***1 element***
	Affected elements of public water supply	***1 element***
ECONOMIC ACTVITY	***Damage in industrial sites***	***100 000 BGN/ 50 000 EUR***
	Affected industrial sites	***1 site***
	Affected elements of infrastructure (roads, railways, bridges)	***1 element***
	Affected agricultural acreage	***10 ha***
ENVIRONMENT	***Wastewater installation***	***1 installation***
	Affected protected areas	***1 area***
	Affected water protection areas	***1 area***
CULTURAL HERITAGE	***Global significance***	***1 site***
	Natural importance	***1 site***

Table 1.2 *The values that define a flood as being significant in terms of size and damage*

2. Risk Assessment - National Maps of Hazard in Greece, Bulgaria, Italy and Spain

Introduction

The assessment of flooding risk in Europe is based on the Directive 2007/60/EC, known as the Floods Directive. This requires that Member States should assess if all water courses and coast lines are at risk from flooding, map the potential flooded areas and endangered assets and humans in order to take adequate and coordinated measures to reduce the risk. This Directive, as all European regulations, also reinforces and supports the right of the public to access information and to participate in the planning process. As a first step a preliminary assessment by 2011 is required in order to identify the river basins and associated coastal areas at risk of flooding. For all such zones flood risk maps should be prepared by 2013 and subsequently flood risk management plans focused on prevention, protection and preparedness by 2015. The Directive applies to inland waters as well as all coastal waters across the whole territory of the EU.

The Directive shall be carried out in coordination with the Water Framework Directive 60/2000, notably by flood risk management plans and river basin management plans being coordinated, and through coordination of the public participation procedures in the preparation of these plans. All assessments, maps and plans prepared shall be made available to the public. The Directive also foresees that Member States shall coordinate their flood risk management practices in shared river basins, including with third counties, and shall in solidarity not undertake measures that would increase the flood risk in downstream countries. Furthermore, Member States will take into consideration long term developments, including climate change, as well as sustainable land use practices in the flood risk management cycle addressed in this Directive (Fig. 2.1).

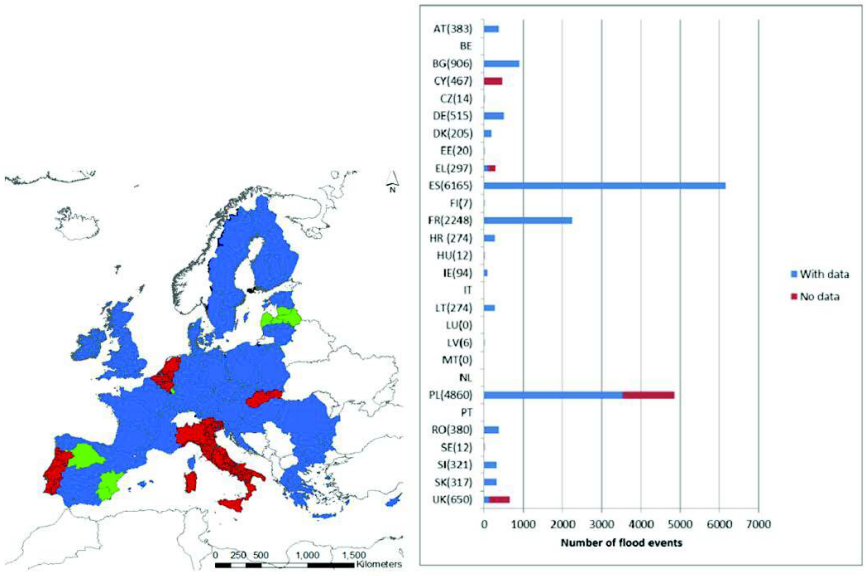


Figure 2.1 *Approaches used by Member States in assessing flood risk and identifying areas of potential significant flood risk and the number of reported historic flood events by Member State (http://ec.europa.eu/environment/water/water-framework/pdf/4th_report/CSWD%20Report%20on%20the%20FD%20.pdf 2015)*

2.1 Greek Flood Risk Assessment and Hazard Map

In Greece the Directive became part of national legislation with the Common Ministry Decision 31822/1542/E103 (Gov. Gaz. B' 1108/2010) and the Special Secretariat for Waters of the Ministry of Environment was set responsible for its implementation. The full implementation of the directive has not been achieved so far. However, the following have been implemented:

The Preliminary assessment for the flooding risk has been finalized and submitted to the EU on March 2012 (Special Secretariat for Waters, Ministry of Environment, Energy and Climate Change, Preliminary Study of Flood Risk in Greece 2012). The assessment was based on the 14 Water Management Districts that have been set for the implementation of the Directive for Water management 60/2000 instead of the River Basin areas. Based on this assessment the detailed Areas of Potentially Significant Flood Risk will be identified, hazard and flooding risk maps will be produced. These studies are however in delay and just on December 2014 the studies for five of the 14 Water Management Districts have initiated.

Figure 2.1.1 *The 14 Water Management Districts in Greece (Special Secretariat for water resources, Greek Ministry of Environment Energy & Climate Change)*

The Preliminary Study for Flooding Risk in Greece

The study was focused on the identification and mapping of areas where a flooding is possible to happen (Flood Hazard Areas) and where a high flooding risk occurs (Areas of Significant Flood risk).

For the Flood Hazard Areas the criteria used were:

a. Occur on recent alluvial deposits

b. Present morphological inclinations less than 2%

Various maps on scale 1:50000 from the Management Plans of former Ministry of Development and the Digital Elevation Models of the National Hydrological Bank and of the Geographical Service of the Greek Army were used.

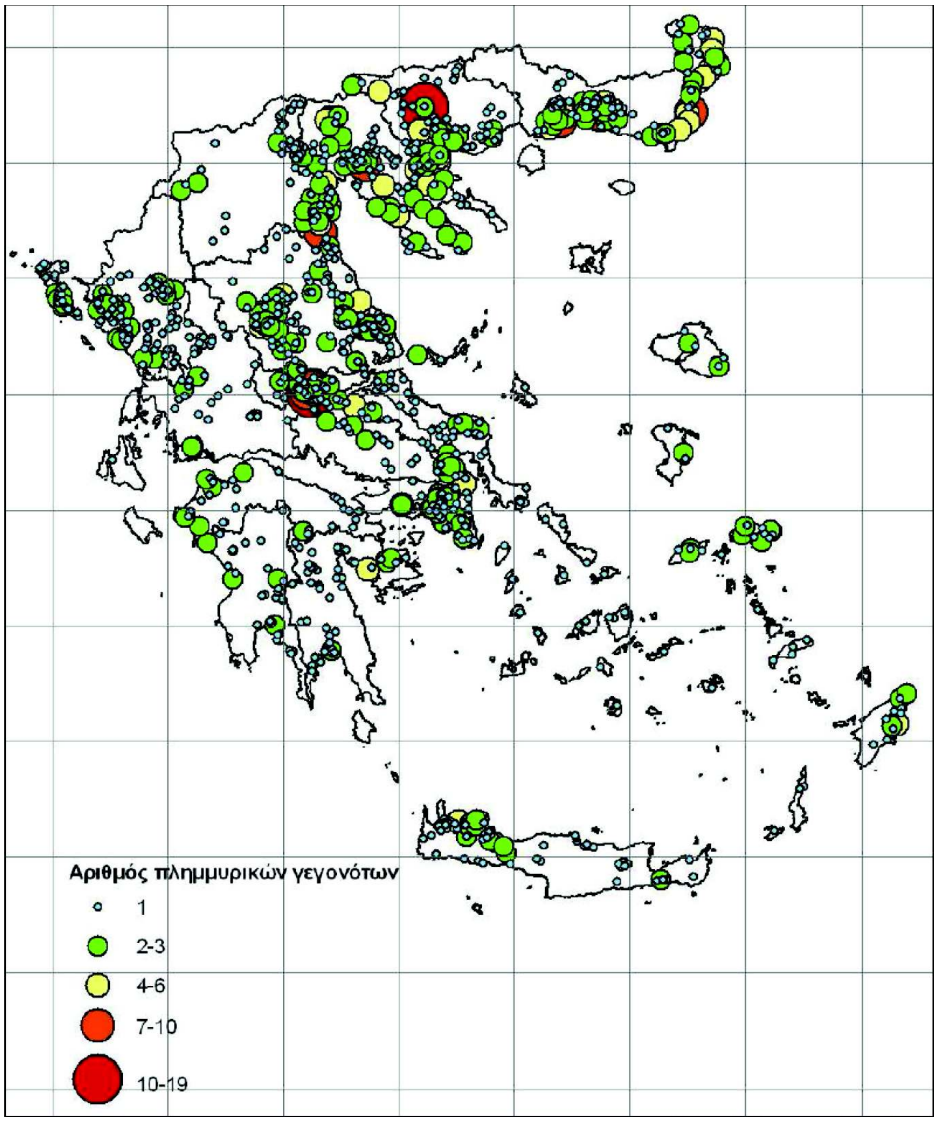


Figure 2.1.2 *Number of recorded historical floods in certain areas (Special Secretariat for water resources, Greek Ministry of Environment Energy & Climate Change)*

In order to identify the Areas of Significant Flood Risk, data from the Flood Hazard Areas, areas with potentially significant flood impact, and the important historical floods were combined. These areas are those where the areas of Potentially Significant Impact in future Floods and areas of Flood Hazards coincide.

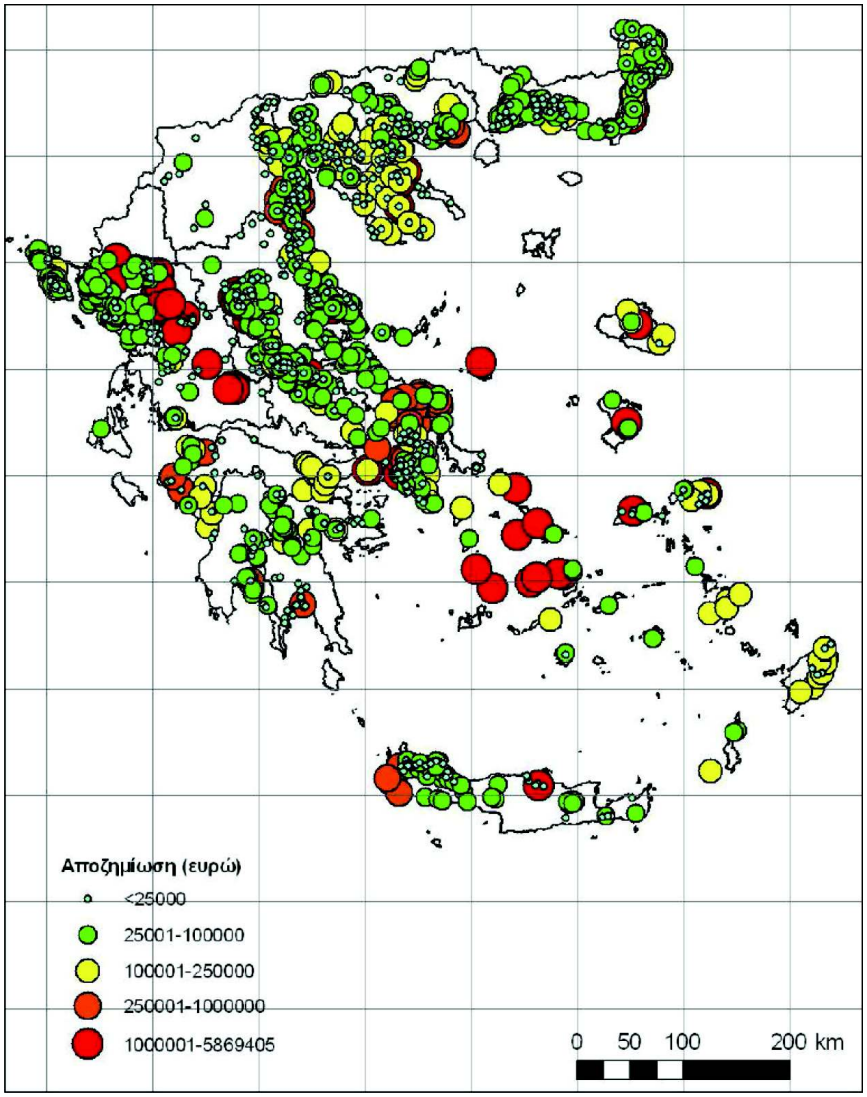


Figure 2.1.3 *The Financial impact in € in certain flood cases (Special Secretariat for water resources, Greek Ministry of Environment Energy & Climate Change)*

Finally, areas with dimensions less than 25Km^2 were not taken into account in this study except if there were records of significant past floods, as well as areas of past floods that were not included in the derived Areas of Potentially Significant Flood Risk. The general maps of Areas with Potential Significant Flood Risk are presented for each Water Management District, and in the following combined map.

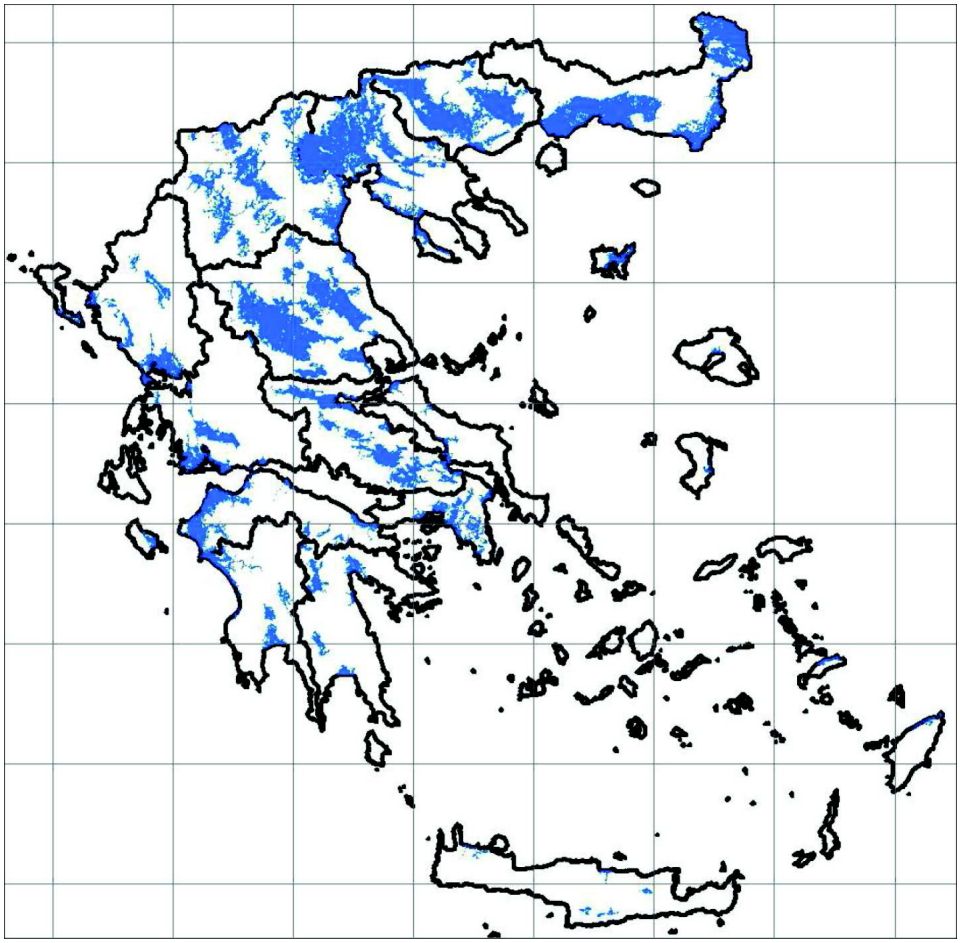


Figure 2.1.4 *The Preliminary Assessment (2012) of Areas of Potentially Significant Flood Risk in Greece (Special Secretariat for water resources, Greek Ministry of Environment Energy & Climate Change)*

2.2 Bulgarian Flood Risk Assessment and Hazard Map

Bulgaria is a country with an impressive variety of natural resources - high mountains, vast fields, maritime coastline and many rivers. (Bulgaria is one of the European countries on the route of the Danube river – it forms the natural geographical, as well as the official state border to its northern neighbor Romania.)
In terms of flooding potential the country is divided into 4 regions, according to the direction of water flow from the respective catchment area. Drain regions as the object of administrative management are entrusted to the homonymous basin directorates that are directly subordinated to the Ministry of Environment and Water. The four areas of basin management in Bulgaria are:

- West Aegean region of drainage;
- East Aegean region of drainage;
- Black Sea region of drainage;
- Danube region of drainage.

Waters from the first two areas flow into the Aegean Sea and those of the other two areas into the Black Sea and the Danube River, respectively. Determination of flood risk for potentially flood-prone areas including cross-border flooding, includes an assessment of potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity, taking into account topography, the position of watercourses and their general, hydrological and geo-morphological characteristics, including floodplains as natural retention areas, the effectiveness of manmade infrastructure for flood protection, the position of populated areas, areas of economic activity and long-term urban amenities, including impacts of climate change on the occurrence of floods.

1. West Aegean region of drainage

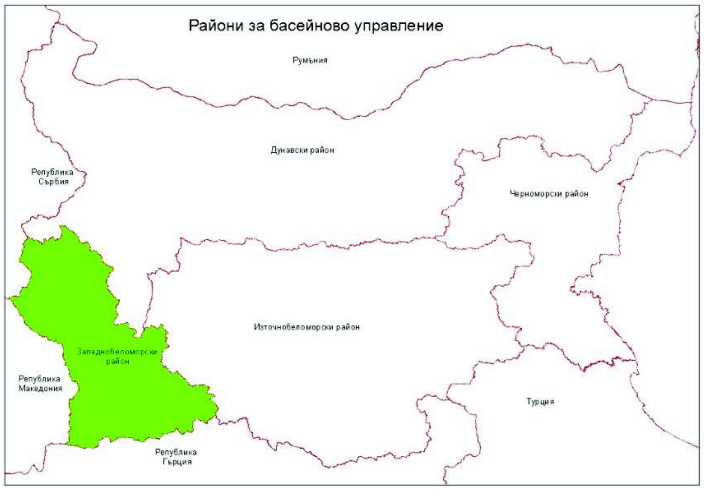


Figure 2.2.1 *West Aegean region of drainage (West Aegean River Basin Directorate http://www.wabd.bg/)*

The main rivers of the region are Struma, Mesta and Dospat. They spring from the high mountains in southwestern Bulgaria, run in the south-southeastern direction and cross the border with Greece, where they flow into the Aegean Sea. The catchments are highly dependent on snowmelt due mainly to the mountainous nature of the region through which the flow. Furthermore, they are characterized by comparatively large catchment areas and large average annual quantities of water.

2. East Aegean region of drainage

Figure 2.2.2 *East Aegean region of drainage (East Aegean River Basin Directorate-http://earbd.org/)*

The East Aegean region of drainage includes the watersheds of the rivers Maritsa, Arda and Tundzha. It is characterized by large spatial variability of rainfall: from the relatively small annual rainfall of 450-500 mm/m^2 in the western part of the Thracian lowland to more than 1000-1200 mm/m^2 in high mountain areas.

3. Black Sea region of drainage

The Black Sea basin management includes all rivers forming their currents mainly on Bulgarian territory, which flow into the Black Sea, directly or through coastal lakes and bays, including internal waters and territorial sea.

Figure 2.2.3 *Black Sea region Black sea region of drainage (Black Sea Basin Directorate-http://www.bsbd.org/)*

4. Danube region of drainage

The Danube basin region is part of the international Danube Basin. It covers almost the whole of northern Bulgaria and covers an area equal to 42.5% of the country. It covers all the rivers that flow into the Danube on Bulgarian territory or cross the territory of Serbia.

Figure 2.2.4 *Danube river region Danube region of drainage (Danube Basin Directorate- http://www.bd-dunav.org/)*

Risk assessment for the Danube region of drainage

Bulgaria could be compromised by a high wave coming from the upper currents of the Danube. Direct threat to our country lies in the potential failure of the joint Serbo-Romanian hydrokinetic power plant "Iron Gate" - the largest hydroelectric power plant on the Danube and one of the largest in Europe. Operation and maintenance are shared between Romania and Serbia. Possible failure of the equipment of the plant would release huge volumes of water. It is difficult to calculate exactly how high the tide would be, but certainly all the coastal settlements on the Bulgarian and Romanian side would be affected. Moreover, the only operating nuclear power plant in Bulgaria is situated on the Danube river banks. It draws water from the river for cooling the reactors. Although the plant has protective devices against high flood waters, there is a real danger of plant failure, which can lead to leakage of various radioactive elements into the river. The Danube River is the main water source for irrigation of agricultural land in northern Bulgaria. Such an accident would lead to tragic consequences for agriculture, flora and fauna. Moreover, the river will take contaminated water straight into the Black Sea. International attention and coordination between all countries of the Danube basin, and in particular Serbia and Romania, is necessary for the operation of HPP Iron Gate and the controlled release of water from the plant.

The country has over 3,000 dams - state, municipal and private property, but there are also ownerless properties. Those, though few in number and small in size, hide a serious danger to nearby settlements, since it is unclear who has the responsibility to maintain and coordinate facilities and release of water. In recent years dozens of such cases emerged and the institutions are passing the ball to one another. Ultimately, no one can guarantee the operability of these reservoirs. According to various sources (mainly

the media) there are between 30 and 70 orphan dams on the territory of Bulgaria. Experts assess a total of 78 dams to represent a danger to the country, the owners of some of them are unknown as well. Poor or lacking management led to dozens of local floods in recent years and some even took human lives (eg. flood in the village of Biser in 2012). Unfortunately, tragedy could repeat itself, since in some places no preventive measures have yet been taken.

Large and dangerous dams in the Danube valley are:

- **"Alexander Stamboliiski"** - only 18 km from the town of Pavlikeni, it has a capacity of about 200.0 million cubic meters.
- **"Ogosta" –** situated in northwestern Bulgaria, the dam with the fourth largest surface area and the second largest volumetric capacity amongst the artificial reservoirs in the country. It is located just 600m from the residential areas of the district town of Montana with a population of 45 000 people. If the wall breaks, the water will reach the first residential areas in about 1 minute. The town would be flooded with about **506 million cubic meters** of water.
- **"Iskar"** - dam and cascade - the largest lake in surface area and volumetric capacity in the country, containing up to **655 million cubic meters** of water. It is part of the Iskar cascade, together with 5 hydropower plants and two additional small dams - Kokalyane and Pancharevo. We should pay special attention to the consecutive arrangement of Iskar dam -> HPP Pasarel -> Kokalyane dam –> Pancherevo dam. In case of disaster, unleashed water masses will pass successively through the above described cascade of reservoirs. The last reservoir wall, Pancharevo, is located only 2 km from the capital's suburbs. The prognosis is the bleak for the suburban village of German, and the neighborhoods Gorubliane and Druzhba, which numbers 75,000 inhabitants. Total population of the endangered neighborhoods and agglomeration settlements is approximately 100 000 people. The water masses would paralyze much of the capital (the largest city in the country with almost 1.3 million inhabitants) as well as close off completely Sofia International Airport, and break the connections of the city with railways and highways to the east and north. After the wave passes through the city, it would reach the small town of Novi Iskar, which is located on the path of the river with its 27 000 inhabitants. The water would then continue to flow through the mountain chain of Stara planina, where a micro cascade of small hydropower plants is located, which experts estimate will be swept away, thus adding new quantities of water. Downstream, the towns of Svoge (8000), Mezdra (10 000) and many villages would be severely affected. Then the river would spill widely within the Danube Plain. Experts calculate that the water from the Iskar dam would reach Sofia in about 20 minutes, way too little time to organize the evacuation. Within the Sofia plain water would be spilled widely, which would reduce the power of the blast. Settlements downstream would have about 12-18 hours time to evacuate, but material damage would be serious. Such an accident would cause damage to an exceptional extent.

