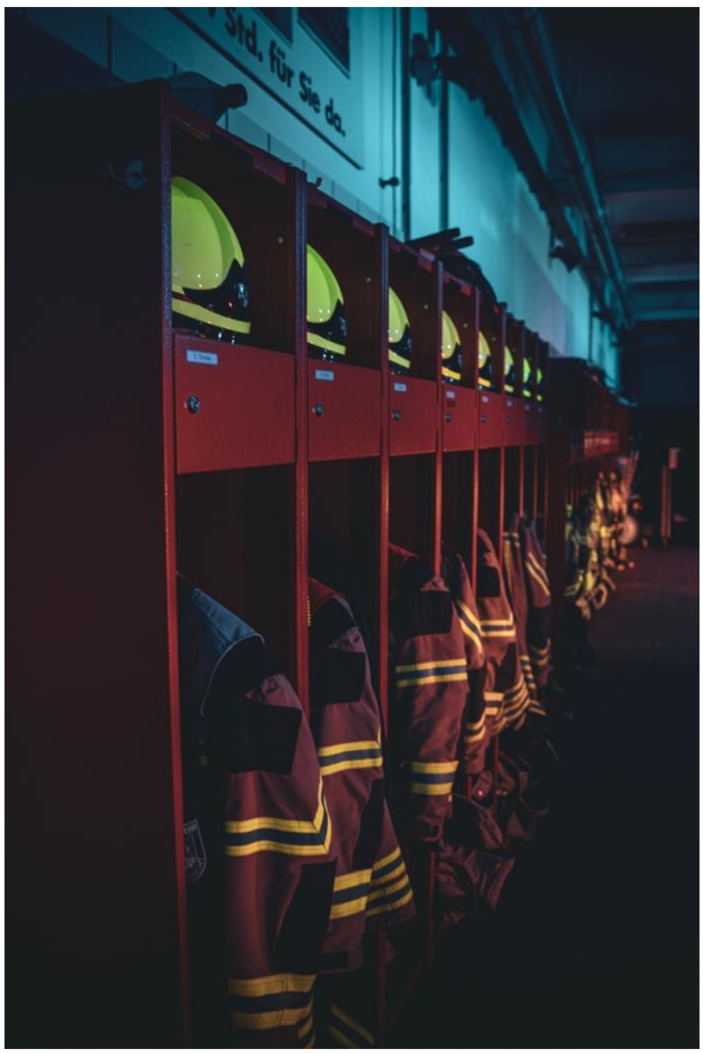
# *Twenty Innovative Best Practices from Leading Countries in Disaster Prevention and Planning and Their Possible Implementation in the Bulgarian Black Sea Coastal Region*



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## Aim of Study and Methodology

The current study aims to identify at least **20 existing innovative best practices** in Disaster Preparedness and Prevention (**DPP**) and evaluate the feasibility of their implementation in the Bulgarian Black Sea coastal region. These practices will be sought **among leading countries in the field**, with expected contributions from at least 5 different nations.

The following is a rigorous study of good European and global practices for disaster prevention measures already implemented with prevailing success. Such research landscape is characterized by certain disaster features and inclinations of the various implementing institutions which have led us to explore those systems and programs that have reported back measurable and adequate action to deal with accidents and disasters. Most of the measures against critical events are dedicated to preserving **natural resources** and minimizing their **impact on human society**. We provide examples of real situations recorded historically by mostly developed countries. Such interventions have often prompted new and updated measures to deal with unplanned phenomena, as well as their timely reporting to society.

The main benefits of this study are conveyed by the bringing together of innovative technologies (technical means) and systematic approaches (policies) that deal with environmental disasters and accidents – and are more importantly deemed as **relevant and applicable in the Bulgarian Black Sea region**. Most of these would also be applicable to various additional partners and stakeholders in different stages of their Disaster Preparedness and Prevention efforts; thus, even indirectly related institutions and entities could borrow and adapt innovation in the field. Ultimately, achieving the above goals will be instrumental in promoting a **more effective DPP ecosystem** and **more efficient emergency management institutions** and **practices** in the subject Region and its trans-regional partners.

In seeking to reach the above objectives, we will need to explore actual solutions via the **comparative approach** – analysing the nature, goals, history, and background of how these solutions came to pass and why they are effective in their context of application.

In light of current events such as Covid-19 and a chain reaction of socio-economic vulnerabilities which it unlocked, even more developed societies have shown their potential vulnerabilities and certain scenarios which could leave them exposed. Often, achieving sufficient **regional capacity** to prepare and prevent such critical events is simply beyond reach, as it requires a working **national DPP system** or even transnational cooperation platforms.

However, we have found out in our previous studies that most of the actual Disaster Risk Reduction (**DRR**), Preparedness and Prevention (DPP) occurs on a local and regional scale – actually implementing identified measures and executing monitoring afterwards. Therefore, a generally efficient emergency management requires a well-structured and well-developed regional system.

As noted above, we will employ an exploration of the sector through the methods of **comparative public policy**. Largely based on an explicit methodology, it has a close relationship with sociology and economics, as well as other political sciences. Actual comparisons need both an access to **case studies** and **statistical databases**.

Case studies are utilised in a number of ways: to generate hypotheses and describe them, to confirm an already identified theory or attempt to expose exceptional scenarios (exceptions). Publicly notable cases are relatively easy to identify and analyse, yet they do not allow for far-reaching **generalisations**. Statistical inference, on the other hand, is employed to **control identified relationships** by confronting values and observing their importance to the overall hypothetical trend by altering or tracing a certain set of variables.

Quite essentially, such comparisons help **identify most significant hazards** faced by policy makers and emergency services, the varying impacts of historical or potential disasters on given regions and nations, as well as the degree of vulnerability in those locations and areas. We will see that in the below segmentation of global regions.

One common principle which defines most DRR/DPP managers is the fact that disasters and recurring critical events are almost always segmented into five distinct phases: **Prevention, Mitigation, Preparedness, Response, and Recovery**. Even where those are not categorised in such a way, they represent functionally such stages in facing a disaster matched to a region's specific vulnerabilities and capacities. Planning and operational responses are divided accordingly as well: the twenty existing innovative good practices that our study will outline below are to be considered according to their **relevance to one or more of the above five phases** of emergency manifestations.

Another common trend is also notable on a global level: the need for increased application of **innovation and technology** in DRR. Such technological integration has never been greater, as it fosters new developments and implementation scenarios of more effective **evidence-based approaches**. The **Sendai Framework** for Disaster Risk Reduction encourages better access and support for innovation and technology as well as **increased investment** in DRR to develop new innovations that are both cost-effective and beneficial when applied in all disaster management phases.

As a result, inevitably, the field of emergency management is increasingly being **professionalised** and internationalised. City and Regional emergency managers are now more knowledgeable than ever before in the past, including as a result of shared international experience, technology and transnational cooperation initiatives. This is a trend which suggests an increased effort to expand this particularly valuable area of public service on a global scale.

Hence, the best practices below will also be assessed according to their **added value** – in terms of beneficial political and organisational culture, socioeconomic status of participants (interest groups, institutions), public policy relevance, mechanisms of decision making and development.

Lastly, such good practices are also evaluated according to their **potential applicability** (in our subject region) and **likely implementation success