Risk assessment for the Black Sea region

The Black Sea region is characterized mostly by typical coastal hazards that might disrupt infrastructure, such as storms, sea waves, etc. A typical risk is the backing up of some rivers' estuaries in case of prolonged headwind which can temporarily increase the water level upstream. Of course, all other hazards apply here as well, like the clogging of troughs, dam accidents and breakdown of cascading facilities for example. Occasionally there are flash floods following intense rainfall and snowmelt. There is a risk for almost all types of floods in the area, as well as in the majority of the country. Here, however, floods often have local

character. Here we have some additional risks that are typical of coasts. Fortunately, in our country the occurrence of tsunami from the sea is hardly possible. In some cases dam failure can cause serious damage to cities like Bourgas, Varna, Nessebar and others. Another problem is the preservation of the natural habitat of many endangered species. Here passes the migratory route of birds - Via Pontica. Many birds nest on the shores of coastal lakes. Each flood could lead to the extinction of rare species of birds. In terms of cultural heritage there are over 100 potentially endangered sites. Total to the country there are about 1,400 sites of global, national and local importance.

Risk assessment for the East and West Aegean regions of drainage

As implied, drain regions in southern Bulgaria take their waters to the Aegean coast. Logically, the two regions are connected with neighbouring Greece and Turkey.

In the *West Aegean drainage region* there is an existing risks for almost all types of floods - heavy rains, dam accidents and others. Here, some of the rivers passing through Bulgaria may pose a specific problem. Several rivers originate in Serbia and FYROM, run through Bulgaria and flow into the Struma river. If a problem arises on the territory of our western neighbours, it will reach the valley of the Struma river, i.e. high waters from Serbia or FYROM will pass through Bulgaria and reach Greece. This emphasizes once more the need for cooperation on a neighbourly level.

Besides the usual risks, the *East Aegean drainage region* shows some interesting features. As noted before, several major rivers flow from Bulgaria to the south in the direction of the Turkish-Greek border. These are Tundzha, Arda and most abounding Bulgarian river - the Maritsa. The annual flow of the region is about **6.575,106 m3**.

High waters from Bulgaria are about twice as high after the three rivers meet in the border regions of Greece and Turkey. Water from the East Aegean region are used extensively for irrigation of agricultural land and drinking water. This has caused the need to build reservoirs to collect and organize the water. Some of the constructed reservoirs produce electricity as well. Here the main danger is for the lower parts of Aegean Thrace in Greece and Turkey, where the breaking of the dam could unleash billions of cubic meters of water and cause human casualties and huge material damage.

International cooperation

It is clear that Bulgaria is threatened by the potential hazards of the western and northern neighbours. On the other hand possible disasters on Bulgarian territory carry a potential risk to our southern neighbours. It is also clear that damage control and prevention requires international cooperation and coordination. The need for international cooperation led to the signing of international agreements and treaties for cooperation between Bulgaria and the neighbouring countries:

- With Greece - 1964.
- With Turkey - 2012.
- With Romania – 2004
- With Serbia - pending negotiations are coming to an end.
- With FYROM - 2000.

Furthermore, Bulgaria has signed cooperation agreements for environmental protection and rational management of water with Poland, Mongolia, China, Denmark, Germany and Austria.

5. Global warming and climate change

Global and regional climate change is another important factor for flood risks. Global warming and climate change are the biggest environmental threats humanity faces in the twenty-first century. Global warming is becoming a major cause of climate change worldwide, and is about to cause the disappearance of hundreds of animal and plant species[1]. According to research, based on calculations of NASA, Goddard Institute for Space Studies, 2005 was the warmest year since the beginning of measurements exceeding the previous record set in 1998 by a few hundredths of a degree. Scientists predict continuation of global warming in the future as a consequence of the greenhouse effect. In 2100 average temperature will have increased by 1 to 6 degrees Celsius. Warming of the earth's atmosphere will cause a rise in ocean level by more than a meter over the next hundred years. Melting ice caps, glaciers and Arctic icebergs would cause flooding in coastal areas, changing ocean currents that regulate the temperature of individual regions. Global warming increases the climatic anomalies. According to the upcoming 5th assessment report of the Intergovernmental Panel on Climate Change, downpours and droughts will become more frequent with rising temperatures, as will become the monsoons that cause floods. The frequency of strong storms day with torrential rains will increase at least twice.

Weather in Bulgaria becomes more extreme. Periods of drought increase in duration and frequency, followed by severe storms and flooding with heavy damage and casualties. The climate south of the Stara Planina mountain range becomes more Mediterranean and fertile lands on the north are threatened by desertification. Snowy months in the mountains become less. Snowfalls now begin after Christmas, thus reducing the amount of water we dispose over throughout the year.[2] According to a study of BAS, it is possible that by 2050 the climate in Bulgaria could be altered to subtropical and temperatures could have risen by about 5 degrees.

As a result of climate change and migration in our country, in recent years the temperatures in cities have risen between 1.2 and 2.5 degrees. According to BAS, temperatures in Bulgarian cities have risen by around 1.8 degrees. The snow-retention period is reduced by 40 % and the overall amount of rain is reduced by over 30%. Fires have increased 7-fold and burnt areas have increased by a factor of 24. As a consequence, there is a significant increase in the amount and frequency of extreme rainfalls. Again according to BAS in the last 20 years days of torrential rains have increased dramatically, parallel to a decrease in snow coverage.

Due to the lack of adequate statistical information, it is difficult for the global scientific community to give realistic forecasts for major climate changes by 2050, but major serious changes are expected by 2080.

There may be an increase in average temperatures of 2 to 5 degrees, which will result in a shift of the subtropical climate to the north. This means that the climate of northern Greece will be observed in southern Bulgaria, while that of South Bulgaria will be seen in northern Bulgaria. An increased frequency of extreme events like floods, droughts and windstorms is to be expected.

In terms of risk assessment for the occurrence of flooding, global practices (applicable here) find that the most serious floods occur once every 100 years. This estimate is based solely on surveys and organized collection of statistical data that have been carried out for just a little longer. This also means that the likelihood of such a great flood to happen is 1% per year.

2.3 Italian Flood Risk Assessment and Hazard Map

Italy is prone to natural hazards of many kinds including landslides, mudflows, avalanches, earthquakes, volcanic eruptions, floods, storms and storm surges, tsunami and land subsidence. Given the rugged, mountainous topography, landslide-prone geological setting, and the Mediterranean climate variability, the areas prone to significant flood and/or landslide risk exceed 29 500 km2 (9.8% of the Italian territory) and affect more than 6600 (82 %) municipalities
(MATTM, 2008) Fig. 2.3.1

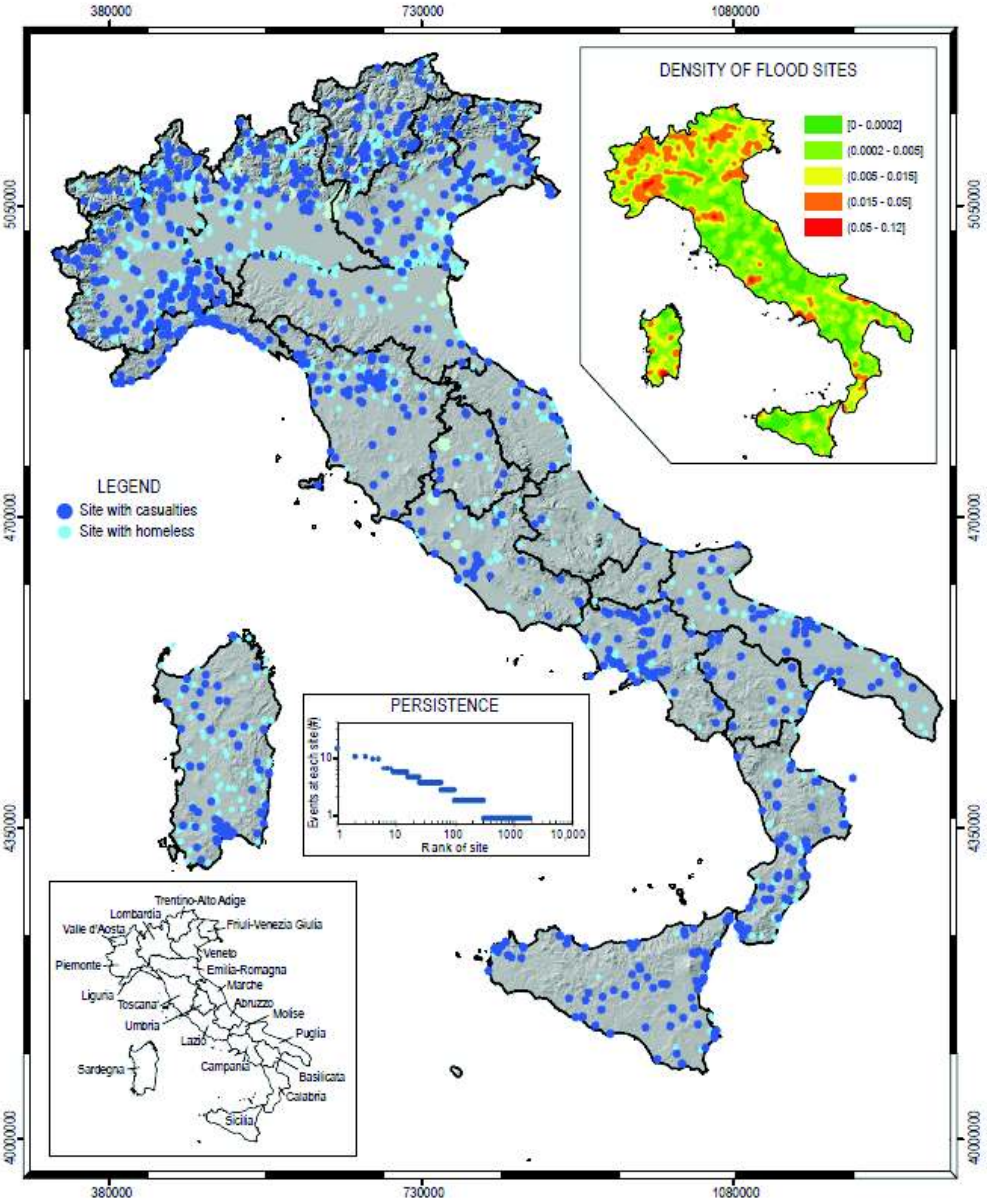


Figure 2.3.1 *Map showing the location of 1836 sites affected by flood events with direct consequences to the population of Italy, in the 1419-year period 590–2008. Map in the upper-right corner shows density of flood sites per square kilometre, in five classes. Plot in the central inset shows number of flood events at each site (y-axis) against rank (x-axis), in logarithmic coordinates. Map in the lower-left corner shows location of the 20 Italian Regions. (Salvati et al, 2010)*

In 6 out of 20 administrative regions, all (100 %) municipalities show a high exposure to landslides and floods either individually or in combination.

A recent study (Legambiente e Dipartimento della Protezione Civile, 2010) conducted on a subset (30 %) of the risk-prone municipalities found that it was common that dwellings or whole residential quarters were located in floodplains or areas exposed to landslides. Worse, in about onehalf of the sampled municipalities the hazard-prone areas contained industrial facilities, and in one-fifth of the cases hospitals, schools or other public facilities.

The study estimated that some 3.5 million people (6% of the Italian population) stay in the risk areas every day.

The population exposed to flood risk in Italy is equal to 1,905,898 inhabitants in the scenario of high hydraulic hazard P3 (return period between 20 and 50 years); to 5,842,751 inhabitants in the scenario hazard P2 (return period between 100 and 200 years old) and 8,641,815 inhabitants in the scenario hazard P1 (low probability of floods or extreme event scenarios). (ISPRA, 2015) Fig.2.2

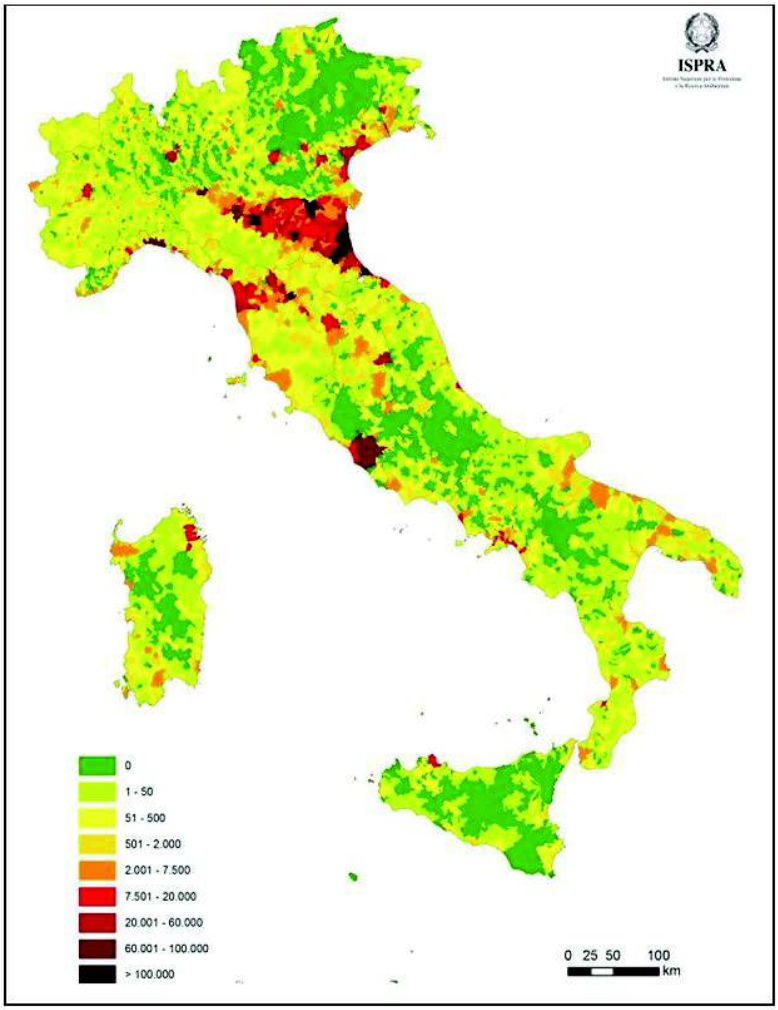


Figure 2.3.2 *The population exposed to flood risk in Italy in the scenario hazard P2 (Ispra 2006)*

In the ranking of the regions with the greatest geological risk, with 100 percent of the municipalities exhibited, we are on top of the Calabria, Molise, Basilicata, Umbria, Valle d'Aosta, in addition to the

province of Trento. Then Marche, Liguria 99%; Lazio, Tuscany at 98%; Abruzzo (96%), Emilia-Romagna (95%), Campania and Friuli Venezia Giulia to 92%, Piedmont (87%), Sardinia (81%), Puglia (78%), Sicily (71%), Lombardy (60 %), the province of Bolzano (59%), Veneto (56%). In 2013, the population living in areas of risk was most numerous in the northeast (1,629,473 people), followed by the South (1,623,947), the northwest (1,276,961), the center (1081596) and from the islands (90,794).

A systematic review of the significant hazard events (Salvati et al., 2010) recorded some 3139 landslide events and 2595 flood events in the period between 68 CE and 2008 that resulted in deaths, missing persons, injured people, and homelessness.

Italy's vulnerability to floods and other natural hazards is amplified by weak enforcement of building restrictions and low compliance with sound floodplain management principles.

Increasing population and concentration of wealth in floodprone areas, along with continuing practice of soil sealing at the current pace, will inevitably lead to higher flood losses.

Climate-change-induced alteration of rainfall patterns (form, intensity and timing of rainfall) is very likely to have significant effects on frequency and intensity of floods, if no appropriate risk mitigation measures are put in place. (Mysiak et al, 2013)

Landslide and flood hazards, and the associated risk, have been determined on various geographical scales in Italy, from the site-specific (local) to the synoptic (national) scale.

On the local scale, detailed investigations have produced zonations of landslide and flood hazards and risks ("Piani di Assetto Idrogeologico"), which are used to design defensive structures and to implement mitigation strategies.

On the synoptic scale, little is known regarding the public perception of the risk posed by landslides and floods in Italy. (Salvati et al 2010)

The causes:

For the Forest Service in recent years there has been an extraordinary increase of flood and landslide risk, especially in the south of Italy and especially in smaller regions. Among the causes which condition and amplify the "weather-hydrogeological and hydraulic risk" include "human action", with neglect and decay, overbuilding, deforestation and forest fires. But for the Forest Service, the real cause is certainly the lack of a serious maintenance that is increasingly based on 'urgent interventions ', often emergency, and not to promote a systematic prevention policy.

RISK ASSESSMENT IN LIGURIA

The Liguria Region of northern Italy is located to the south of the Alps and Apennines mountain ranges and covers an area of 5418 km2. Mean annual precipitation ranges from 750–1250 mm in the west to 1350–1850 mm in the central and eastern parts of the Region. Due to the geographical location and to the morphological and geological setting, landslides and floods are frequent in Liguria (Fig.2.3.3)

According to Italian archive of historical information on landslides and floods (http://sici.irpi.cnr.it), 1806 landslide events damaged 1233 localities, and 982 flooding events inundated 528 localities during the period 1800–2001 in the four Provinces of the Liguria Region. The historical information reveals that

damaging events are most frequent in the rainy season, i.e., during the period September through December, in all four Provinces. (Guzzetti et al, 2004)

The main reason of flood event in Liguria is the geographical and geomorphological setting: The coastline often presents very steep cliffs and is divided by the interland basin by a watershed placed very close to the shoreline. As a result, the coast is interrupted by several small valleys shaped by very steep streams.

The cold air that flows into the Atlantic from the Gulf of Lion meets the warmer waters of the Liguria Gulf, whereby the thermal contrast generates instability.

Climate changing induced an increase of rapid and extreme rainfalls events (Houghton et al., 1996; Hulme, 1996). It implies an increase of the geomorphological hazard as well as of the vulnerability of the human communities.

Figure 2.3.3 *Tipical Liguria region landscape (photo: A.Mandarino)*

2.4 Spanish Flood Risk Assessment and Hazard Map

INTRODUCTION

As in other European Union nations, flooding in Spain is a natural risk that has taken lives and caused costly property damage.

In Spain, flooding is the most common natural phenomenon, and nearly 30% of deaths caused by natural disasters are due to floods related to the Mediterranean climate. However, location, urban growth and prevention/control methods are also factors.

NO. OF DEATHS 1,056 (100%)	NATURAL DISASTERS
304 (28.8%)	Floods.
222 (21.0%)	Deaths on land resulting from rough seas.
183 (17.3%)	Storms, lightning and strong winds.
124 (11.7%)	Forest fires.
107 (10.1%)	Heat waves.
48 (4.5%)	Snow avalanches.
36 (3.4%)	Landslides.
23 (2.2%)	Snow and cold weather.
9 (0.9%)	Earthquakes.

Table 2.4.1 *Deaths caused by natural disasters, 1995-2012. (Data provided by the Home Office)* link link

The solutions implemented against the effects that cause floods and that have traditionally been addressed by building dams, canals and protective dykes have proved to be insufficient in certain cases. In recent decades, they have been combined with non-structural efforts, such as civil protection plans, alert systems, hydraulic-forest corrections of basins and land ordinance measures aimed at alleviating potential consequences. In many cases, and in line with the initial objectives, the economic costs and the environmental aggressions have been lower.

These approaches already appear in the Directive 2000/60/EC and in the Water Framework Directive (WFD), which states that water protection must help minimise the effects of flooding and drought. In turn, flooding is the specific development aim of the Directive 2007/60/EC on the assessment and management of flood risks, and it was transposed into Spanish legislation through the Royal Decree 903/2010.

The aim is to reduce the negative consequences of floods, specifically on human health and life, the environment, cultural heritage, economic activity and infrastructures. Initiatives include studies carried out by the central government for Preliminary Flood Risk Assessments (PFRA) and for identifying Areas with a Significant Risk for Potential Flooding (ASRPF).

Below is a work diagram for a Preliminary Flood Risk Assessment (PFRA), which has the aim of identifying areas where there is a significant risk of potential flooding.

Figure 2.4.1 *Preliminary Flood Risk Assessment (PFRA) link*

Managing flood risks is a responsibility that is shared by various agents and entities.

Figure 2.4.2 *Shared responsibility diagram. SANCHEZ MARTÍNEZ, F.J. (2015) link*

In Spain, the classification of potential risk areas by analysing past floods is shown in the following map.

Figure 2.4.3 *Potential risk, from the Instituto Geográfio Nacional (IGN, the National Geographic Institute)* *link*

There are also differences within and between Member States in terms of existing floods, risk assessments and flood hazards. Blue indicate where a preliminary flood risk assessment under the Floods Directive has been undertaken, leading to the identification of areas of potential significant flood risk in the corresponding river basins for the potentially significant sources of flooding. In green areas, existing flood risk assessments have been used to identify areas of potential significant flood risk for relevant sources of flooding. Finally, in red areas, it was decided to use existing flood hazard and flood risk maps without undertaking a preliminary flood risk assessment (as described in the Floods Directive), leading to the identification of areas of potential significant flood risk.

The highest number of historic flood events reported was by Spain (6,165) followed by Poland (4,860) and France (2,248).

RISK ANALYSIS

As mentioned earlier, in our legislation, the transposition of the Directive 2000/60/EC of the European Parliament and of the Council dated 23 October 2000, which establishes a framework for Community action in the field of water policy (known as the Water Framework Directive, WFD), was done with the Royal Decree 903/2010 of 9 July on the Assessment and Management of Flood Risks, to create the flood risk management plans by the end of 2015 by following the work diagram below in recent years.

Figure 2.4.5 *Work plan. SANCHEZ MARTÍNEZ, F.J. (2015) link*

At this time, by analysing the flood risk in Spain, it is possible to create a map that includes the regions defined as Areas with a Significant Risk for Potential Flooding (ASRPF) based on the preliminary flood risk assessment carried out by the corresponding authorities on water, coasts and civil protection.

ASRPFs are identified in the preliminary flood risk assessment that is prepared using registered data and long-term evolution studies, including the impact of climate change and taking into consideration existing land use, the existence of infrastructures and actions aimed at protecting against floods, and the information provided by the National System of Flood Zone Maps and the corresponding administrations.

As a result, the map available through the MAGRAMA SNCZI viewer includes:

- The classification of potential risk areas in accordance with the number of floods registered.
- The identification of populated areas that may be affected by flooding.
- The number of residents affected in the event of a flood.

This makes it possible to determine:

- The extent of the flood.
- Water depths or levels, as applicable.
- The speed of the corresponding water flow or current.

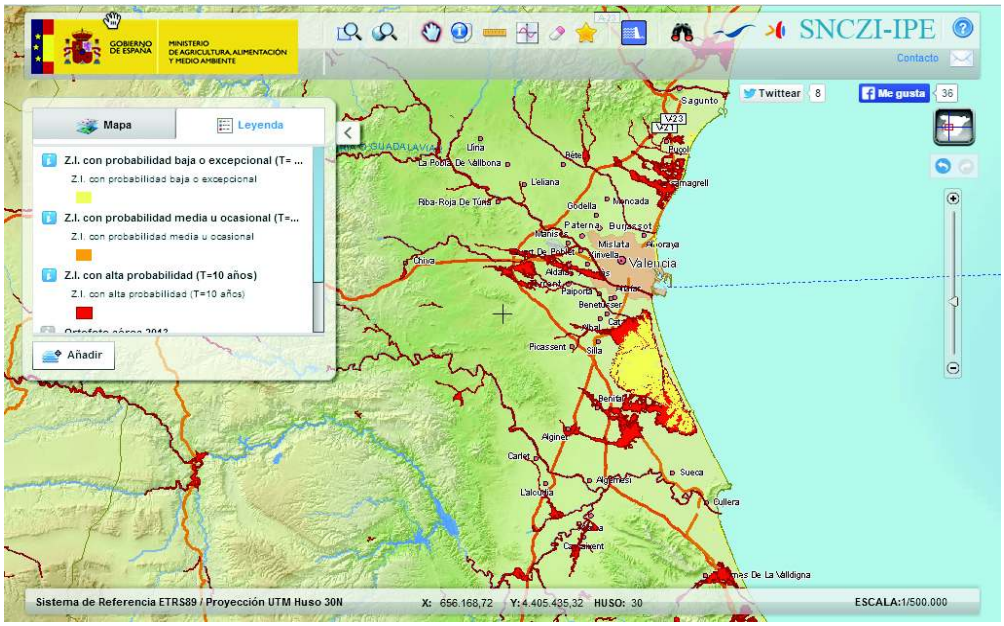


Figure 2.4.6 *Image of the Areas with a Significant Risk for Potential Flooding (ASRPF) viewer link*

The data analysed in the hazard maps for each Area with a Significant Risk for Potential Flooding (ASRPF) considers several scenarios:

- High probability: 10 years.
- Medium probability: 100 years.
- Low probability: 500 years.

In addition, we can extract from the preliminary risk assessment the number of areas and kilometres subject to flooding by Hydrographic Demarcation in accordance with the source of the risk (the type of waterway, sea water, underground water or rain water), as shown in the following table.

Demarcación	Fluvial		Fluvial / Marina		Marina		Fluvial / Pluvial		Fluvial / Aguas subterráneas		Pluvial		TOTALES	
	Longitud total (km)	Nº de ARPSIs	Longitud total (km)	Nº de ARPSIs	Longitud total (km)	Nº de ARPSIs	Longitud total (km)	Nº de ARPSIs	Longitud total (km)	Nº de ARPSIs	Longitud total (km)	Nº de ARPSIs	Longitud total (km)	Nº de ARPSIs
CANTÁBRICO OCCIDENTAL	544,48	85	211,65	11	74,83	14	-	-	-	-	-	-	830,96	110
CANTÁBRICO ORIENTAL	310,94	57	110,26	12	17,72	4	-	-	-	-	-	-	438,92	73
CEUTA	5,99	4	-	-	2,77	3	-	-	-	-	-	-	8,76	7
CUENCAS INTERNAS DE CATALUÑA	444,84	15	-	-	190,38	27	-	-	-	-	-	-	635,22	42
CUENCAS MEDITERRÁNEAS DE ANDALUCÍA	765,34	133	-	-	239,34	67	-	-	-	-	-	-	1.004,68	200
DUERO	422,59	26	-	-	-	-	-	-	-	-	-	-	422,59	26
EBRO	1.084,60	38	186,64	1	-	-	196,86	7	-	-	-	-	1.468,10	46
EL HIERRO	,82	1	-	-	4,70	6	-	-	-	-	-	-	5,52	7
FUERTEVENTURA	17,15	7	-	-	30,12	27	-	-	-	-	-	-	47,27	34
GALICIA-COSTA	544,19	168	-	-	188,50	42	-	-	-	-	-	-	732,69	210
GRAN CANARIA	18,57	6	-	-	64,91	41	-	-	-	-	-	-	83,48	47
GUADALETE Y BARBATE	179,84	19	-	-	114,93	19	-	-	-	-	103,71	6	398,48	44
GUADALQUIVIR	767,19	94	-	-	73,04	3	-	-	-	-	98,93	13	939,16	110
GUADIANA	840,56	39	16,72	1	13,72	3	-	-	-	-	-	-	871,00	43
ISLAS BALEARES	31,06	11	-	-	60,69	32	-	-	-	-	-	-	91,75	43
JÚCAR	257,69	19	567,05	10	140,01	28	-	-	-	-	-	-	964,75	57
LA GOMERA	9,15	3	-	-	5,54	4	-	-	-	-	-	-	14,69	7
LA PALMA	5,96	3	-	-	10,18	9	-	-	-	-	-	-	16,14	12
LANZAROTE	7,49	6	-	-	64,71	31	-	-	-	-	-	-	72,20	37
MELILLA	8,58	2	-	-	3,82	3	-	-	-	-	-	-	12,40	5
MIÑO-SIL	401,75	21	-	-	-	-	57,99	2	31,23	1	-	-	490,97	24
SEGURA	327,68	13	224,00	9	78,63	22	-	-	-	-	-	-	630,31	44
TAJO	539,40	33	-	-	-	-	-	-	-	-	-	-	539,40	33
TENERIFE	22,61	8	-	-	48,42	37	-	-	-	-	-	-	71,03	45
TINTO, ODIEL Y PIEDRAS	151,46	25	-	-	45,40	6	-	-	-	-	30,47	4	227,33	35
TOTAL	7.709,93	836	1.316,32	44	1.472,36	428	254,85	9	31,23	1	233,11	23	11.017,80	1341

Figure 2.4.7 *Preliminary risk assessment (number of areas and kilometres subject to flooding by Hydrographic Demarcation). SANCHEZ MARTÍNEZ, F.J. (2015) link*

The Community of Valencia is the region with the highest flood risk, and 12% of its population lives in areas that are subject to flooding. This affects 442 of the 542 municipalities in the Community.

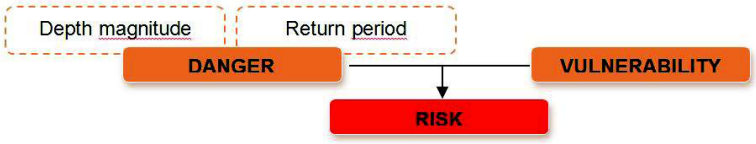


Figure 2.4.8 *Risk assessment diagram.*

For each probability scenario in Spain, important data is analysed to assess the degree to which a flood can affect a certain area. The frequency and the depth that a flood can reach estimate the hazard, which results in different risks for different areas, depending on the vulnerability in question.

This combination of factors determines where there is a significant flood risk with potential effects on human health, economic activity, the environment and cultural heritage.

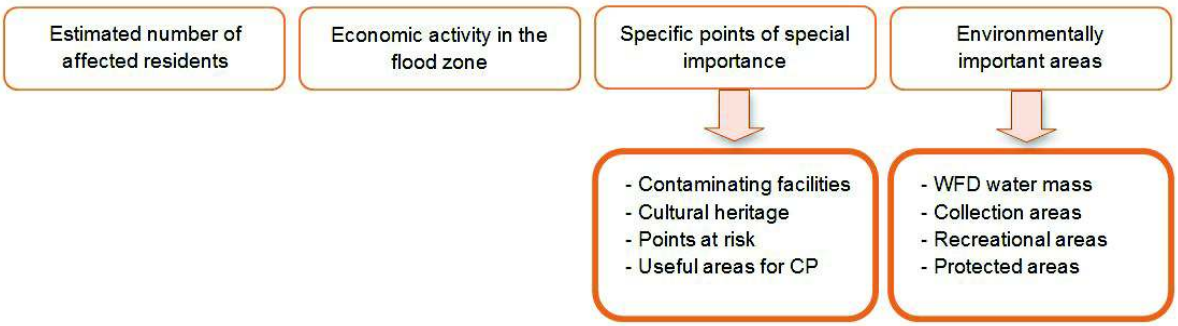


Figure 2.4.9 *Factors to be analysed for each probability scenario. (2015) link*

In the event of a flood warning, a procedure prepared by Spain's Civil Protection General Directorate is established to address flooding in accordance with the pre-established situations and phases, as shown in the final diagram that is attached. The following management principles adapted to flood risk must always be followed.

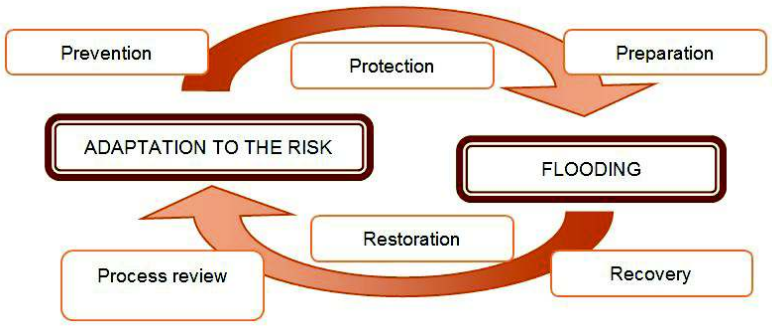


Figure 2.4.10 *Regional Action Plan for Flood Risk Prevention, CV - PATRICOVA link*

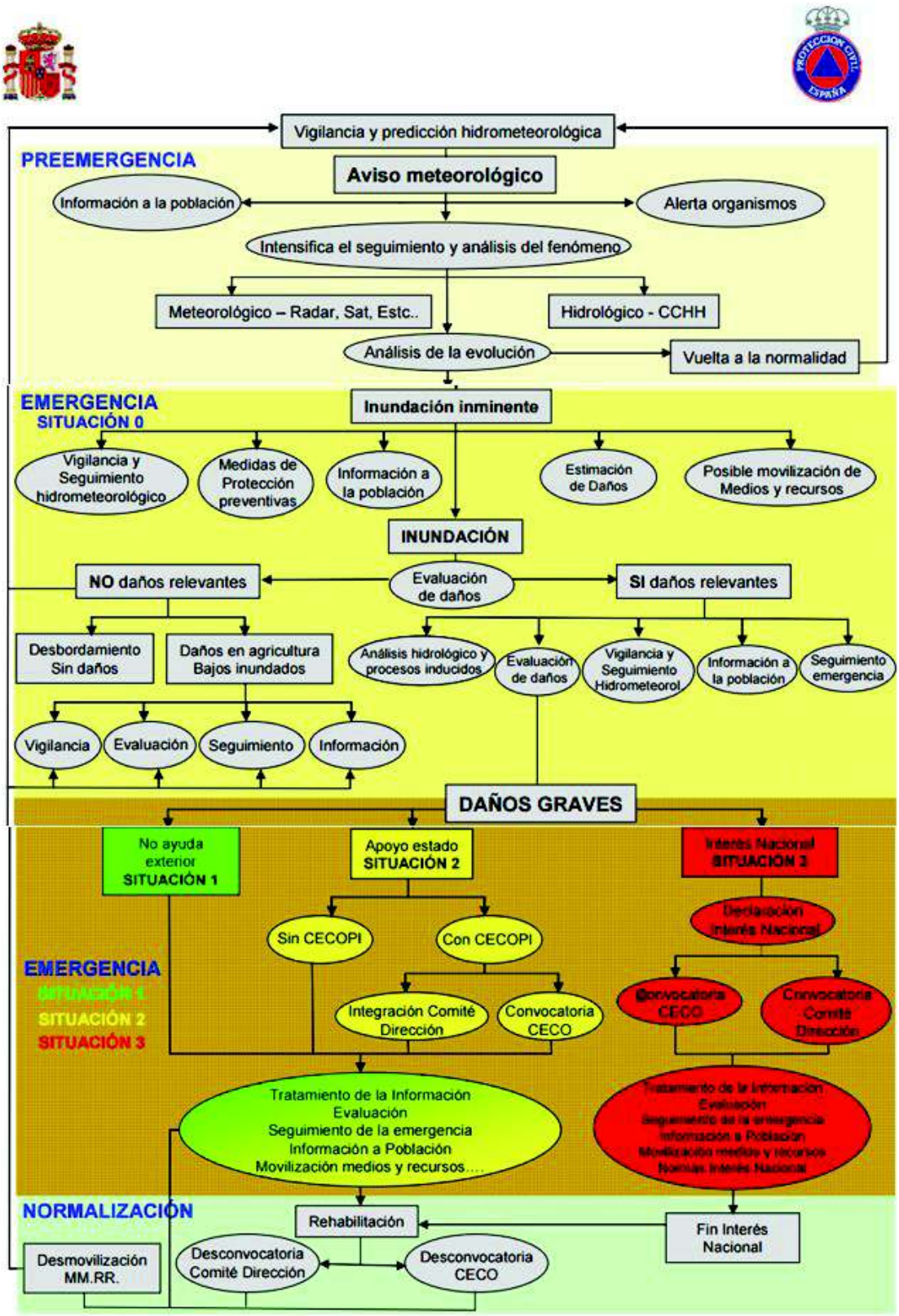


Figure 2.4.11 *Diagram of the National Civil Protection Plan for Floods link*

3. Prevention - Mitigation

'Prevention' comes from the Latin (praeventio) and means anticipating, warning. It is a term of criminal psychology, where it signifies the preliminary enforcement measures taken to prevent the commission of crimes and other offenses. From there it has been transferred into the concept of disaster protection, designating activities which aim to reduce the risk of disasters. In other words, preventive actions are those, trying to prevent disaster occurrence at all.

Priorities

1. Taking measures to reduce the loss of human life and health.
2. Measures for the preservation of cultural heritage
3. Measures to limit potential damage to the economy, including agricultural crops.
4. Measures to limit damage to the environment - water, forests and others.

Flood protection is continuous and operational. Continuous efforts largely cover preventive activities:

• construction and maintenance of dikes, repair and maintenance of rivers and gullies and other hydraulic and protective equipment;
• creation and maintenance of monitoring, forecasting and warning systems;
• regulation of ground water during times of dangerous increase or decrease;
• activities to protect water catchment areas from water erosion;
• maintaining the conductivity of river beds;
• construction and maintenance of strengthening and/or protective installations along river banks and beaches to protect from the impact of waves;
• measures to prevent and limit the damage caused by natural flooding, conducted in accordance with flood risk management plans, and liquidation of potentially dangerous dams, whose technical condition does not allow further exploitation.

The most important law reference in Europe about floods is the Directive 2007/60/EC of the European Parliament and of the council of 23 October 2007 on the assessment and management of flood risks.
It aims to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. To manage this risk Member States were given the choice to use either the River Basin Districts (RBDs) coming from the Water Framework Directive 2000/60/EC (WFD), or to designate others Units of Management (UoM). For the majority of RBDs Europe Member States used the same ones as for the WFD.
The second FD article defines a flood as "the temporary covering by water of land not normally covered by water" and so floods from "rivers, mountain torrents, Mediterranean ephemeral watercourses, and floods from the sea in coastal areas" are included and floods from sewerage systems may be excluded.
The path to implement FD is articulated into three steps; firstable, by 2011, Member states have had to identify areas where potential significant flood risk exists.
After by 2013 where this risk really exists flood hazard maps and flood risk maps for those areas where the risk exists flood hazard maps and flood risk map have been developed, identifying three levels of flood probability: low, medium and high. Finally, by 2015, competent authorities must compose flood risk management plans to list all measures to reduce the likelihood of flooding and its potential consequences.
Every six years a management cycle end and plans must be reviewed, in coordination and synchronization with the Water Framework Directive deadlines.
These plans are really important because they address all phases of the flood risk management cycle but focus particularly on prevention, protection and preparedness.

The 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy introduced the aforementioned “River Basin District”, i.e. “the area of land and sea, made up of one or more neighbouring river basins together with their associated ground waters and coastal waters, which is identified under article3(1)as the main unit for management of river basins”.

3.1 Emergency planning

The national planning represents the maximum level of planning and wants to define and to organize rescue actions for people to take on the worst calamitous events.

An Emergency Plan is the totality of operative procedures to follow when an event referred to a specific scenario happens.
The flood emergency management plan is a detailed document containing sub-plans that address, among other things, preparedness for and implementation of responsive activities to be taken depending on the severity of a flood. Its primary aim is to clearly identify the responsibilities and appropriate activities to be taken by stakeholders during an actual flood.

Generally Emergency plans are distinct for different kind of risk and limited to specific areas; they represent the shared, compatible and identified with reality project that are able to guarantee the realization of the maximum possible level of efficiency and efficacy in contrasting calamitous events, following standardized and clear procedures.
The main objective of an emergency plan is saving people, in particular acting to reduce to the minimum the time that is between the event and the firs rescue and interventions.
Emergency planning is in general organized in different levels: the main central authority, such as the Civil Protection Department defines the general criteria to prepare plans; the other authorities, in particular local authorities realize plans following its guidelines. In a plan there must be a general characterization of the area in which that plane produce effects, the list of extent risks with different scenarios, and for each of them the strategy of actions, the intervention models, the list of procedures, the responsibilities, the information and data exchange system.
During an event, following the requirement of plans, authorities must act the subsidiarity concept and so looking at the importance of the event it must be faced b the appropriate authority.
Local authorities have a key role in flood emergency management with respect to flood warning, provision of labour and equipment, evacuation, management of safe havens and assessing and addressing relief camp needs – these functions need to be worked out during the development of the flood emergency plan.
In planning and preparing for a flooding emergency, the government’s strategic objectives are to:
- protect human life and alleviate suffering; and, as far as possible, property and the environment;
- support the continuity of everyday activity and the restoration of disrupted services at the earliest opportunity; and
- uphold the rule of law and the democratic process.

The National Flood Emergency Framework is intended to focus on the first of these. In doing so, it covers the development, maintenance, testing and, where necessary, implementation of operational response arrangements that are:
- able to respond promptly to any changes in alert levels;

- developed on an integrated basis, combining local flexibility with national consistency and equity;
- capable of implementation in a flexible, phased, sustainable and proportionate way;
- based on the best available scientific evidence;
- based on existing services, systems and processes wherever possible, augmenting, adapting and complementing them as necessary to meet the unique challenges of a flood emergency;
- understood by, and acceptable to, emergency planners and responders;
- designed to promote the earliest possible return to normality.

Local flood emergency plans may detail:

- Nature of the flood threat
- Areas that could be affected by flooding
- Sources of flood intelligence (for example, fundamental data through constant monitoring of floods)
- Roles and responsibilities of listed agencies before, during and after flood episodes
- Control arrangements
- Trigger conditions for plan activation
- Liaison and communication arrangements
- Arrangements for public education, warning, the passage of information to flood-affected communities, road control, sandbagging, evacuation, re-supply, rescue, registration and welfare of evacuees, initial recovery and post-flood debriefing.

About the general characteristics, an emergency plane on floods must be detailed, simple and understandable, complete, updatable, digitized and simply popularized.

An Emergency plan can reach its objectives only if people are ready and aware of what is happening. This particular case is possible only if the competent authority gave instruction to population and for this reason it's very important that there are information activities and formation campaign.

3.2 Raising awareness

Floods are part of nature; they have existed and will continue to exist. This is the beginning of the "Best practices on flood prevention, protection and mitigation" document, a proposal document written in 2003 thinking to the future FD. In this case best practices are all sustainable measures and actions that must be carried out to prevent, to protect and to mitigate river flood effects.

According to European documents the main best practices are above listed:

1. Integrated river basin approach. A river or a flood isn't something that can be considered a punctual problem or resource (it depends), because of the nature of a water body that flows from mountains downstream, also for hundreds of kilometers. River basins are complex systems driven by many variables; managing floods, only having a catchment, holistic and integrated approach it's possible to carry out effective measures.
2. Public awareness, public participation and insurance. The awareness is really important, people who live or work in the potential flooded areas must know the risk and what they have to do in case of flood. For this reason regional and municipal authorities must act a public information action and they must involve people in the decision process about the implementation of measures; furthermore information must be easy and accessible to the public. Finally an important role can be played by insurances. They can better the awareness and reduce the financial risk for individuals; insurance is a powerful means of motivating the insured to take measures aimed at loss reduction, reducing the vulnerability of objects located in flood exposed areas.
3. Research, education and exchange of knowledge. This sector can't go on without research; different level authorities must support works aimed at flood management and integrated river basin analysis. Free databases must be create and works and knowledge must be exchanged without problems, working everybody for the risk reduction common objective.
4. Retention of water, land use and non structural measures. "*Every cubic meter of water not drained away immediately to the next body of water is a gain for the water regimen and it also takes away some of the burden in floods*". This is the key concept unlucky often forgotten; vegetation, soil ground and wetlands has got an important storage effect that is in able to reduce flood effects. Furthermore a river basin is an only system and so solidarity is essential; it's not possible to drain problems downstream from one part of the river basin to another. It's necessary to improve river basin land-use; on one hand forest population in the river basin need to be maintained and expanded and on the other land waterproofing and building development in risk areas must be stopped. About the zones near rivers measures aimed at conserving, protecting effectively and, where possible, restoring degraded wetlands and floodplans, must be carried out.
5. A sort of "space of freedom" must be guarantee to promote the river dynamics reactivation to alleviate flood impacts; wetlands, floodplains, oxbows and meanders must be protected by law. In this way there could be a strong change in river management: from construction of protective structures and obstacles to the natural flow of waterways to the restoration of natural forms and processes.
6. Structural measures and their impact. In the last decades to manage floods have been built many flood-control structures but "*Flood events of the recent past have shown the vulnerability of the flood protecting structures*". In fact flood protections like dykes, dams or walls are never absolute; they can reach only a certain level of protection, above that we can find the residual risk, i.e. that risk that isn't possible to remove. People must understand that structures aren't the best or the

general solution to contrast floods but that they are only measures that can be implemented in urban areas or in particular contests. Hydraulic structures often represent a false sense of safety; on the contrary people must know what could happen and what they have to do.

7. Early warning system and flood emergency management. Early warning system is a really important component of a flood management system; it's based on traditional and innovative measure instruments that can coexist with the common scope of give effective data to use to forecast floods. To have more information it's useful to consider historical information and experiences. Data must be collect to create an extended database working at least at the entire river basin scale. This must be easily consulted and uploaded by competent authorities. Research in this sector can be really helpful studying and developing the aptest models and instruments to forecast floods. Many professional figures are involved: meteorologists, hydrologists, hydraulicians, geologists and crisis managers must work together and create efficient forecasters teams. Another important stage in early warning system is the connection between forecasters and competent authorities and citizens. By using classical and new media instruments such as television, radio, internet, mobile phones, people can be advised about what's happening and what could happen.

A short reaction time must be carried out, in particular in urban areas and in case of flash floods.
The system runs only if citizens have been thought and they know what to do before, during and after the flood. Self protection measures and evacuating processes must be known. A broad information action and civil protection plans explanation is clearly essential for the operations success. Regular joint exercises should be involved to test both citizens and competent authorities preparedness and organization.
About the emergency management every action must agree with the integrated flood defense plans that are the main reference.
In case of major emergency a mutual assistance must be carried out and so riparian countries and also different Member States must work together and rescue flooded citizens.
On one hand they give information about citizens protection and rescue and on the other they list all flood fighting activities to control the spreading of water inundating the floodplain.
After floods it's necessary to valuate flood damages in order to ask for immediate needs and to restore what have been damaged.
Experts from different organizations arrive in flooded areas and produce a status report including recommendations form improvements and usually a proposal for short and midterm action.
Prevention of pollution. Floods can cause severe pollution episodes with considerable environmental and health consequences; the disruption of water distribution and sewage systems and water and soil pollution caused by water run-off diffusion of substances are the most critical aspects. Preventive measures should be taken to reduce negative effects of foods on ecosystems: it' necessary to minimize pollution from water surface runoff and minimize the amount of water surface runoff and infiltration entering in sewerage system; hazardous substances in flood-prone areas must be stocked upstairs or outside those areas. Emergency management plans must consider these aspects and this kind of problem and specifying all measures to carry out to avoid pollution episodes.
When developing an awareness campaign, many things have to be taken into consideration. The attitude towards private flood preparedness depends on perceived risk and self efficacy. As different people have different interests, attitudes, behavior, and different perceptions, it is important that there is a clear understanding of the target audience's needs, wants, perceptions, and present patterns.
When raising a flood awareness message it is vital to notify the individuals of the risks whilst also supplying solutions on how best to prepare their homes and businesses against the risk of flood damage. Using various awareness strategies increases the impact of a campaign. The use of multiple activities will reach

further to the target audience. Different awareness techniques will be suitable for different demographics and multiple messages will create more impact as they are reinforced by one another.
If we want people to become more self-reliant in case of flooding we need to understand the need of people to receive information. What we want to accomplish with awareness campaigns is to have people who are living in flood risk areas on the 'maintenance' level. They know it can happen, they know what this means and they have a plan to deal with it.
Based on different studies, it's possible to give a framework on which the development of a social marketing programme, comprising several campaigns to raise awareness and self-efficacy, can be based.

This framework comprises of five steps who need to be taken in account:
Step 1: identifying the level of awareness;
Step 2: Finding out the needs of the target group(s);
Step 3: Finding out the best way of distributing information;
Step 4: Starting the campaign
Step 5 Evaluate and moving on.

The key to reducing loss of life, personal injuries, and damage from natural disasters is widespread public awareness and education. People must be made aware of what natural hazards they are likely to face in their own communities. They should know in advance what specific preparations to make before an event, what to do during an earthquake, flood, fire, or other likely event, and what actions to take in its aftermath.

Flood emergency preparedness activities at various levels

Individual, family and household level (fig. 3.1)

- Know the risks: drowning, waterborne diseases, electrocution, poisonous animals
- Install protective railings around house to protect children from falling into the water and to provide support for the elderly
- Scout for safe areas and know how to get there
- Know what to do when a warning is received
- Know whom to contact in case of emergency
- Keep life jackets or buoys or tires ready for use
- Keep first aid kits ready for use
- Store clean water and food in a safe place
- Listen to daily flood forecasts
- Move valuable items to higher ground
- Get ready for evacuation
- Protect livestock

Figure 3.1 *A family preparing a flood emergency preparedness kit (www.fema.gov)*

Community or village level (Fig. 3.2)

- Identify and maintain safe havens, safe areas and temporary shelters
- Put up signs on routes or alternate routes leading to safe shelters
- Inform the public of the location of safe areas and the shortest routes leading to them
- Have all important contacts ready: district or provincial and national emergency lines; and have a focal point in the village
- Make arrangements for the set-up of teams in charge of health issues, damage and needs assessment
- Set up community volunteer teams for a 24-hour flood watch Improve or keep communication channels open to disseminate warnings
- Distribute information throughout the community
- Organize training seminars for teachers, volunteers or engineers on flood protection issues.
- Implement lectures for civil protection personnel, volunteers, students, business staff, people with disabilities, employees in hotels e.tc.
- Compose informative material (booklets, posters, books, CD-ROM, website, advertising TV messages) for different target groups (students, teachers, general public, tourists)
- Participate in preparedness drills in schools and working places.

Figure 3.2 *A training moment in a local school on flood protection (photo: Beigua Geopark)*

Municipality, district, province and national levels fig. 3.3

- Determine roles and responsibilities of each agency during response, relief and recovery phases
- Prepare maps (flood risk/inundation/vulnerability maps, resource maps) to provide essential information and data on current situation and to plan for assistance in those areas
- Make sure that critical roads are built up to a certain height – to create safe areas for flood affected communities and to ensure continuous transportation critical for flood relief
- Identify new safe areas and maintain existing shelters, making sure they have sanitary and other basic necessities

- Implement public awareness activities to create a pro-active and prepared society, which can cope effectively with hazards and their aftermath
- Educate the public on what to do and what not to do to prevent harmful activities in the floodplain
- Organize training seminars for teachers, volunteers or engineers on flood protection issues.
- Implement lectures for civil protection personnel, volunteers, students, business staff, people with disabilities, employees in hotels e.tc.
- Compose informative material (booklets, posters, books, CD-ROM, website, advertising TV messages) for different target groups (students, teachers, general public, tourists).
- Educate the public on environmental management, water resource use and land-use planning Stockpile relief goods
- Prepare resource inventories – how much is available locally and how much is needed from the outside
- Plan resource mobilization
- Set up emergency teams (for example, health, search and rescue teams)
- Plan to assist in emergency response at the local level – Conduct drills for search and rescue teams
- Make sure that communication channels to the community are functioning well
- Issue orders for various agencies and organizations to get prepared
- Inspect flood mitigation infrastructure (for example, dykes, levees and floodwalls)
- Disseminate public safety information through the establishment of early warning systems
- Specify the source and actions to be taken immediately after receiving warnings.

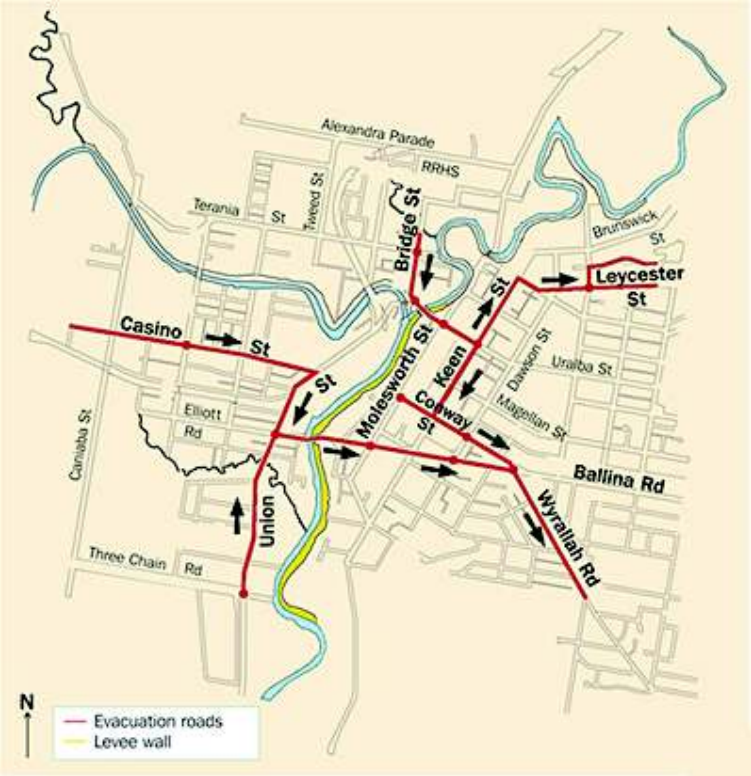


Figure 3.3 *Example of evacuation road map during a flood in a municipality (http://www.lismore.nsw.gov.au/)*

4. Preparedness

General Introduction

Risk is a function of the hazards to which a community is exposed and the vulnerabilities of that community. However, that risk is modified by the level of the local preparedness of the community at risk Risk Reduction involves measures designed either to prevent hazards from creating risks or to lessen the distribution, intensity or severity of hazards. These measures include flood mitigation works and appropriate land-use planning. They also include vulnerability reduction measures such as awareness raising, improving community health security, and relocation or protection of vulnerable populations or structures.

Emergency preparedness is a programme of long-term activities whose goals are to strengthen the overall capacity and capability of a country or a community to manage efficiently all types of emergencies and bring about an orderly transition from relief through recovery, and back to sustained development. It requires that emergency plans be developed, personnel at all levels and in all sectors be trained, and communities at risk be educated, and that these measures be monitored and evaluated regularly.

Preparedness is essential in securing the right to life with dignity. States bear the primary responsibility for protecting their populations and ensuring a dignified life but the modern approach to preparedness extends well beyond those traditionally involved in relief efforts, such as civil protection forces, emergency offices and humanitarian organizations. Communities need to work closely with local authorities, public organizations and the relevant section of the private sector, in order to strengthen their own capacities to prepare for and manage the consequences of various risks.

The health impact of emergencies and crises can be substantially reduced if both national and local authorities and communities in high-risk areas are well prepared and are able to reduce the level of their vulnerabilities and the health implications of their risks. International initiatives by the humanitarian community are geared increasingly towards supporting this objective. The challenge is to put in place systematic capacities such as legislation, plans, coordination mechanisms and procedures, institutional capacities and budgets, skilled personnel, information, and public awareness and participation that can measurably reduce future risks and losses.

(World Health Organization, 2007)

4.1 Protective guidelines before, during and after the phenomenon

Before the flood

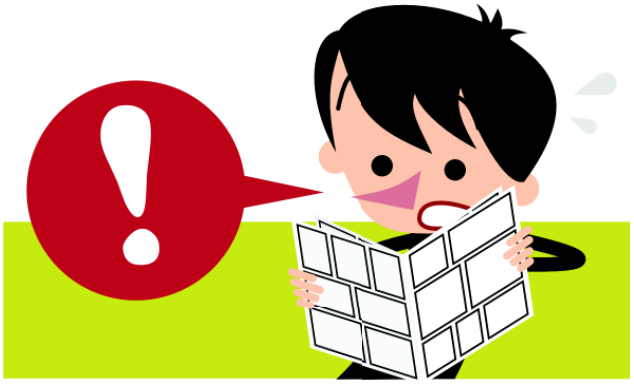


Figure 4.1 *Before the flood it's important the knolwedge of the territory*

Know if the area you live/ work reside in flood risk helps to prevent and better deal with emergency situations. Fig.4.1

Remember:

- It is important to know what are the typical flood of your territory
- If there were floods in the past, it is likely that there will be in the future
- In some cases it is difficult to accurately where and when flooding will occur and you may not be alerted in time
- Water can rise suddenly, even one or two meters in minutes
- Some places flooded before others. At home, the most dangerous areas are the cellars, basements and ground floors;
- Outdoors, are more at risk underpasses, traits close to the banks and bridges, roads with steep slopes and in general all the lower areas than in the surrounding area
- The power of water can also damage buildings and infrastructure (bridges, embankments, dikes) and the most vulnerable could yield or collapse suddenly

You, too, with simple actions, you can help reduce the risk of flooding.

- Please respect the environment and see if bulky waste abandoned, clogged drains, waterways etc. partially clogged. report it to the City.
- Ask your municipality about the emergency plan to know which areas are dangerous, escape routes and safe areas of your city: if there is not, you pretend to be prepared, so that you know how to behave.
- Find tools that the City and the region use to send out the alert and keep constantly informed.
- Make sure that the school or the workplace receive the alerts and have a contingency plan for flood risk.
- If in your family there are people who need special care that occurs in the municipal emergency plan are provided for specific measures.

- Avoid store valuables in the cellar or basement.
- Make sure that in case of need is easy to quickly reach the upper floors of your building.
- Keep copies of documents in the house, a first aid kit, a flashlight, a battery-operated radio and make sure that everyone knows where they are.

What to do - During the Flood

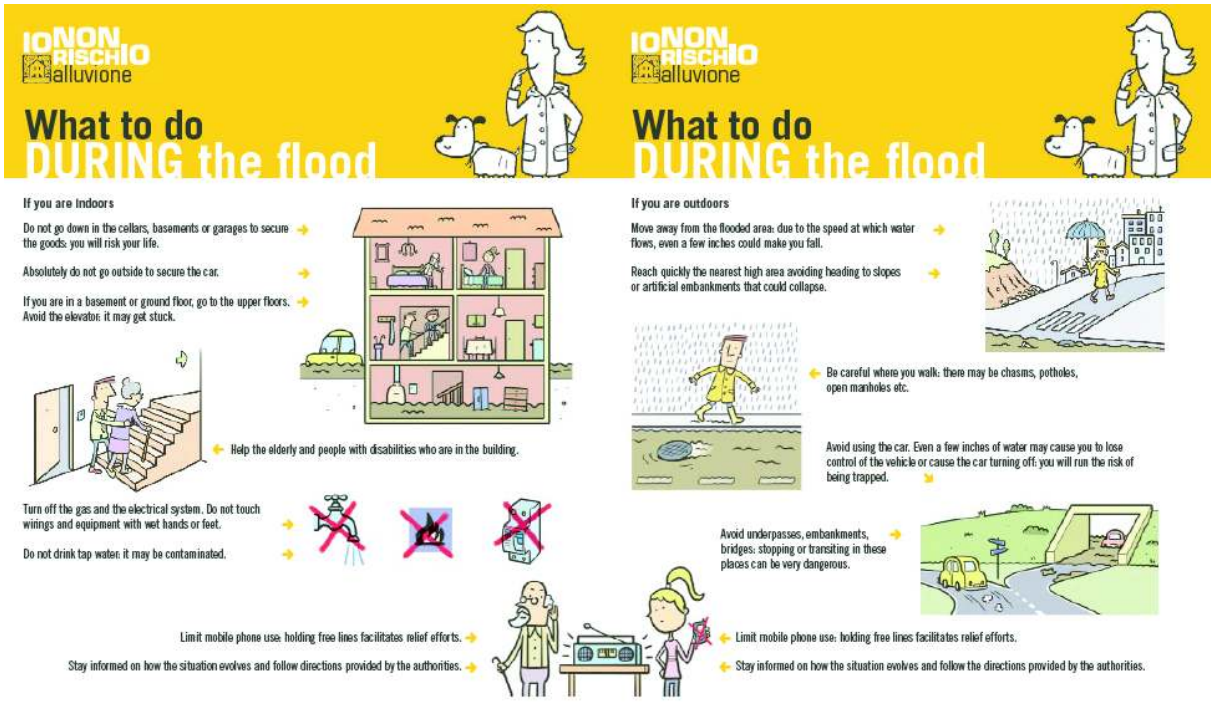


Figure 4.2 *What to do during the flood. (www.iononrischio.protezionecivile.it)*

- Stay informed about critical issues in the area provided and the measures adopted by your municipality.
- Do not sleep in basements and avoid staying there.
- Protect with bulkheads or sandbags locals who are on the street level and close the doors of cellars, basements or garage only if you do not expose yourself to danger.
- If you have to move, first evaluates the path and avoids areas floodable.
- Currency well if to secure the car or other property: it can be dangerous.
- Share what you know on the lookout and on correct behaviour.
- Check that your child's school is informed of the alert in progress and is ready to activate the emergency plan.

<u>If you are in an enclosed:</u>

- Do not go down into cellars, basements or garages to secure assets: risk your life.
- Do not go out completely to secure the car.
- If you are in a basement or ground floor, go up to the upper floors. Avoid the elevator: you can block. It helps seniors and people with disabilities who are in the building.

- Close the gas and turn off the electrical system. Do not touch equipment and electrical appliances with wet hands or feet. Do not drink tap water: it may be contaminated
- Restrict the use of the phone: hold free lines facilitate relief efforts.
- Stay informed about how the situation evolves and follow the instructions given by the authorities

If you are outdoors:

- Step away from the flooded area: the rate at which water flows, even a few centimeters could make you fall.
- Reach quickly the area close higher by not to head to the slopes or artificial embankments that could collapse.
- Be careful where you walk: there may be potholes, potholes, open manholes etc.
- Avoid using the car. Even a few centimeters of water could make you lose control of the vehicle or cause shut down: Risk of being trapped.
- Avoid underpasses, embankments, bridges halt or transit in this area can be very dangerous.
- Restrict the use of the phone: hold free lines facilitate relief efforts.
- Stay informed about how the situation evolves and follow the instructions given by the authorities.

What to do - After the flood

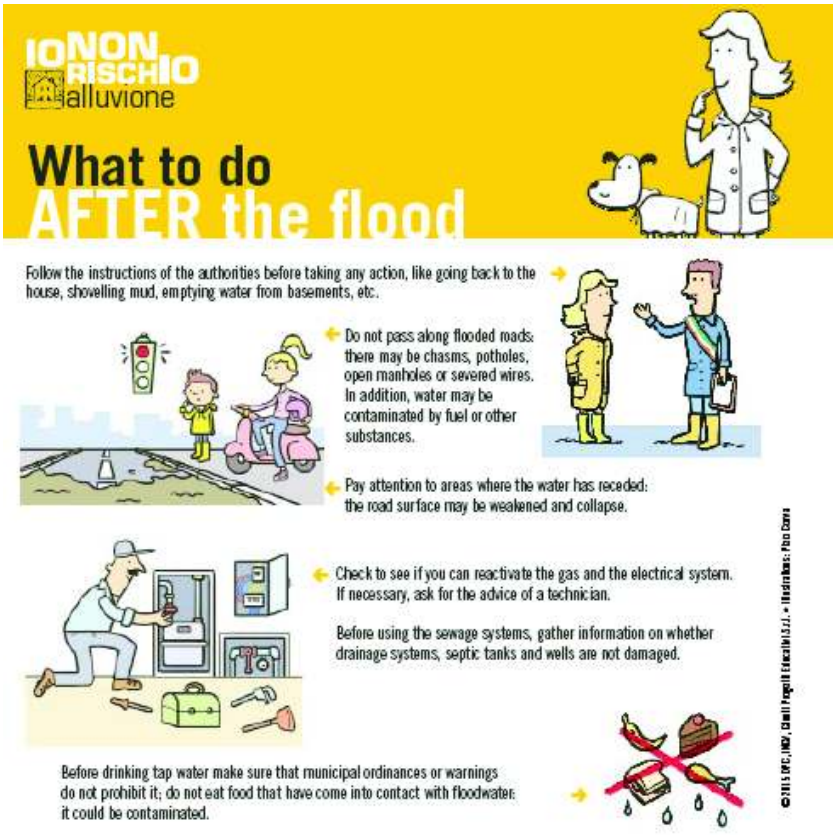


Figure 4.3 *What to do after the flood (www.iononrischio.protezionecivile.it)*

- Follow the instructions of the authorities before taking any action, like back in the house, shoveling mud, empty water from the cellars etc.
- Do not pass along flooded roads: there may be potholes, potholes, open manholes or electrical wires sheared. Also, the water may be contaminated by fuel or other substances.
- Pay attention to areas where the water has receded: the road surface may be weakened and give in.
- See if you can wake up the gas and the electrical system. If necessary, ask the opinion of an expert.
- Before using the exhaust systems, informed that collecting systems, septic tanks and wells are not damaged.
- Before drinking tap water make sure municipal ordinances or warnings is not prohibited; do not eat foods that have come into contact with floodwater: could be contaminated.

4.2 Guidelines for family emergency planning

After getting flood insurance, there are several things ton do to minimize losses in your home and ensure your family's safety.

Safeguard your possessions

Create a personal flood file containing information about all your possessions and keep it in a secure place, such as a safe deposit box or waterproof container. This file should have:

- A copy of your insurance policies with your agents contact information.
- **A household inventory:** For insurance purposes, be sure to keep a written and visual (i.e., videotaped or photographed) record of all major household items and valuables, even those stored in basements, attics or garages. Create files that include serial numbers and store receipts for major appliances and electronics. Have jewellery and artwork appraised. These documents are critically important when filing insurance claims.
- Copies of all other critical documents, including finance records or receipts of major purchases.

Prepare your house

- First make sure your sump pump is working and then install a battery-operated backup, in case of a power failure. Installing a water alarm will also let you know if water is accumulating in your basement.
- Clear debris from gutters and downspouts.
- Anchor any fuel tanks.
- Raise your electrical components (switches, sockets, circuit breakers, and wiring) at least 12 inches above your home's projected flood elevation.
- Place the furnace, water heater, washer, and dryer on cement blocks at least 12 inches above the projected flood elevation.
- Move furniture, valuables, and important documents to a safe place.

Develop a family emergency plan

- Create a safety kit with drinking water, canned food, first aid, blankets, a radio, and a flashlight.
- Post emergency telephone numbers by the phone and teach your children how to dial 911.
- Plan and practice a flood evacuation route with your family. Know safe routes from home, work, and school that are on higher ground.

- Ask an out-of-state relative or friend to be your emergency family contact.
- Have a plan to protect your pets.

Here's what do to stay safe during a flood:

- If flooding occurs, go to higher ground and avoid areas subject to flooding.
- Do not attempt to walk across flowing streams or drive through flooded roadways.
- If water rises in your home before you evacuate, go to the top floor, attic, or roof.
- Listen to a battery-operated radio for the latest storm information.
- Turn off all utilities at the main power switch and close the main gas valve if advised to do so.
- If you've come in contact with floodwaters, wash your hands with soap and disinfected water.

As soon as floodwater levels have dropped, it's time to start the recovery process. Here's what you can do to begin restoring your home.

- If your home has suffered damage, call your insurance agent to file a claim.
- Check for structural damage before re-entering your home to avoid being trapped in a building collapse.
- Take photos of any floodwater in your home and save any damaged personal property.
- Make a list of damaged or lost items and include their purchase date and value with receipts, and place with the inventory you took prior to the flood. Some damaged items may require disposal, so keep photographs of these items.
- Keep power off until an electrician has inspected your system for safety.
- Boil water for drinking and food preparation until authorities tell you that your water supply is safe.
- Prevent mold by removing wet contents immediately.
- Wear gloves and boots to clean and disinfect. Wet items should be cleaned with a pine-oil cleanser and bleach, completely dried, and monitored for several days.
-

Figure 4.4 *Some ideas to develop an emergency plan in a family*

4.3 Guidelines for Emergency Planning at schools, work places etc

School preparedness requires the participation of Directors, teachers, students, and parents, as well as those who design, build, regulate, and maintain school buildings in order to deal with a flood event.

Before the flood

Each school /director is responsible to:

- Prepare students and school staff to react safely.
- Know if the school / work area reside in flood risk helps to prevent and better deal with emergency situations
- Remember: It is important to know what are the typical flood of your territory
  If there were floods in the past, it is likely that there will be in the future
  In some cases it is difficult to accurately where and when flooding will occur and you may not be alerted in time
- Develop and update of School Flood Risk Emergency Plan. To be operational, this Plan should be clear and straightforward and should contain description of procedures and actions to be taken before, during and after a flood event.

During the flood

Stay informed about critical issues in the area provided and the measures adopted by your municipality.
If indoors, the students and teachers should:

- Remain calm, do not run and stay inside
- Do not go down into cellars, basements or garages to secure assets: risk your life.
  - Do not go out completely to secure the car.
- If you are in a basement or ground floor, go up to the upper floors. Avoid the elevator: you can block. It helps seniors and people with disabilities who are in the building.
- Close the gas and turn off the electrical system. Do not touch equipment and electrical appliances with wet hands or feet. Do not drink tap water: it may be contaminated
- Restrict the use of the phone: hold free lines facilitate relief efforts.
- Stay informed about how the situation evolves and follow the instructions given by the authorities.

After the flood

- Follow the instructions of the authorities before taking any action, like back in the house, shoveling mud, empty water from the cellars etc.
- Do not pass along flooded roads: there may be potholes, potholes, open manholes or electrical wires sheared. Also, the water may be contaminated by fuel or other substances.
- Pay attention to areas where the water has receded: the road surface may be weakened and give in.

5. Response

5.1 First response actions

Quick and appropriate response is crucial in the event of flooding. They can occur suddenly and unexpectedly or be the result of bad coincidence that gradually leads to flooding. Besides good preparation, very often the first few minutes are crucial, as well as good coordination between different institutions. Emergency duty teams of medical services, fire and police have the capacity to respond to individual incidents. Since a disaster happens on a much larger scale, the reaction has to be a lot more serious. Institutions involved in disaster response act in accordance with pre-established plans, where responsibilities are clearly divided.

The specifics of flood disasters make them relatively easy to predict, as they can be foreseen for a period of several hours to several days.

The reaction in case of flooding is divided into the following categories:

Activities when in imminent danger of flooding:

- Monitoring of water levels and the condition of hydraulic structures.
- Emergency dredging of water-drainage channels (on municipal property terrains).
- Alleviating the backing up of water currents.
- Upgrading of existing dikes and/or construction of temporary dikes; stacking up sacks with inert materials. etc.
- Evacuation of sources of ionizing radiation and biological contamination within the floodplain.
- Establishment of camps for temporary housing.
- Checking the floodplains for the presence of humans, animals, material and cultural valuables.
- Performing inspections of the state of critical infrastructure.
- Detecting people in distress.
- Evacuation of people and animals of floodplains; removal of material and cultural valuables.
- Preparation of buildings for temporary accommodation.
- Other activities, depending on the current situation.

Actions during the flood itself:

- Inspection of the floodplains and places, where it is possible to find endangered people, animals and cultural valuables, using helicopters, drones and other equipment.
- Inspection of the state of the roads and approaches, leading into to the flood area.
- Detection of people caught in emergency situations.
- Rescue of humans, animals and portable cultural values from the flooded areas.
- Monitoring of water levels and the condition of hydraulic structures.
- Emergency repairs or interventions on elements of hydraulic structures (including: opening or closing the outlets; deepening of spillways, alleviating the pressurization of watercourses; digging water-drainage channels; coordination and participation in upgrade of existing dikes and building temporary dikes)
- Stacking up sacks or piles of inert materials.

- Evacuating poisonous industrial substances, ionizing radiation sources, potential sources of biological contamination within the floodplain, which would cause damage to people or pollution.
- Establishment of tent camps for temporary accommodation for endangered population.

Actions after the flood:

- Search and rescue operations
- Removing bodies of drowned/deceased people and animals from the rivers and floodplains.
- Draining the water from buildings and other infrastructure.
- Clearing of affected roads of debris.
- Exterminating rats in residential and green areas

In rare cases of sporadic sudden occurrence of flooding, response should be rapid and adequate. Upon receiving the signal for disaster occurrence from 112 (or otherwise) the following steps should be implemented without delay:

Warning of the population in the affected area - this process is facilitated by established early warning systems for disasters through sound signals and voice commands.

Announcement to employees of all the constituents of URS - all departments, voluntary formations and others. This could be done electronically - via automated voice calls (by entering a personal code), so that information and instructions for action can reach many people relatively quickly. It can also be done via other media - a radio link, phone calls, etc., depending on the degree of technological development and readiness to respond to flooding by local authorities.

These two procedures make it possible to quickly inform the population about what is happening and the measures to be taken by each individual, on one hand, and to mobilize the necessary resources to respond to arising or imminent flooding, on the other. In case of an incoming high wave or rising waters, following those procedures is often life-saving, because they provide the population with valuable time to leave endangered areas, or at least to occupy the highest accessible parts of buildings. To facilitate and shorten the response time, 112 emergency centers electronically distribute disaster signals simultaneously to all institutions that are pre-prepared for reaction.

According to the action plans in the event of flooding (depending on its size) local, regional or national headquarters for coordination are summoned. They are usually composed of the heads of all departments bearing responsibilities in the management of floods, or included in the response plan, as well as other experts. Headquarters are chaired respectively by the mayor, the governor or the prime minister, or any other authorized official, exceptionally. Immediately after its formation the headquarters take over leadership of the emergency. Special protected frequencies are used for communication. If needed, national and private radio, television and electronic networks are used without exception.

After mobilization of resources and distribution of warnings to the population, the headquarters take over coordination and organization of activities for managing and mitigating the flood - before, during and after the events.

Emergency response is an exclusive task of the local authorities. Individual municipalities, districts and other local government units must maintain a continuous supply of remedies, water, food, blankets and more. Each municipality is required to maintain such an emergency reserve sufficient for its population. Affected individuals must be provided with essentials as soon as possible.

For greater security and actual availability of necessary funds, it is good to dispose over and have access to national emergency stocks. Individual departments such as the army, the Red Cross and others can also keep stock to be made available to the public. By order of the chief of headquarters additional resources can be demanded from all institutions, individuals and legal personas who are obliged to provide unquestioningly.

5.2 Post assessment of buildings and infrastructure

Assessment of damage to buildings and other infrastructure is usually carried out by expert committees, formed by specialists, engineers and others from different institutions. Prioritization of assessment and restoration of buildings and sites should happen in the following sequence:

- Restoration of critical transport infrastructure - roads and their unique facilities;
- Sites and infrastructure, defining the vital activity of the municipality and providing essential goods;
- Communal energy networks;
- Sites of health care and education;
- Residential and commercial buildings.

Following a major flood assistance and recovery is required. This includes the provision of emergency and rehabilitation assistance to victims and carrying out urgent reconstruction work. Emergency recovery activities are organized by the executive authorities in accordance with their functions. Usually special committees are formed, which have the following responsibilities:

- To carry out inspection and assessment of damage to engineering, transport and housing infrastructure
- To prepare a list of all objects in order of priority.
- To advise on the preparation of technical projects for the restoration of the sites.
- To give a proposal for the funds, necessary for their rehabilitation or construction.
- To organize the contract award procedure.
- To keep track of construction/rehabilitation works and grant approval.
- To allow the population and/or owners back into the buildings (in case they are in good condition or the damage has been removed).

5.3 Temporary shelters

Temporary housing is provided in case of:

- dam rupture;
- high waters within the river bed;
- increasing water levels with long heavy rainfall;
- forced release of dams;
- increased risk of flooding due to the formation of a "high wave" from the outflow of gullies and others;
- endangering collapse of residential and commercial buildings due to flooding;
- structural damage;
- secondary consequences such as landslides and erosion, threatening the health and lives of people living in the area.

Evacuation of schools and childcare facilities in case of flooding of the territory is carried out during working hours. During the rest of the day students and children leave the area with their parents, with their personal transport or buses for transportation of the population.
If it is impossible to leave the endangered territory, people use the upper floors or roofs of houses, from where they will be evacuated later.
Temporary evacuation is carried out with decision of the municipality's mayor, who is chief of headquarters. Subject to evacuation are:

- schools and childcare facilities;
- population within floodplains;
- district administration.

Subject to removal are:

- valuable historical and archival documents, exhibits from museums and exhibitions;
- medicines, medical and sanitary materials, medical equipment and electrical equipment;
- foods and industrial goods of first necessity;
- spare parts, explosives, fuel and lubricants, raw materials and finished goods (if necessary).

Material resources are transported after removal of the population from the region, or at the same time in the case of vehicles.
Evacuation of the population from the region is carried out by territorial principle (neighbourhoods, settlements etc.) The temporary removal is done on foot, by car or both. This is determined by the necessary reaction time and options for secure transportation.
Children from kindergartens, childcare facilities and students up to 4^{th} grade, as well as mothers with small children up to 7 years old, sick and elderly people, who cannot travel by foot for a long time, are evacuated with vehicles.
Students between 5^{th} and 12^{th} grade and individuals, who do not dispose of personal or corporate transportation, are evacuated by foot.
The following need to be determined for organized evacuation:

- evacuation assembly points – in residential areas, school yards and childcare facilities or close by;
- interim evacuation points – alongside evacuation routes, where people traveling on foot are loaded onto returning empty vehicles (if there are such) and are transported to the temporary housing facilities;

- export freight stations – those are determined when there is a need to move material and cultural valuables;
- accommodation facilities for temporary housing of students, children and the general population.

Evacuation routes are determined by the mayors and deputy mayors. The goal is to occupy high areas. After scouting the flooded area and obtaining reliable information, the chief of headquarters announces the evacuation route on the spot.

5.4 Financial aid and other benefits

Financial aid for reconstruction of affected buildings can be granted in form of one-time extraordinary payments from the municipal budget by decision of the local authorities

Mainly, financial assistance comes from the republican budget for emergency situations, and is granted under certain conditions. Right to recovery assistance for sites affected by disaster have the owners of legally built housing, that is their only property. Recovery assistance is provided by the mayor for the purchase of building materials for the performance of construction services or for assistance in a manner that is proposed by the municipal Committee. The support provided for each object is determined depending on the damage suffered, and in amount, providing for the minimum necessary living conditions of individuals. Assistance for current cosmetic repairs is not granted. Recipients of recovery assistance shall use the aid only for the purpose for which it was provided – restoration of single legally built house/apartment. In an established case of misuse of the aid for purposes for which it was not provided, the recipients owe the amount in full.

The Committee, which manages and manages and supervises the provision of targeted funds from the state budget is composed of local, regional or national officials. It deals with:

- Funding of preventive activities for flood protection;
- Payment of unforeseen expenses for rescue and emergency work, carried out by forces and means of disaster operation centers of the URS;
- Funding of urgent restoration work;
- Providing rehabilitation assistance;
- Organization and funding of audits on proper implementation of the decisions of the Committee;
- Compensation of civil and legal personas for real damage caused to them during or in connection with performance of statutory action for disaster protection under conditions, order and in size determined by the regulations;
- Coordination of delivery and distribution of aids and donations.

6. Recovery

6.1 Temporary Housing Settlements

Temporary housing for affected citizens is provided by municipal authorities. There are two types of temporary housing:

- Housing for the time of evacuation in order to provide safety for people from the affected areas until the disaster situation is resolved.
- Provision of temporary housing to people whose homes are demolished or permanently uninhabitable. Longer duration – until housing problems are resolved or new homes are provided.

Evacuation housing is clearly defined and outlined in every municipal or national disaster reaction plan. Each municipality maintains the amount of tents, food, water, medical supplies and other items necessary for the registered population. Gathering points, temporary housing locations and transportation vehicles for evacuation of the population are determined in advance. People are evacuated to temporary tent camps, municipal or state property buildings (schools, sports halls, other) or other suitable locations. When needed, municipalities are supported by the state, NGOs and other organizations.

The second type of transient accommodations requires long-term measures – provision of housing for a prolonged period of time. Affected individuals have to be accommodated in municipal or state-owned properties or shelters until returning to their homes. Very often those accommodations and housing arrangements are insufficient, which leads to alternatives like trailer camps etc.

Figure 6.1 *Shelter for evacuated people (www.krakratoday.bg)*

6.2 Spatial regeneration of the affected area

Subsequent restoration of affected areas is of utmost importance. First of all, spaces have to be cleared and restored to ensure the normal functioning of restoration works – headquarters, depository, temporary housing arrangements, food preparation and distribution locations, medical center, etc. Key infrastructure has to be restored gradually – long-distance and inner city public transport, railways, main roads in order to ensure transportation of victims outside the affected area and to bring in help and supplies from the outside. Then, electricity, water supply and heating have to be restored as soon as possible. Last, but not least, risk of infection spreading and epidemics needs to be controlled through removal and management of human and animal dead bodies, clearing of debris, mud, silt, chemical disinfection, insecticides and raticides.

Here, volunteers play an important role, as they provide the necessary live force for reconstruction works and support rescue services with their specific knowledge and skill set.

Figure 6.2 *Volunteers from Sofia Municipality assist recovery works after the flood in Varna -2014 (photo: Tihomira Metodieva, volunteer)*

According to the National Disaster Protection Plan, recovery works in affected areas can be aided by officials, citizens an technology from other municipalities, government officials, army, police, gendarmerie, prisoners (under certain conditions), volunteers and others.

An important role in recovery plays the EU “Solidarity” Fund. It gives the Union an opportunity to react after huge natural disasters in EU member states or candidate countries, and thus to show solidarity with affected countries, regions and municipalities.

6.3 Financial Support for reconstruction

Financial aid for reconstruction of affected buildings can be granted in form of one-time extraordinary payments from the municipal budget by decision of the local authorities.

Mainly, financial assistance for emergency situations comes from the republican budget, and is granted under certain conditions. Right to recovery assistance for sites affected by disaster have the owners of legally built housing, that is their only property. Recovery assistance is provided by the mayor for the purchase of building materials for the performance of construction services or for assistance in a manner that is proposed by the municipal Committee. Under the legal basis, assessment of damage is done within one month. The support provided for each object is determined depending on the damage suffered, and in size, providing for the minimum necessary living conditions of individuals. Assistance for current cosmetic repairs is not granted. Recipients of recovery assistance shall use the aid only for the purpose for which it was provided – restoration of single legally built house/apartment. In an established case of misuse of the aid for purposes for which it was not provided, the recipients owe the amount in full.
An interdepartmental Committee in the Council of Ministers manages and supervises provision of targeted funds from the state budget for:

- Funding of preventive activities for mitigation and overcoming of floods;
- Payment of unforeseen expenses for rescue and emergency work, carried out by forces and means of disaster operation centres of the URS;
- Funding of urgent restoration work;
- Providing rehabilitation assistance;
- Organization and funding of audits on proper implementation of the decisions of the Committee

Compensation of civil and legal personas for real damage caused to them during or in connection with performance of statutory action for disaster protection under conditions, order and in size determined by the regulations.

6.4 Psychological support

Providing psychological support is essential to overcoming the negative consequences of disasters. It is performed primarily on the spot by rescue teams, parallel to the first medical aid. Later it is necessary to provide on-going counselling for victims and rescuers, participating in the management of the disaster. Such support is provided by staff psychologists of the Ministry of Interior, NGOs, and the Red Cross in one of its key roles as an integral part of the mechanism for the management of disasters and dealing with negative implications.

Floods are a typical example of precipitation type events. Floods are events that trigger certain processes in the human psyche. These events are generally associated with a serious threat to life, family and loved ones, home, etc. Processes in human consciousness at this time is divided into two phases:

- Initial phase - immediately after the event - is characterized by "blocking of thought", numbness, inadequacy, disorganization, disorientation, etc.
- Second phase of generating of solutions to tackle the problem - from 24 hours to 2 weeks. In this phase individual mobilize its internal mechanisms to deal with the issue. This point is crucial, because the failure of these mechanisms could bring a serious risk for mental health - The tension increases, it arise the feeling of chaos, lack of control and utter hopelessness. At that time people are prone to various types of addictions.

Lack of adequate intervention and professional help in recovering of normal mental condition can lead to serious consequences for the psychological and physical health of the people.

Some measures to reduce stress that may be applied are to provide information about the processes occurring in the human psyche. Aid in determining risk factors contributes to easier handling and prevent serious injury. Such activities are:

- Providing information on stress - explaining the difference between routine daily stress and the extraordinary stress.

- Providing information on typical signs and symptoms caused by the tragic events, the possible reactions of the body against stress.

- Providing strategies for coping with stress - for example, rescue workers are advised to make frequent breaks and limiting exposure to certain tragic and "heavy" sights and sounds. The duration of work without a break is not more than 1.5 to 2 hours. To receive regular food and beverages, etc.
Mandatory condition for people that give psychological help to rescuers and injured people is to know and to work closely with the various sources of stress, post-traumatic disorder, a psychological crisis intervention, and at the same time to be familiar with the procedures of civil protection.

Psychological interventions are divided into two groups:

- Initial - are done by trained staff in place (in situ). Those interventions are most often carried out by trained rescuers, policemen, firemen, etc., because rarely they can be carried out by psychologists within the tight deadlines for mobilization. They are applicable to people with visible symptoms of distress - emotional instability, angry reactions, shock, confusion and others. Initial interventions - as consultations - are made to rescue the management and staff at the site of intervention - they

have the character of advice on planning and organization of the breaks of stress exposure, without requiring or to interfere in the work of professionals.

- Secondary - immediately after the event and may last for several weeks or months. This requires strictly individual assessments of the status and programming of interventions.

Decompression and venting of the emotions - take small group meetings between colleagues, for example, close to the scene, but outside the scene of action. Sessions must have three parts:

- Introduction, which outlines the framework of the conversation and ensure confidentiality;

- Phase of the facts in which participants describe what happened and how they reacted;

- Information phase - inform participants what techniques to apply to reduce the level of stress

Techniques that are applied to deal with stress among rescuers and victims are:

de-escalation and demobilization - this is a technique that is designed to limit the stress in transition from traumatic event to the usual routine work or family obligations. Represents group meetings held away from the scene, usually when staff or citizens are free to participate in rescue and restoration activities. People are split into small working groups, after a brief conversation, devoted to techniques to combat stress enabling them to ask questions. Follows a short break, distribution of materials, brochures, flyers, etc. and return to work.

Debriefing - group meeting, about 3 hours. Results from specialists. It has the following structure:

Introduction - outlines basic rules them explains that this is not a cure, and a discussion with a training element. Participants can speak but also to remain silent.

- Phase of the facts - participants describe what happened during the flood on their own terms.

- During the third phase, the participants tell about their thoughts that have arisen in the course of the event. Thus, participants connect common events with individual experiences.

- The fourth phase directs participants to the discussion of the emotions associated with that event. Participants openly and freely should outline the worst part of the event for themselves.

- Overview of the signs and symptoms of distress - are considered symptoms of stress during the flood after him at the time of the discussion. So comparing the three "snapshots" and tendency to deepen or disappearance of symptoms.

- Learning phase - to be given information regarding the responses to stress, the normal psychological state, as well as specific techniques which may limit the symptoms of stress. This phase is adapted to the needs of the group and elements outlined in the previous phases.

- Final phase - makes a summary, ask additional questions and the session ends.

After 7-10 days is provide follow-up meetings to see whether in some victims still have symptoms of stress. Questions are posed for disaster situation, leisure and others.

This technique is used both for the rescuers involved in flood control and for victims citizens, students and other groups. Can be applied to spouses and families of the victims and rescuers.

7. Case Studies related to Floods

7.1 Greek Case Study

The Giofyros floods

Introduction: Giofyros river basin

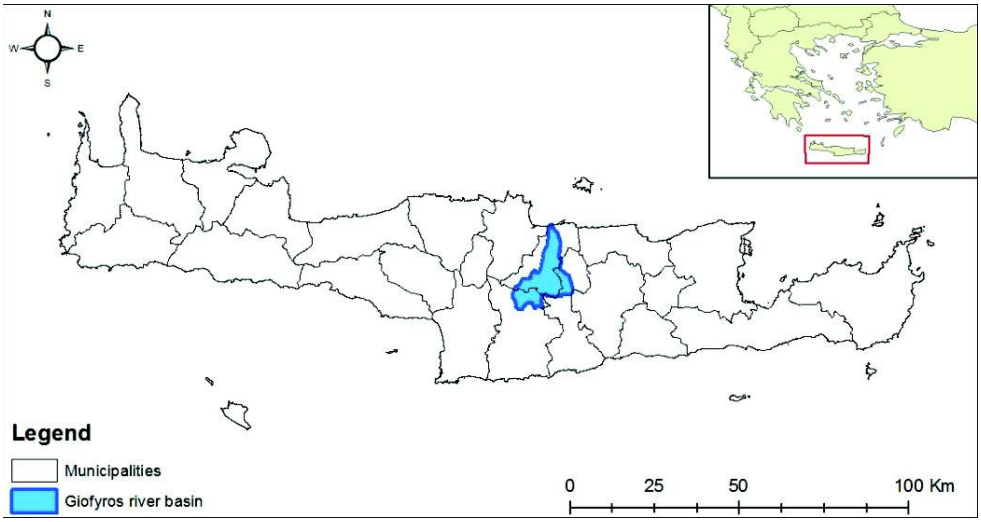


Figure 7.1.1 *Giofyros basin map. (Source: NHMC)*

Giofyros river runs off into the sea at the north of Crete and just by the western suburbs of the largest city of Crete, Heraklion. It has a surface water flow from autumn until spring, as most of the rivers of the island. Giofyros basin extends to the interior for about 25 km and occupies a large part (with its tributaries) of the municipality of Heraklion (approximately 190 square kilometers), is wide in the south area (about 17 km) and narrows in the coastal zone (about 1,000 m). Within its catchment occur about forty small sized towns and villages, with Aghia Varvara being the biggest (after Heraklion) with 2115 inhabitants. In total, excluding Heraklion city, a population of about 12,500 inhabitants live and work within the basin area, mostly in rural farming. This area forms the southwestern suburban area of Heraklion. The town of Heraklion is the biggest in Crete. The remaining portions of the basin compose hilly terrains and semi mountainous areas.

The real population of Iraklion town in 2011 was 179993 inhabitants, which is the fourth largest in Greece. The population of rural area of Giofyros basin (excluding the town of Iraklion and its suburbs) is continuously increasing till 2011 reaching 16101 inhabitants. The built up environment of the town of Iraklion from the '70s to present day has been increased up to three times (358%), whereas the sparse built up zone up to eleven times (1127%). Regarding the rest settlements of the Giofyros basin no significant changes were recorded (see Figures 2 and 3in the next pages).

Landscape is mainly mountainous and hilly at the uppermost part with agricultural and live stock rising uses. The central and lower part of the basin is formed into an oblong flat central valley with 11 km length and width of 600-1000 m, with high productivity land fully cultivated, which results in the southwestern suburban area of Heraklion. In most of the basin area there are rural farming uses, but at the lower, to the mouth portion of the terrain is formed into an oblong flat central valley with 11 km length and width of

600-1000 m, with high productivity land fully cultivated, which results in the southwestern suburban area of Heraklion. The remaining portions of the basin compose hilly terrains.

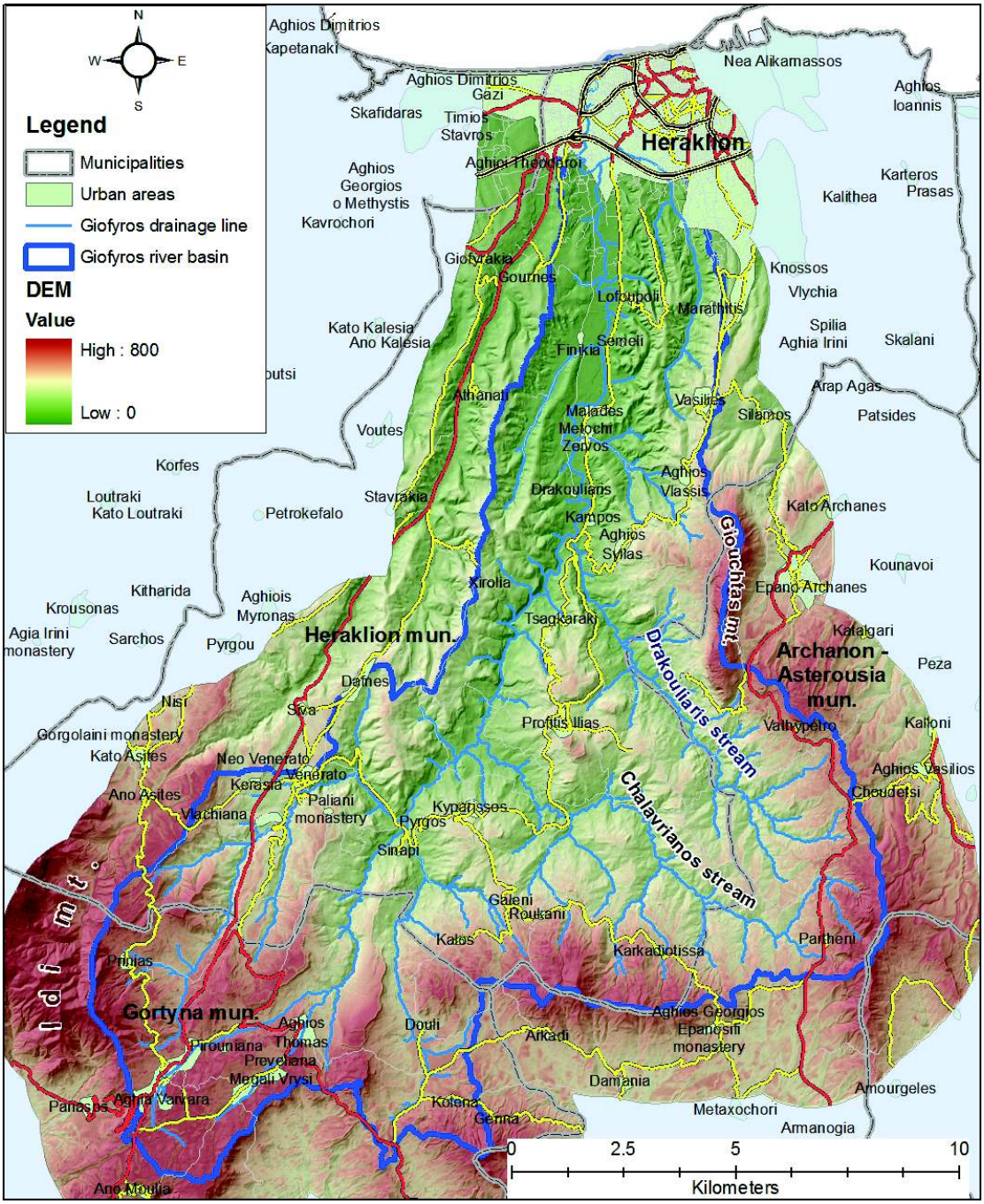


Figure 7.1.2 *Map of Giofyros basin (Source: own illustration)*

and semi mountainous areas. At this lower part and just outside the town occur low industrial activities like the Waste Water Treatment Station, small industries, workshops and crafts, as well as large night entertainment and catering centers, the Olympic stadium and several tourist activities.

The urban areas (within the urban planning zone of Heraklion) extend east of the valley of the river to the highway at a distance of 1,500 m from the sea and peri-urban (off the urban planning zone) areas extend

west of the river and south of the highway to its intersection Tributaries 'Chrysovalantou' about 2,200 m from the sea. In both these areas illegal construction is a common practice, plus the installation of commercial uses are key factors of environmental degradation. Thus, this area can be classified as one of the most deprived in the wider area of Heraklion, taking also into account the frequent floods, the most significant of which, was the one of January 1994.

Farming uses are dominant, about 90%, while residential and other uses ranging around 10%. Main agricultural cultivation, especially at the plain, are vine yards, while olive groves are more frequent at the slopes. There are also vegetable and other crops to the bottom of the valley where the land is irrigated.

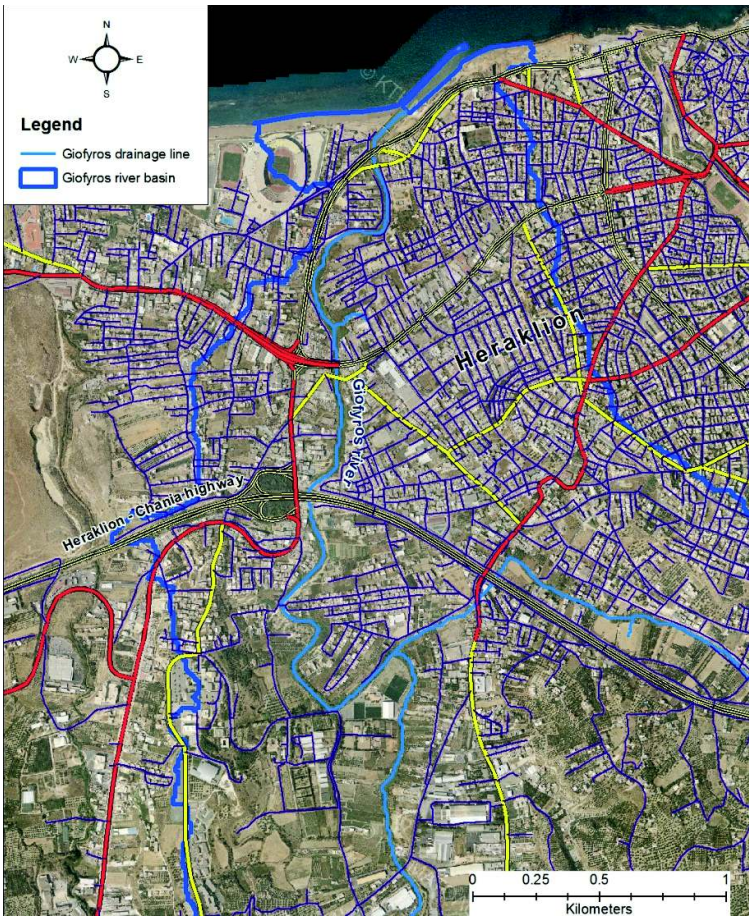


Figure 7.1.3 *Map of Giofyros river mouth area (Source: NHMC illustration based on ortho photo maps by the Greek National Cadastre and Mapping Agency)*

Flood risk

Risk in Giofyros river basin is induced by the human activities that have reduced the actual river bed and run off areas, certain assets and constructions like old stone and iron bridges that can act as dams in case of intense rain, and serious changes in land uses.

Figure 7.1.4 *An old stone bridge at Giofyros intersection.*

Figure 7.1.5 *An old iron made bridge at the area of river run off.*

In the last thirty years two major flash flood events occurred with significant damage output in private properties and public infrastructures. The first one, in the 17th of January 1985, after intense rainfall in middle and north Crete for a short period of time. In Heraklion the estimated rainfall was only 40 mm. River bed near the sea was altered.

The second one took place in 13th January 1994 and was the most important of the latest years even though in Heraklion the rainfall did not exceed 36 mm. Cattle, cars and other goods were swept away and traffic was interrupted. The largest part of river basin, more than 11 kms in length and from 250 m to 1000

m wide, flooded with water level reaching up to 3 meters in certain places. The estimated cost of the event was 30 million Euros of which ~0.6 million Euros was the estimated cost to the sewage process unit under construction at that time. Since 1994 there were several days of high alert due to the dangerously high level of water in the river.

Another flood was in the early days of January 2012, when again rainfall in Heraklion was low but there was intense rainfall in hinterland. Only small scale damages from flooding occurred. All of the above incidents occurred after a short period of intense rainfall, while the ground was saturated due to previous mild but prolonged rainfall and snow melting.

Last one took place on the 13th of January 2015 after a heavy rain during the night. It resulted in a serious flood of the northern-central part of Giofyros, the part existing upland of the old stone bridge, damaging a large number of households, artisans and other buildings. The Waste Water Treatment Station of the town of Heraklion was set out of order for several days, as well as many small industries and artisans of the Fikinia area.

Figure 7.1.6 *Images from the January 2015 flood in Giofyros*

Assessing Flood vulnerability

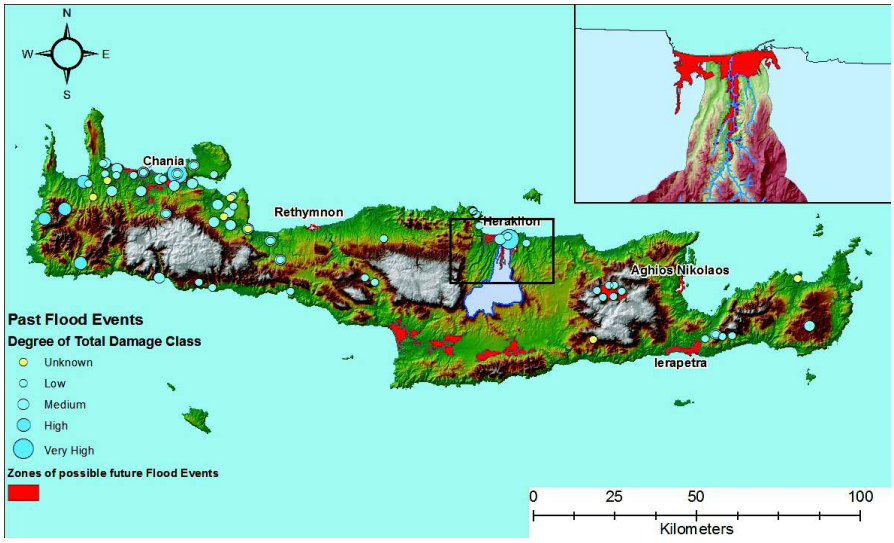


Figure 7.1.7 *Historical flood events in Crete and zones of possible future flood hazards (Source: NHMC illustration based on the assessment and management of flood risks according to Directive 2007/60/EC, by the Greek Ministry of Environment Energy & Climate Change (http://www.ypeka.gr/Default.aspx?tabid=252&locale=en-US and http://www.ypeka.gr/LinkClick.aspx?fileticket=n3s0vqXxQig%3d&tabid=252)*

Risk analyses (Ministry of Environment, Energy and Climate Change, Preliminary Study of Flooding Risk in Greece 2012) indicate that the whole coastal area west of the town of Heraklion is facing the risk of a flooding event. The floods of 2015 very obviously affirmed the above estimations.

In addition, general town planning studies for the area of Giofyros, both the urban part and rural have resulted in two protection zones in respect to their possibility of flooding (Karamanou &Rodolakis 2006). According to this study it is proposed that the river side area of Giofyros river basin can be divided in two main zones, which may be also attributed to their vulnerability status:

- Zone A which includes the buffer zone of **80-130 meters** according to the morphology of landscape, where a high risk of flooding occurs and thus a **high vulnerability exists**, and
- Zone B, which includes the buffer zone of 600 meters either side of riverbed which exposes a **low vulnerability**.

The zone A is presented on the following map. As we can see large part of the general residence constructions, public interest buildings, the waste water treatment plan, the Forest and Agricultural service buildings, crucial road segments (like the Messara-Heraklion highway) and intersection bridges are located with the Zone A of higher vulnerability.

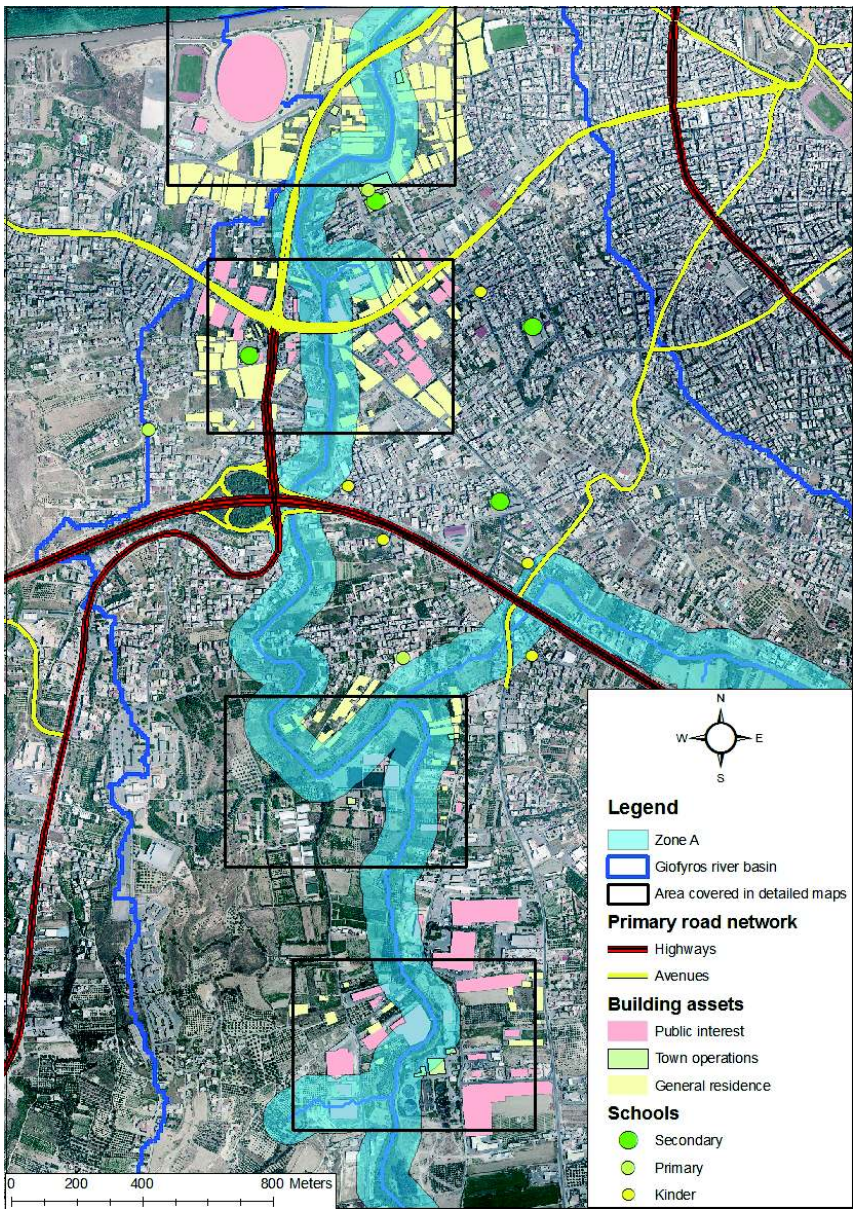


Figure 7.1.8 *Vulnerability map of flooding threat in the study area (RISK Project). Source: NHMC*

7.2 Bulgarian Case Studies

The case Asparuhovo in Varna

General information

Varna is located on the Black Sea coast and is the third largest city in the country with a population of about 330 000 people. Asparuhovo is a small suburb with a beautiful location on the shore of the Varna Lake and the sea on the slopes of the Balkan mountain.

Estimating the risk of floods

The area is well protected from possible sea floods because it is located high above the sea level. Through the area flows a small river which sometimes gets dry during the summer. As a whole there are no flood risks for the Asparuhovo district.

Flood – June 19, 2014

In the evening on the 19th of June 2014 in Varna there was a heavy torrential. At about 19:00 hours a two-meter high wave carrying mud and debris hit the Asparuhovo district. For a while, the district was isolated from the rest of the world and the electricity was disrupted. The population was in panic. No one could guess where this wave was coming from – there is no water reservoir above Asparuhovo. During the following hours the authorities tried to reach the affected parts of the neighborhood on boat and heavy duty vehicles. The water slowly drained away. It became clear that 11 people had died, among two children at the age between 7 and 11. After the drainage of the water the neighborhood was covered in a 80-90 centimeter layer of mud and rubbish. The amount of the damage was estimated at over 2 million levas.

Pictures of the flood

Figure 7.2.1 *The flood in Asparuhovo (photos: Tihomira Metodieva, volunteer)*

Reconstruction

The machinery

Figure 7.2.2 *Damages of the flood in Asparuhovo (photo: Tihomira Metodieva, volunteer)*

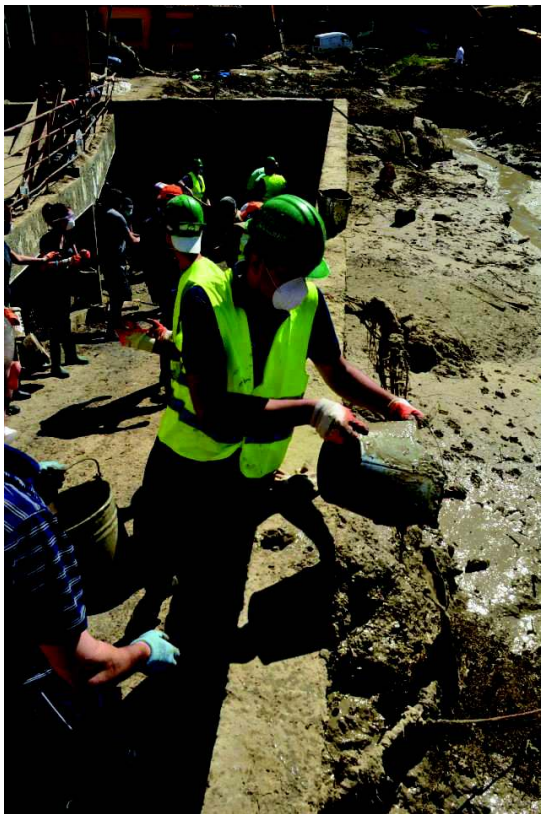


Figure 7.2.3 *Volunteers are helping in the recovery activities in Asparuhovo after the flood (photo: Tihomira Metodieva, volunteer)*

Causes for the flood

The investigation which was afterwards carried out found out the causes for the unexpected and surprising flood. It became clear that this flood was caused by the coincidence of a number of tragic circumstances – natural and caused by human activities.

Natural causes:

- Heavy torrent

The main cause of the disaster was the intense rainfall, exceeding by far the monthly average.

- Ultimate wetting of the ground.

One of the factors for the ultimate wetting were the almost daily rainfalls from May to the first half of June which made impossible for the ground to absorb the huge water amounts.

- Erosion processes

Another cause is the constantly growing water flow over the years, which was a result of the creeping house construction in the area.

Technical causes:

- Blockage caused by human activities

Blockage of the water course in the gullies caused by piling up of dry trees and branches, illegally cut down forest, waste dumps of old household appliances and different kinds of waste.

- Neglected water reservoir used by the army

There is a navy base in the area***.*** In this base there is a neglected water reservoir which is filled by the water of the river. At the moment of the flood the above facility was abandoned but it continued to get filled with water without any supervision.

- Widespread illegal construction

Illegal construction had spread throughout the neighborhood against all regulations. At certain places in the Romani neighborhood the houses were built directly in the river bed, but there are also some blocks of flats in the flooding areas of the river. Besides the buildings there is also illegally built infrastructure – moving of gullies and drainage canals for the constructions of streets, pipelines without securing the necessary drainage flow.

- Warn out water supply and sewerage system

The water supply and sewerage system and especially the rainwater drains in potentially dangerous areas were in a very bad condition.

- Lack of rain and household sewerage at existing water supply, which does not correspond to the technical norms and rules in potentially dangerous areas.

In this specific case large amounts of water collected in the gullies and broke the dams formed by fallen trees. A wave was formed which flowed through the abandoned military reservoir, it reached a height of two meters, hit the buildings in the river bed and spread throughout the neighbourhood. In the end the wave carried away tree trunks, cars and other objects directly into the sea.

Measures

There are three compulsory measures which must be taken immediately:

- Removing all illegal structures in the gullies, catchment areas.
- Removing all buildings which are potentially dangerous for their inhabitants.

- Ceasing the illegal cutting down.
- Clearing all gullies and maintaining them in proper condition afterwards.

Video materials

https://www.youtube.com/watch?v=g7O0aGxoYac

https://www.youtube.com/watch?v=Fxmd1Tk-XHo

https://www.youtube.com/watch?v=gE7p3d3HVhk

https://www.youtube.com/watch?v=fqQXwApDCaU

https://www.youtube.com/watch?v=nd8awXl9Ndo

Reason

https://www.youtube.com/watch?v=crlyVHMocns

https://www.youtube.com/watch?v=bs3kHSOV-5g

The case Novi Iskar

General information

The Sofia Valley takes an area of 1180 sq. km. The Iskar river takes away the water from the whole valley to the Danube in the north. All rivers in the Sofia Valley flowing to the Iskar river.

During the Pliocene and Quaternary Period the valley was enveloped by differentiated negative movements. The flow of the Iskar river was blocked by the Balkan Mountains and the whole valley was a big lake. The lake disappeared after the river wore a channel through the Balkan Mountains and created its present bed.

At the place where once the stopper which lead to the transformation of the valley into a lake was, is located the town of Novi Iskar. With its adjacent villages Novi Iskar has a population of about 32 000 people. The area around Novi Iskar is the point on the map where all the waters flow away from the Sofia Valley.

Estimating the risk of a potential floods

As a result of the blocking of the river bed millions of years ago and the subsequent break by the river, a stopper was formed which slows down the waters of the river and prevents their flow-out like a dam. In other words the waters of the Iskar river flow through this dam as if through a siphon. The so formed stopper could prevent a potential high wave from flowing out fast.

The high wave could be caused by a number of factors. This is the only point for flowing out of the water from the huge Sofia Valley. On the course of the Iskar river, before Sofia, the biggest water reservoir in the country is located. It has a volume of over 600 million cubic meters. There are also a number of smaller reservoirs. Along the courses of many of the tributaries of the Iskar there are also a lot of different in size reservoirs. At any moments some of these reservoirs could come out of order or overflow if for instance it is not maintained properly.

This will surely lead to a high wave for the town of Novi Iskar.

Experts have investigated the area around the river stopper. The investigations prove categorically that the stopper in question continues in act as a blockage for underground waters which are a rest from the old big lake. If the stopper is removed the fruitful Sofia Valley will lose all its underground waters and this will have a devastating effect on the agriculture. As a whole, it turns out that the potential dangerous of flooding in the town of Novi Iskar always exists. The river stopper blocking the waters cannot be removed. Hence, the question is not whether, but when Novi Iskar will suffer from another flood.

http://bsdi.asde-bg.org/riskwatch.php

http://bsdi.asde-bg.org/floods.php?vodosbori=iskar&set=Novi_Iskar&id=2%20#karti

The flood in 2005

The floods in the summer of 2005 were the most devastating disaster that happened to Bulgaria. 31 people died. The wave in July caused damages of 274 million dollars (205280800 euro). The second flood in August the same year cost another 200 million dollars (149840000 euro). It was the largest number of disaster-stricken sites in the country. Victims were over 13 000 but the number of people affected was more than 60,000. 70% of the country was affected, 11,000 farm animals were drowned and more than 3,000 buildings were unfit for living.

According to the experts and hydrologists the August rains are an extreme natural disaster, whose probability (according to statistical criteria) to happen is one time in thousand and 10 thousand years. Almost 1 billion liters of water poured on 6 thousand sq. km. of the Bulgarian territory. The free volume of the reservoirs in the affected areas is only 250 million cubic meters. This parallel shows that this disaster was inevitable.

The flood was caused by the badly constructed sewerage system and the negligence at the exploitation of the reservoirs located near the urban areas which overflow as a result of heavy torrents. The lack of dams at certain points allows the water to reach the residential areas.

Pictures of the flood

Figure 7.2.4 *Picture of the flood in Novi Iskar, 2005 (www.noviiskar.bg)*

Figure 7.2.5 *Picture of the flood in Novi Iskar, 2005 (offnews.bg)*

Prevention

This year, because of the large amounts of rain, preventive measures were taken for cleaning of the Iskar river bed. Teams from The Chief Directorate Fire Safety and Civil Protection together with the Sofia Municipality and the Volunteer Unit for control of disasters and emergencies took immediate measures such as:

- cleaning of the river bed from alluviums and household waste;
- emergency construction and strengthening the dams in critical areas;
- erection of temporary dams with sacks of sand;
- at the discharge of the Iskar reservoir along the river at certain places, teams were placed; they observed the level of the river and the possible risks for overflow.

The prevention

Figure 7.2.6 *Volunteers are participating in the prevention activities (2015) (photos: Yasen Tzvetkov, volunteer)*

Video materials
http://vbox7.com/play:63a2631f

7.3 Italian Case Study

The flood of 4/10/2010 in the Beigua Geopark

Two critical pluviometric events occurred in the central-western Ligurian Riviera, 30 and 5 km west from Genoa (NW of Italy) on October 4, 2010. These events caused landslides and floods at Varazze and Sestri Ponente and in the inland area of the Teiro Stream and Arzocco Creek valleys at Varazze, and between Molinassi Creek and Chiaravagna stream valleys at Sestri Ponente. This area is comprised in the Beigua Geopark area (Fig.7.3.1)

Events were caused by two different thunderstorm supercell systems triggered from the same meteorological situation.

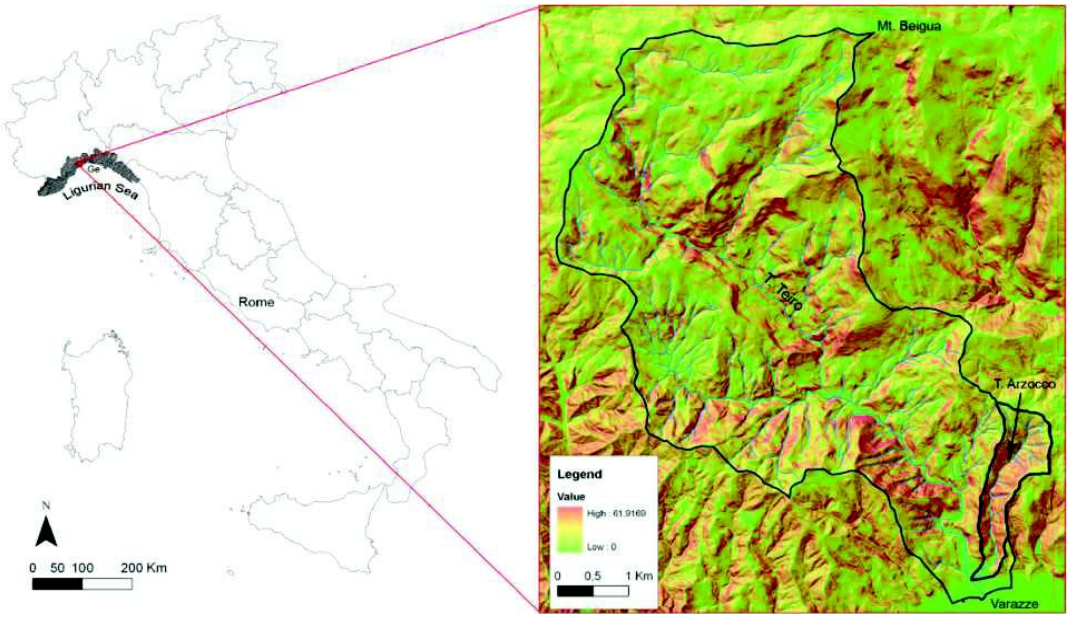


Figure 7.3.1 *The area of the flood (Teiro river, Beigua Geopark)*

From a meteorological point of view, the synoptic situation at October 4, 2010, highlighted a deep through in the Biscaglia Gulf and a wide frontal system in the Western Europe. Consequently a secondary depression (Genoa Low) started forming in the Ligurian Gulf with surface north current westward Varazze. This situation developed a warm conveyor belt on the Ligurian Sea, as usual very warm at the end of the Summer. Wet south-eastern winds converged over the sea at low atmospheric levels near the center of the Genoa Gulf and south-western winds at medium level. The orographic effect of Ligurian mountains, the convergence of wind and the wind shear between different atmospheric levels caused a stormy pre-frontal activity and generated a stationary supercell system that about 6.00 AM started to produce heavy rainfall on Varazze.

Some hours later a little change in the wind direction took the surface convergence westward and another supercell system developed on Sestri Ponente.

The most intensive downpours stroke with a thunderstorm steady system which later extended its influence over Northern Italy with very less intensity. After the pluviometric peak thunderstorm moved eastward gradually losing intensity for the coming of the cold front. The rain gauge measured from 6 to

10.30 AM, 255 mm of rain, with a maximum of 180 mm between 8 and 10 am. Between 9 AM and 3 PM the rain gauge of Mt.Gazzo (Sestri Ponente), registered 400 mm of rain with a peak of 124 mm between 1 and 2 pm. (Sacchini et al, 2012) (Fig.7.3.2)

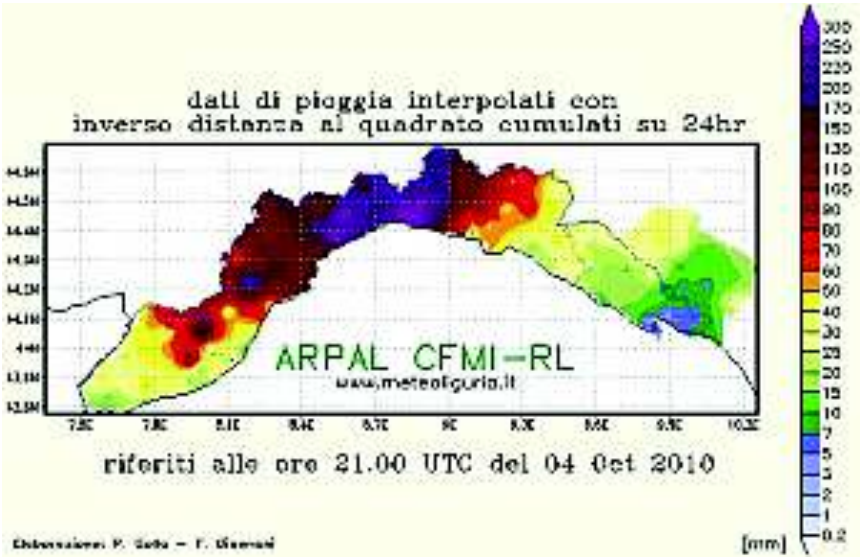


Figure 7.3.2 *Meteorological situation of the flood of 4/10/2010*

Water levels in the Streams immediately increased: Teiro stream increased 1,3 m in 1,5 hour overflowing, while its eastern tributary, Arzocco creek sudden inundated the plane.

The flooding has affected the coastal plain where lies the city of Varazze and flooded areas were well provided for by the Basin Plan.
This event affected streams by causing a sudden flood with major solids transport and erosion along the scarps and unprotected embankments. Roads were flooded, the hamlets on the adjacent hills were isolated.
The mobilized debris flows rapidly channeled along watersheds and depressions, causing critical hydraulic conditions in the secondary hydrographic network and reduced outflow. Artificial canals at the road intersections were rapidly obstructed, forming huge deposits. The flooding has fortunately caused no casualties.

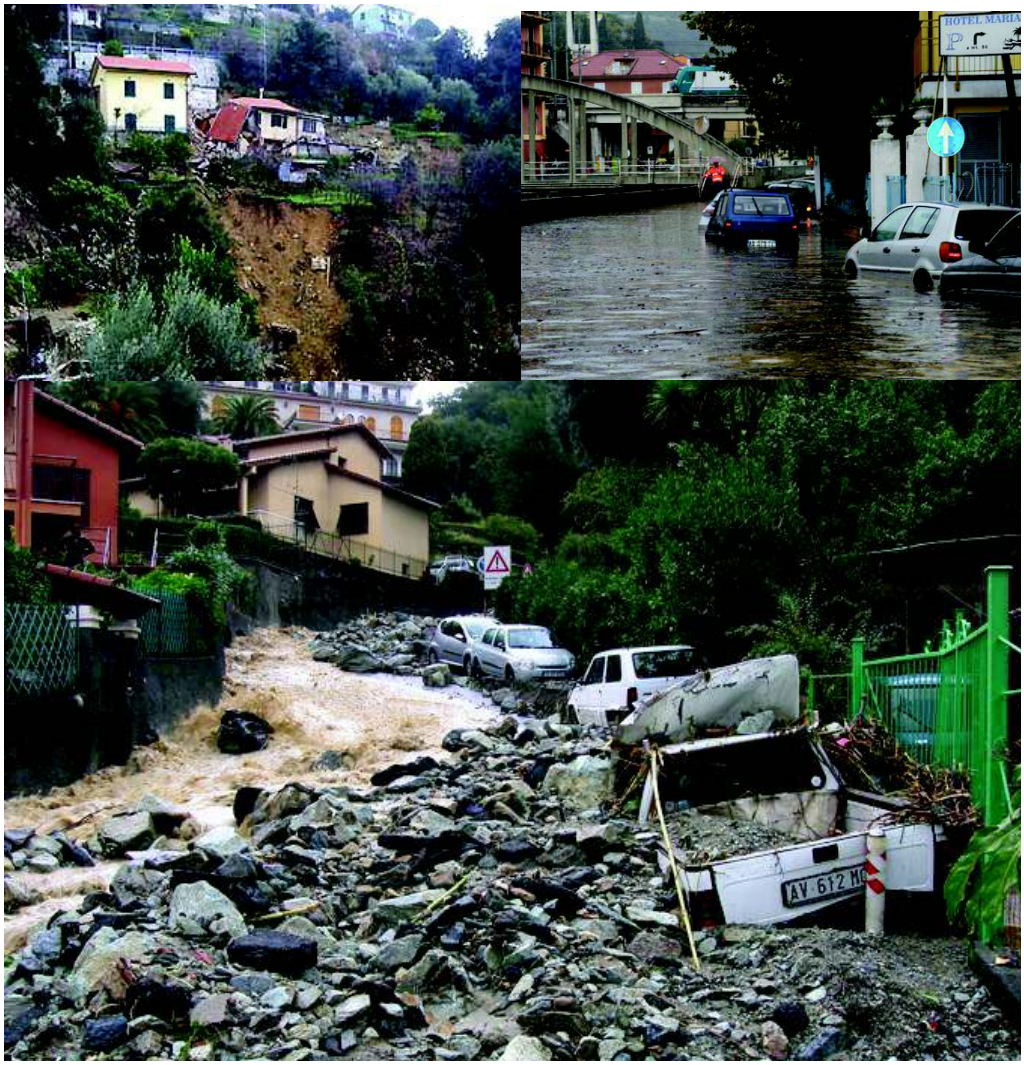


Figure 7.3.3 *Examples of damages in Varazze (photo: www.ligurianotizie.it; www.ilsecoloxix.it)*

Approximately more than 100 critical situations were reported in the Teiro, catchment. Most were concentrated in the middle and lower basin sectors. Most of the observed gravitational phenomena that occurred following the October, 4, 2010 event can be defined as debris flows and debris slides and were triggered along the side valleys of the streams. Fig.7.3.3
More than 2/3 of the case occurred in area defined at medium or low risk in the Master Plan.

In addition Civil Protection activities in emergency only partially succeeded because of the very fast occurrence of the flood and the very limited area hit by each disaster.
The recent intensification of flash floods in the Mediterranean area and in Liguria in particular and the urban development of coastal plain and slopes seems to be major causes of these geohydrological events, The above considerations highlight some lacks of the Master and Emergency Plans and big problems from the urbanization. Therefore, to update land planning and civil protection tools, it is necessary on one hand to extensively investigate local geomorphological and soil characteristics and their influence in the recent urban development, on the other hand to predispose instant alarm for people and preparedness activities.
Following severe damage in the town of Varazze they were made many interventions for the safety of the territory.

In press release dated 03/12/2015 of Varazze Municipality, it's possible to read the situation of the interventions of the work following the flood of 4 October 2010.

Specific situation:
1) Accommodation road via Canavelle: the intervention is over and covered the reconstruction of tombinatura del rio Galli and the road accommodation via Canavelle. The works were completed at a cost of 220,000 Euros.
2) Via Costa 1st phase: the intervention is over. Rebuilt the tombinatura del rio Galli and the road accommodation at a cost of 180,350 Euros.
3) Via Costa 2nd phase: operation running. The works have been waiting slowdowns of an authorization of a variant submitted to the Region of Liguria but just recently resumed. the bridge that crosses the river Galli has been redone over the road accomodation, walls and retaining structures, road and bridge accessory works of a tributary of the Rio Galli in the same area. They will still be realized works of the road holding (subject to variant) and protection works of the road itself. The total amount is EUR 767,000. And 'scheduled to end works in the summer of 2015 and testing by December 2015.
4) Rio Galli - via Fossello: construction of a sedimentation tank and resurfacing of the bridge leading to via Fossello. Term work on July 31, 2015. The amount of EUR 550,000.
5) Making the hydraulic adjustment of the Rio Mola in Via Marconi crossing: are making micro piles which will follow supporting works of the new crossover in progress. The completion of work is planned during the summer. Amount allocated 350,000 euro.
6) Rio Cable: execution of two bridges, one in via Bruzzone (former seat FS) works amounting to € 200,000 and the other in Via Santa Caterina (opposite Restaurant Cable) works similar to those on the rio Mola; the works are quite demanding results due to the movement of underground utilities (phone, gas etc.). the support posts on either, will now be carried out in support of the new bridge works have been completed. In particular via Santa Caterina (opposite the restaurant Cable) is going to finish Administration, barring unforeseen circumstances, for the celebration of St. Catherine (30 April).
7) Torrente Arrestra - ford ro. Island: it is an intervention of fundamental importance in relation to the already known landslide in Desert. Amount allocated: 438.000 EUR.
8) Rio Galli bottom: work in the final stage, are concluded for some 90%. This is the contribution to the valley of the house known caved in Casanova. There have been works of enlargement of the riverbed and banks made new addition to bridles to hold the transport of solid material. Realized, finally, works to stabilize the landslide. Contract value: 2,100,000 euro.
9) Scolmatore rio Garombo (Via Moerana) in the city center: published the tender for the identification of the company carrying. Contract value: 340,000 euro.
10) Rio Arzocco (lower part of Via Milano, municipal warehouse area) in the city: the works were awarded by public tender. Work will begin later this month. Contract value: 854,000 euro.

Moreover Also many environmental education projects have been launched for schools and the population to raise awareness of the risks and self-protection regulations.
The Beigua Park has worked for two years free projects for schools of Varazze on the hydrogeological risk.
"Hydrogeological hazard" is an education project to understand: Vulnerability of the territory; Causes and effects of the urbanization; Hydrogeological risk connected to extreme precipitations events in own city; Self - protection rules. Fig.7.3.4.

Moreover different brochures with self- protection rules were realized by Beigua Geopark. Fig.7.3.5

Figure 7.3.4 *The education project: "Hydrogeological hazard"*

Figure 7.3.5 *The brochure about self-protection rules*

References:

Sacchini, A., Ferraris, F., Faccini, F., and Firpo, M.: Environmental climatic maps of Liguria, Journal of Maps, 8 (3), 199-207, 2012.

7.4 The Spanish Case Studies

Floods In Ebro Basin, North of Spain February-March 2015

Introduction

Since the last days of January and during much of February consecutive rainstorms, snow and wind have affected almost the entire country and particularly the northern half of the Peninsula.

Figure 7.4.1 *Ebro basin location at Spain's rivers basins map. Source: Ebro Basin Confederation (Ministry of Agriculture, Food and Forestry).*

Ebro Basin is distributed in nine Autonomous Regions in the following proportions:

Autonomous Regions	Total area in Km2	Basin area in Km2	% of Region in basin	% total area in basin
Cantabria	5.327	775	14,55	0,91
Castilla y León	94.227	8.148	8,65	9,52
La Rioja	5.045	5.023	99,56	5,87
País Vasco	7.230	2.678	37,04	3,13
Navarra	10.390	9.229	88,83	10,79
Aragón	47.720	42.111	88,25	49,21
Castilla-La Mancha	79.462	1.119	1,41	1,31
Comunidad Valenciana	23.254	851	3,66	0,99
Cataluña	32.091	15.635	48,72	18,27

Table 7.4.1 *Ebro basin distribution among Spain's Autonomous Regions. Source: Ebro Basin Confederation (Ministry of Agriculture, Food and Forestry)*

The rainfall recorded in January occurred almost entirely in the last three days of the month, in large areas of the Cantabrian exceeded twice the monthly average values. Between 29 and 31 January, heavy and persistent rainfall in the northern peninsular strip and in areas of the Central System, were initially in the form of rain to great heights then the snow level down progressively. The accumulated amounts exceed 200 mm. in various parts of the interior of Cantabria, Basque Country and northern Navarre.

February has left temperatures below normal values throughout Spain, the highlight was the episode of very low temperatures that occurred between 3 and 9 January, because an entry of very cold air from inside Europe, this led to snowfall in northern Spain, even at sea level and heavy frost at higher elevations.

Throughout the month, there were several episodes that led to heavy rainfall in the north, which were often snow in lower altitudes. In all these situations of heavy rainfall, the most important was the one that hit between 23 and 26 in the Basque Country, northern Navarra, Cantabria and northern Aragon, with amounts accumulated over 200 mm in parts of the Basque Country and northern Navarre.

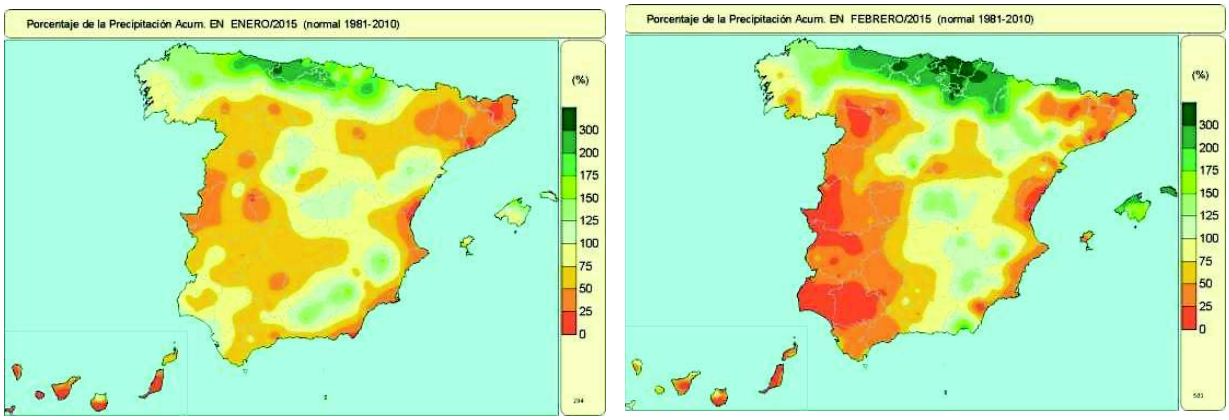


Figure 7.4.2 *Maps percentage of accumulated precipitation, January and February (Spain's AEMET Agencia Estatal de Meteorología - State Meteorology Agency)*

A) <u>State of soil saturation:</u>

The amount of water in the soil, in the north of the peninsula, as shown on maps, of January 31, 10, 20 and 26 February, is close to the upper retention values; this causes the water from rainfall and snowmelt not seep underground and becomes surface runoff.

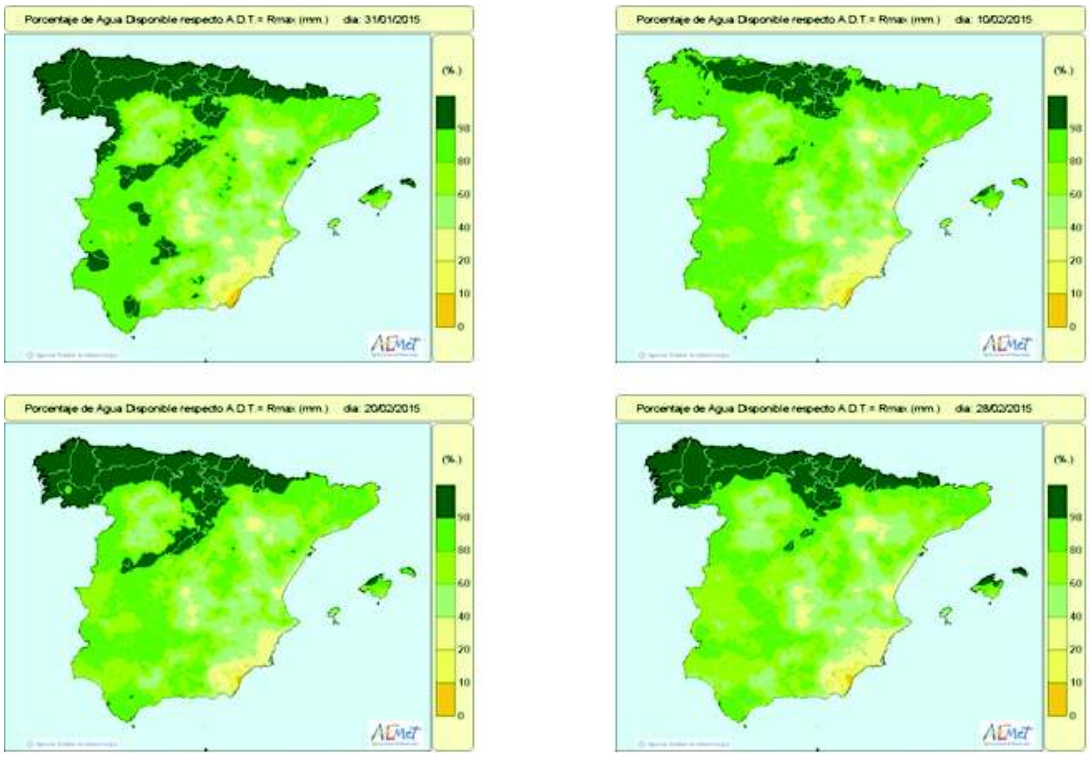


Figure 7.4.3 *Decadal maps of soil saturation (Spain's AEMET Agencia Estatal de Meteorología - State Meteorology Agency)*

Rainfall that have been observed since late January, mostly in the month of February when 300% of the average rainfall in much of the Basque Country and in some areas of Cantabria, La Rioja and Navarra have led a significant increase in both, the flow of some of the major rivers and the volume of water stored in the Ebro basin increase, which has caused most of the reservoirs located on the left dams are close to or have exceeded 90 % capacity.

B) <u>Occupation of reservoirs:</u>

The latest update on the volume of water stored in the Ebro basin amounts to 82.3% (Hydrological Bulletin No. 9, 2 March) meeting reservoirs consumptive use header with a percentage above 90%.

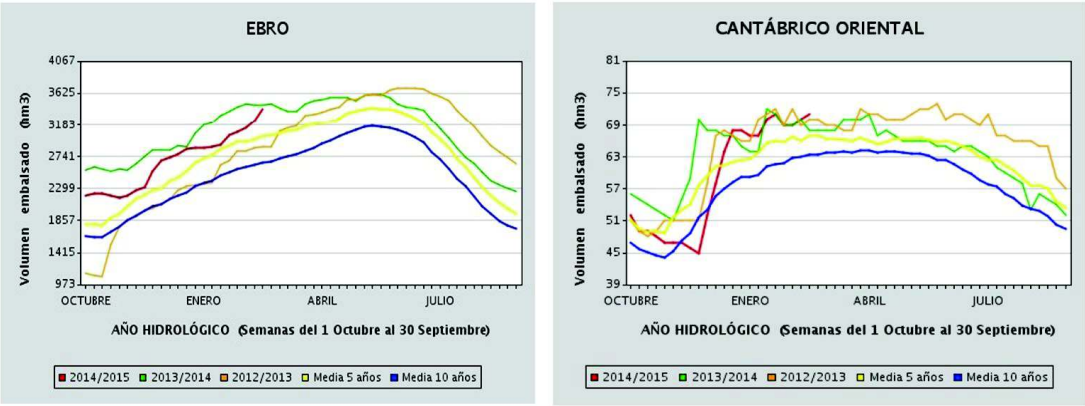


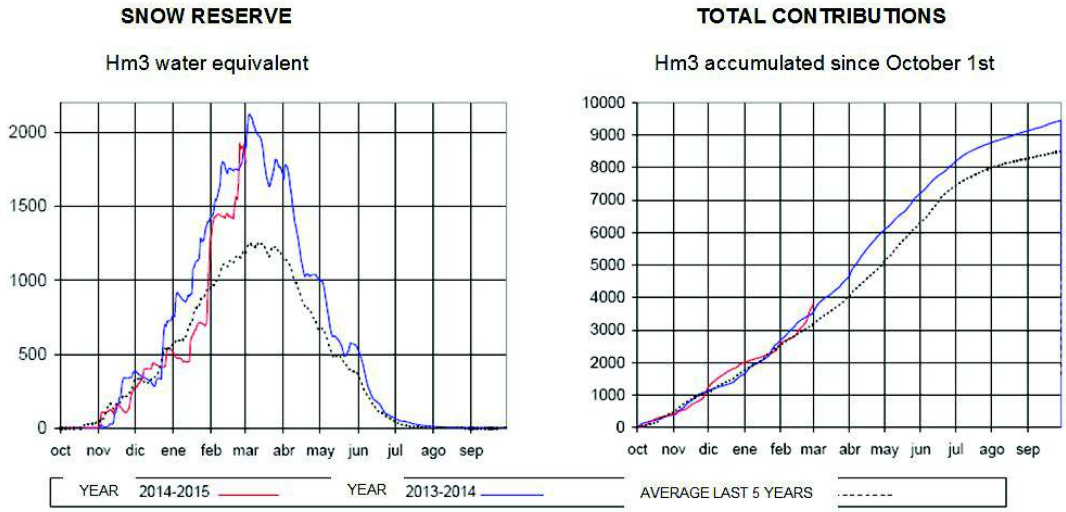
Figure 7.4.4 *Status of the reservoirs of consumptive use of the Ebro basin and Eastern Cantabrian March 2, 2015 (Spain's AEMET Agencia Estatal de Meteorología - State Meteorology Agency)*

C) Contributions level:

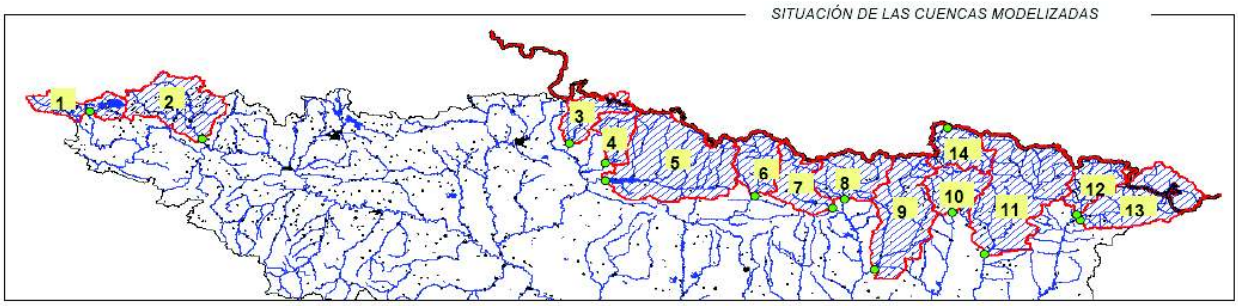
Moreover, the contribution of the melting of the snow on the mountain ranges of northern Spain has contributed to increased flows in the headwaters.

This year only we have information on the level of the Ebro basin, since the program ERHIN (Assessment of snowfall Coming Water Resources) has not been developed due to budgetary problems. In the case of the Ebro river, the situation of the snow is of particular concern in the following areas: Upper Basin to the Embalse del Ebro Basin Nela, until Itoiz Irati, Salazar until Aspurz and Aragon to the Yesa Reservoir, as You can be seen in the following table and graphs:

Figure 7.4.5 *Conditions at March 2 of snow reserve in Ebro basin, elaborated by CHE. Modelo ASTER*



Order	Basin	Snow reserve			Contributions 1		
		Today	*One year ago*	*5 years average*	*Today*	*One year ago*	*5 years average*
1	Cuenca hasta el Embalse del Ebro	**48**	16	17	**286**	191	185
2	Cuenca del Nela	**10**	1	3	**596**	307	266
3	Irati hasta Itoiz	**54**	8	14	**363**	401	324
4	Salazar hasta Aspurz	**39**	4	9	**158**	183	145
5	Aragón hasta el Embalse de Yesa	**302**	204	126	**576**	744	641
6	Gállego hasta Sabiñánigo	**165**	203	127	**266**	265	196
7	Ara hasta Boltaña	**71**	84	64	**156**	202	181
8	Cinca hasta Escalona	**127**	143	123	**273**	188	289
9	Ésera hasta Barasona	**108**	149	106	**399**	293	301
10	Noguera Ribagorzana hasta Pont de Suert	**105**	154	89	**168**	148	118
11	Noguera Pallaresa hasta Embalse de Talarn	**318**	387	211	**298**	278	248
12	Valira hasta Seo D'Urgel	**106**	109	56	**76**	68	54
13	Segre hasta Seo D'Urgel	**84**	157	71	**163**	91	86
14	Garona hasta frontera Francia	**257**	272	160	**91**	214	130
	Total:	**1794**	1890	1176	**3869**	3575	3164



1 Aportaciones totales acumuladas registradas en los puntos de cierre ● de cada subcuenca desde el principio del año hidrológico (1 de octubre) medidas en hm^3

After a first episode caused by heavy rainfall between 31 January and 6 February and the first phase of melting, causing significant increases in the flow of several tributaries of the left bank of the Ebro, the heavy rains of last 25 February and thaw by rising temperatures has led to a second episode of floods in the last week of February and first of March, affecting a large number of locations.

On February 26 the hydrological situation in the Ebro river basin was being critical both in the axis of the Ebro and its main tributaries on the left bank. The trend in all of them was up, as was reflected in gauging stations: Ebro-Miranda, Ebro-Zaragoza, Ebro-Logroño, Ebro-Mendavia, Ega-Andosilla, Irati-Liédena, Arga-Funes, Ebro-Castejón, Ebro-Ascó.

Facts

PART 1 FEBRUARY 1st:

- Zaragoza (Aragón): On Tuesday at 13:00, the bigger flood bank passed in the city of Zaragoza causing flooding of children parks near bank and numerous community garages belonging to Almozara neighborhoods, parks and fountains Vadorrey. In the district of Monzolbarba, 20 people were evacuated preventively breaking a speck of protection. The cultivations of the closest towns to Zaragoza have been seriously affected. In the urban center of the capital, there were no conditions beyond the usual in case of floods. In general, the same scenario is repeated conditions than in last January floods. In the afternoon, the same day the flooding in Zaragoza leveled producing a gradual lowering of the river level.
- Navarre Region: the flood alert in recent days caused damage to garages (Funes) in industrial facilities (Lodosa), overflows in Marcilla (Ebro) and Miracle (Ebro) and interruption in electricity supply and service of mobile telephony. This hydro meteorological warning gave way to snow alert with numerous cuts and disruption of traffic.
- Burgos (Castilla y León Region): flooding of low and garages in Miranda de Ebro.

Alert situations declared:

- Catalonia: Activated under the Plan Nevadas Alert (NEUCAT) and pre-alert phase of ALLAUCAT risk of avalanches in the Aran Valley.
- Basque Country: Activated under the Plan Flood Alert for Zadorra basin and Winter Maintenance Plan Operations Phase.
- Navarra: Activated under the Special Emergency Flood Plan.
- Aragon: On Pre-emergency under the Civil Protection Plan Floods possible avenue ordinary river Ebro.
- Castilla y Leon: On Alert Phase Protocol coordination of actions in extreme weather conditions that may affect the state road network in Avila, Burgos, Leon, Palencia, Segovia, Soria, Salamanca and

Zamora. On Burgos level 1 Territorial Plan of Civil Protection (Plancal) by snow. Illes Balears: On Level 0 in the Special Plan by unfavorable weather conditions.

PART 2 FEBRUARY 26th:

- Navarre:
  There was the death of a person accidentally falling into the river Arakil. It has rescued a driver in a flooded area in Sanguesa term Pastoriza.
  As a preventive measure Larraintzar public school ended classes in advance of the schedule, with the possibility of access to the facilities remain unusable.
  In Guenduláin had to intervene firefighters to transfer a patient as the rising river prevented the passage of the ambulance, and in Alsasua a tree fell on a warehouse at Geltoki, causing no injuries, but was hit the roof of the nave.
  As regards roads in the backbone, they are cut by flood kilometer 75 of the N-113 (Pamplona-Madrid), at the height of Castejon; and 0.2 kilometer from the NA-30 (Round Pamplona), access to Landaben. Many roads are flooded or cut by the existence of pools of water in the secondary network. Also there have been occasional impoundment of water and overflows Baztán (Arraiotz) and EGA (Allin).
  The Government of Navarre keeps activated the level 1 Flood Emergency Plan as possible rallies river levels as a result of rains in the northern half, are not discarded and before the forecast of floods expected in the Central Zone and La Ribera. In this situation, all emergency resources are activated, but so far there have been no serious incidents.

- Guipuzcoa (Basque Country):
  In the lower reaches of Urumea many areas have been flooded. It is evacuated camp shacks in Astigarraga.
  In Hernani they were flooded fields. Urumea River has overflowed by 2 points between Hernani and Astigarraga. Gauging stations and Ereñozu Ergobia still on alert with a tendency to stabilize.

- Zaragoza (Aragon Region):
  Area affected: Alcalá de Ebro, Boquiñeni, heifers, Gelsa, Pina de Ebro Pradilla de Ebro and Zaragoza.
  Evacuation: Residence of the 3rd age Monzalbarba. 83 people have been transferred to public schools. Evacuation and resettlement of the population of Boquiñeni, Pradilla and urbanization "The Gardens" in Alfajarín.
  Rescuing people. Roads cut. Damage to houses and buildings. Damage to industrial and agricultural facilities. Damage to infrastructure and buildings.
  At 20:30 on the 26th, the forecasts for peak flows in Zaragoza were 2,100 m3 / s and 5.3 m for the night from Saturday to Sunday. In the town of heifers was forecasting a maximum flood on Friday 27 at noon.

Response

Activation of the emergency military unit

On February 26 at the request of the Government of Aragon intervention EMU with 115 soldiers, 43 vehicles and 2 helicopters, to assist in the tasks of containment, pumping and evacuation, as well as supporting tasks aerial reconnaissance was activated flood Ebro river in the towns of heifers, Pradilla, Boquiñeni, Alcalá de Ebro and also another in the province of Zaragoza.

EMU installed a portable bridge temporarily to allow communication road between the towns of Boquiñeni and Luceni, having to break the road to drain. On March 4 it was demobilized.

The Directorate General of Civil Defense and Emergencies continuous monitoring of hydrometeorological situation as well as monitoring of the activities took place, supporting the actions of the regions affected, managing and processing the requests for help.
Two press releases to inform the population that were gathered by many national media, which are available on the website of the DGPCE were issued.

At the request of the Hydrographic Confederation of the Ebro and the Civil Defence of Aragon (SOS Aragon) was activated twice the Copernicus Programme of the European Union which provides satellite imagery in emergencies. Examples of the more than 18 maps obtained by interpretation of radar images and SENTINEL1 RADARSAT2 satellites are shown.

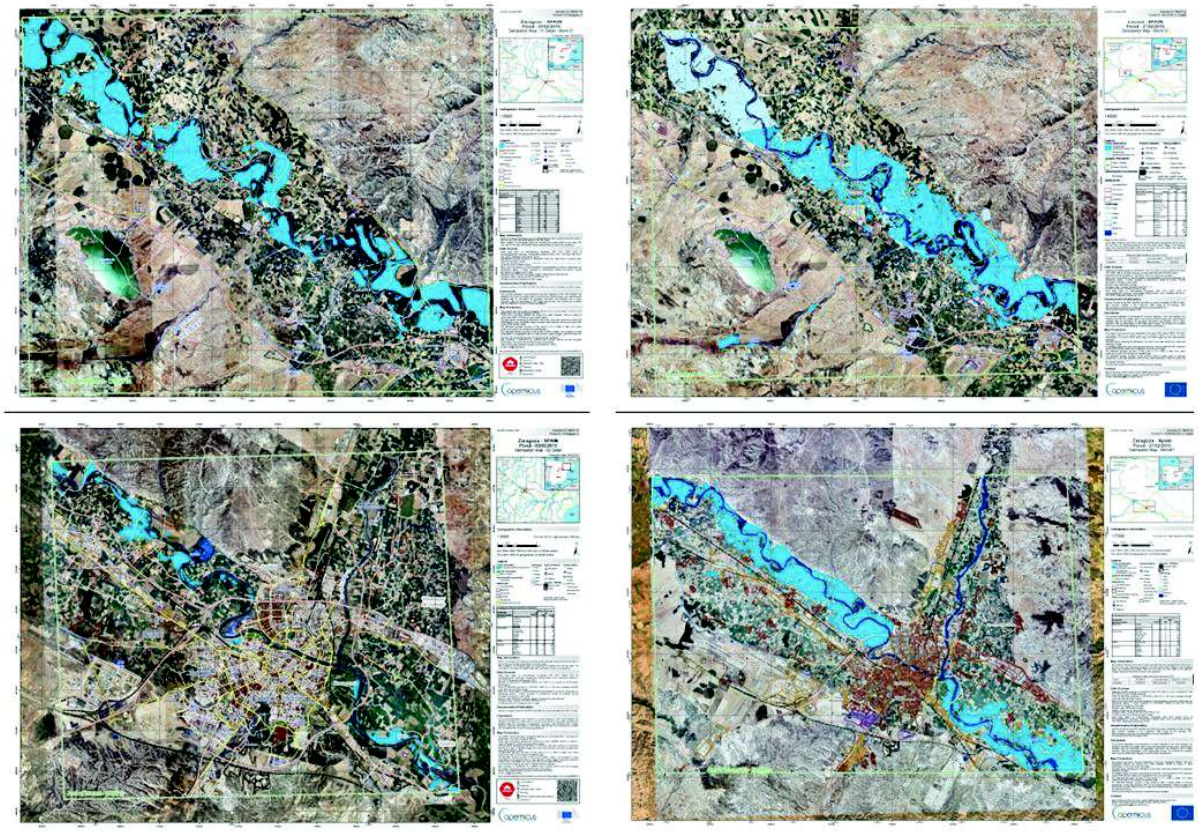
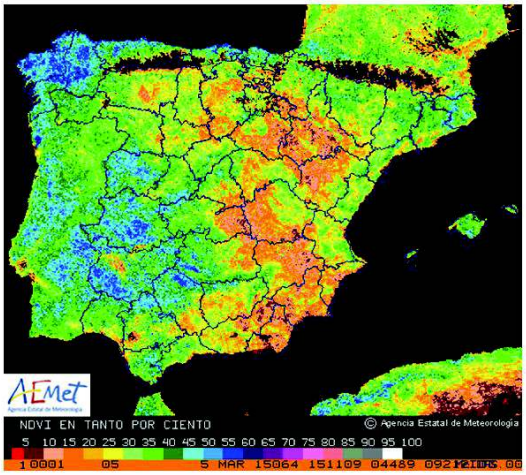


Figure 7.4.6 *Example COPERNICUS supplied photos of the first two episodes left of February to early March right (Spain's AEMET Agencia Estatal de Meteorología - State Meteorology Agency)*

From March 4, rainfall in northern Spain began to recall being, from day 6, all Spain under the influence of high pressure with clear skies and temperature rises.
Furthermore, the vegetation growth and decreased soil moisture are favouring the reduction of circulating flows.



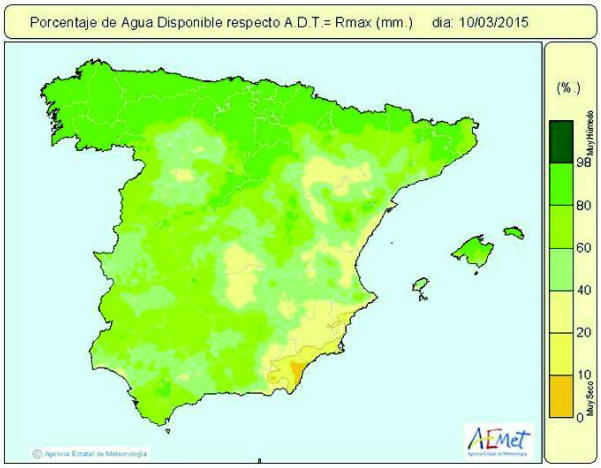


Figure 7.4.7 *Ground vegetation and soil moisture content at present (Spain's AEMET Agencia Estatal de Meteorología - State Meteorology Agency)*

Starting on March 2, when the tip of the avenue came to Zaragoza, with a flow of 2,600 m3 / s and a level of 6 meters, the upstream hydrological situation was stabilizing, largely by laminating jobs Confederation was made and also because rainfall throughout the basin subsided.

The tip Avenue entered the river Ebro Mequinenza dam on 4 March. Upstream the downward trend it was already across the basin.

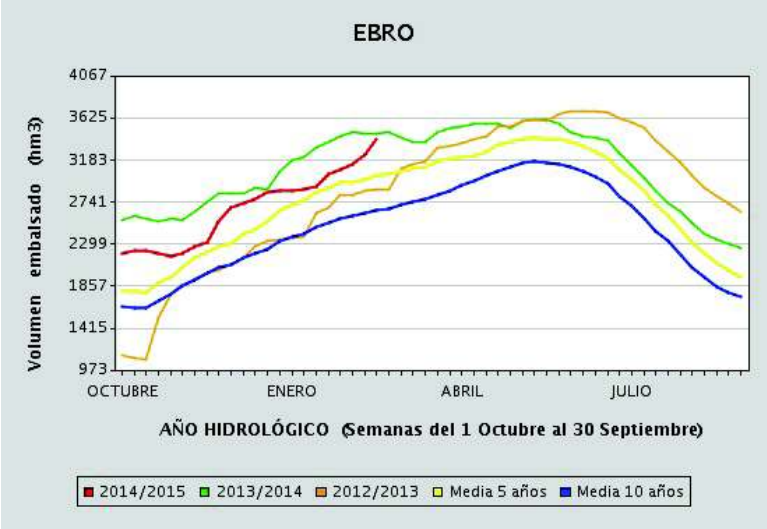


Figure 7.4.8 *Location filling the reservoirs of the Ebro consumptive use (Spain's AEMET Agencia Estatal de Meteorología - State Meteorology Agency)*

The trend of filling the reservoirs remain well above the average of the last 5 and 10 years, but still below the hydrological year 2013/2014.

On the other hand, the amount of snow on the mountain systems remains below the levels of the 2013/2014 season and although there snowfall forecast for the weekend, is not expected in the short term a new episode of rapid ice run though you need to remain vigilant, given the huge amount of snow on the peaks.

Until the arrival of the tip avenue Mequinenza, the system that form the Mequinenza-Ribarroja-Flix has maintained discharges constant of 1,550 m^3/s, but on the morning of March 4 discharges Flix were increased to 1,800 m^3 / s to absorb the peak inflow of 2,500 m^3 / s which was reduced. So, on the evening of 5th inflow into the reservoir it was equal to the output, ie 1,800 m^3 / s, stabilizing the reservoir. These levels desembalse remained until early Monday afternoon 9 when dropped to 1,650 m^3 / s, while the entree was 1,400 m^3 / s. On the 11th, the inflow to the reservoir of Mequinenza was 900 m^3 / s while the discharge flow was less than 1,400 m^3 / s, the elevation of 119.92 meters above sea level reservoir being, representing 94.8% filling with respect to its normal maximum. Discharges similar to these and circulated by the lower Ebro in April 2007 and May 2008.
With these desembalses the Mequinenza-Ribarroja-Flix system were avoided major conditions in the lower Ebro, though gauging stations of Ascó and Tortosa remained on alert for several days, until yesterday that recovered its normal state and the Confederation the Ebro river ended the event of floods.The following graphs can be seen as the Tortosa gauging station had very high levels, exceeding the threshold for a few days of the 5 m, considered Alert at this point, and reaching 5.5m from day 4 March until the 10th, when they began to fall very sharply.

Likewise, in Ribarroja reservoir increased contributions is observed from day 4 through March 10, with occasional downs due to withdrawal. And on day 10 it is considered that the reservoir is in a normal situation but with a stored volume of 95%.

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8. Glossary and Acronyms

Alluvial Fan
A geomorphologic feature characterized by a cone or fan-shaped deposit of boulders, gravel and fine sediments that have been eroded from mountain slopes, transported by flood flows and then deposited in the valley floors and which is subject to flash flooding, high velocity flows, debris flows, erosion, sediment movement and deposition and channel migration.

Area Drainage Master Plan (ADMP)
A plan which identifies the preferred alternatives of those identified in an ADMS. An ADMP provides minimum criteria and standards for flood control and drainage relating to land use and development.

Area Drainage Master Study (ADMS)
A study to develop hydrology for a watershed, to define watercourses, identify potential flood problem areas, drainage problems and recommend solutions and standards for sound floodplain and storm water management. The ADMS will identify alternative solutions to a given flooding or drainage problem.

Base Flood/100-Year Flood
A flood having a 1 % chance of being equaled or exceeded in any given year. This flood is sometimes called the 1% or 100-year flood.

Base Flood Elevation
A base flood elevation (BFE) is the height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929, the North American Vertical Datum of 1988, or other datum referenced in the Flood Insurance Study report, or the depth of the base flood, usually in feet, above the ground surface.

Basin
The area of land that a river drains. This is used to determine how much water will enter a river after rainfall.

Bypass Channel
The construction of a new channel in order to convey stormwater runoff around an area. Usually required due to right-of-way considerations or to avoid environmentally sensitive areas.

Channel
An open conveyance of surface storm water having a bottom and sides in a linear configuration. Channels can be natural or man-made. Channels have levees or dikes along their sides to build up their depth. Constructed channels can be plain earth, landscaped, or lined with concrete, stone, or any other hard surface to resist erosion and scour.

Channel Modification
A man-made change to a channel's characteristics, typically for the purposes of reducing flood damages by increasing its overall conveyance. This can be accomplished by widening and/or deepening the channel, reducing the friction by removing woody vegetation or by lining the channel with various materials.

Confluence
The intersection of two or more streams, or where one flows into another.

Conveyance
The ability of a channel or other drainage element to move stormwater.

Crest
The highest value of the stage or discharge attained by a flood; synonymous with Flood Peak, thus peak stage or peak discharge.

Deposit
Something dropped or left behind by moving water, as sand or mud.

Discharge
The amount of water that passes a specific point on a watercourse over a given period of time. Rates of discharge are usually measured in cubic meter/feet per second.

Drainage Area
The area (acres, square miles, etc.) from which water is carried off by a drainage system.

Drainage Basin
That portion of the surface of the earth which is drained by a river and its tributaries, or which is occupied by a permanent body of water (lake, pond, reservoir) and all of its tributaries.
Alternatively, a geographical area which contributes surface water runoff to a particular point. The terms "drainage basin," "tributary area," and "watershed" can be used interchangeably.

Emergency preparedness
is a programme of long-term activities whose goals are to strengthen the overall capacity and capability of a country or a community to manage
efficiently all types of emergencies and bring about an orderly transition from relief through recovery, and back to sustained development. It requires that emergency plans be developed, personnel at all levels and in all sectors be trained, and communities at risk be educated, and that these measures be monitored and evaluated regularly

Erosion
The wearing away of land by the flow of water.

Erosion Hazard Zone
Land adjacent to a watercourse regulated by Maricopa County that is subject to flood-related erosion losses.

Flash Flood
A flood which follows within a few (usually less than six) hours of heavy or excessive rainfall, dam or levee failure

Flood
A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties (at least one of which is the policyholder's property) from one of the following:

- Overflow of inland or tidal waters
- Unusual and rapid accumulation or runoff of surface waters from any source
- Mudflow
- Collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood as defined above

Flood Control
Various activities and regulations that help reduce or prevent damages caused by flooding. Typical flood control activities include: structural flood control works (such as bank stabilization, levees, and drainage

channels), acquisition of floodprone land, flood insurance programs and studies, river and basin management plans, public education programs, and flood warning and emergency preparedness activities.

Flood Crest/Crest
The highest value of the stage or streamflow attained by a flood; it is the top of the flood wave.

Flood Damages
Flood damages usually are classified as tangible or intangible. Tangible damages are the replacement costs or monetary loans resulting from the effects of floodwater and debris on crops, soil, buildings, furnishings, goods, roadways, utilities and levees; the added costs of protective efforts, evacuation and emergency care; and losses because of the interruption of commercial activities. Intangible damages are those which are difficult to measure in dollars, such as harm to life and health, inconvenience and discomfort.

Flood Damage Stage
Generally comparable to "flood stage", but may be somewhat higher or lower than official flood stage designations; refers to the stage in a stream at which damage becomes significant at any specified location, whether caused by overflow or other causes.

Flood Duration
Generally, the total length of time the stream is above "flood stage"; however, the term "flooding duration" may be used top designate the length of time a flood stage equals or exceeds any specified stage.

Flood Hazard Boundary Map
Official map of a community issued by the Federal Insurance Administrator, where the boundaries of the flood, mudflow, and related erosion areas having special hazards have been designated.

Flood Insurance
The insurance coverage provided through the National Flood Insurance Program.

Flood Volume
The total volume of runoff during a flood, which is equal to the average rate of flow multiplied by time (flood duration). The term "inches runoff" is sometimes used to designate flood volume, which means that the flood volume would cover the drainage area above the point of measurement to a uniform depth equal to the number of inches specified.

Flood Warning
A warning issued by the NWS to warn of river flooding which is imminent or occurring. A flood warning is issued when a river first exceeds its flood stage, and it may be reissued if a new river forecast for a forecast point or reach is significantly higher than a previous forecast

Flood Plain/Floodplain
The lowland which borders a river, usually dry but subject to flooding. Also the portion of a river valley which has been inundated by the river during historic floods.

Floodplain Regulations
A general term applied to the full range of codes, ordinances and other regulations pertaining to land uses and construction within flood plains.

Floodplain Management
A program that uses corrective and preventative measures to reduce flood and erosion damage and preserve natural habitat and wildlife resources in floodprone areas. Some of these measures include: adopting and administering Floodplain Regulations, resolving drainage complaint, protecting riparian habitat communities, and assuring effective maintenance and operation of flood control works.

Habitat Mitigation
The compensation for the removal of natural vegetation during the construction of a flood control project by establishing new vegetation elsewhere.

Hazard
Any phenomenon that has the potential to cause disruption or damage to people and their environment (1).

Hydraulic Structures
The facilities used to impound, accommodate, convey, or control the flow of water, such as dams, intakes, culverts, channels, and bridges.

Hydraulics
The analysis of water or other liquid in motion, and its action. Also a field of study dealing with the flow pattern and rate of water movement based on the principles of fluid mechanics.

Hydrology
The scientific analysis of rainfall and runoff, its properties, phenomena and distribution; as well as water dynamics below the ground and in the atmosphere.

Percolation
The movement of water through the subsurface soil layers, usually continuing downward to the groundwater or water table reservoirs.

Physical Weathering
Breaking down of rock into bits and pieces by exposure to temperature and changes and the physical action of moving ice and water, growing roots, and human activities such as farming and construction.

Retention Basin
A basin or reservoir where water is stored for regulating a flood. Unlike a detention basin, it does not have outlets for releasing the flows, the water must be disposed by draining into the soil, evaporation, or pumping systems.

Return Period
The average time interval between occurrences of a hydrological event of a given or greater magnitude, usually expressed in years.

Risk
The probability of harmful consequences, or expected losses (deaths, injuries,
property, livelihood, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerabilities.

Risk Reduction
involves measures designed either to prevent hazards from creating
risks or to lessen the distribution, intensity or severity of hazards. These measures include flood mitigation works and appropriate land-use planning. They also include vulnerability reduction measures such as awareness raising, improving community health security, and relocation or protection of vulnerable populations or structures.

Runoff
Surface water resulting from rainfall or snowmelt that flows overland to streams

Saturation
Determines how much rainfall can be absorbed by soil. Rainfall on ground that is completely saturated turns immediately to runoff.

Scour
Erosion caused by rapid flow of water.

Sediment
Soil particles, sand, and minerals washed from the land into aquatic systems as a result of natural and human activities.

Storm Water/Stormwater
Precipitation from rain or snow that accumulates in a natural or man-made watercourse or conveyance system.

Tailwater
The water surface elevation in the channel downstream of a hydraulic structure.

Thalweg
The line of maximum depth in a stream. The thalweg is the part that has the maximum velocity and causes cutbanks and channel migration.

Tributary
A stream that contributes its water to another stream or body of water.

Urban Flooding
The inundation of streets, basements, ground level floors of buildings, et cetera in urban areas.

Vulnerability
The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.
The degree to which a population or an individual is unable to anticipate, cope with, resist and recover from the impact of a disaster.

Watershed
An area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community

Zoning
The division of an entire area, such as a county or municipality, into zones, with the type of construction and use allowable in each zone fixed by law. Zoning is carried out under the provisions of a State zoning enabling law.

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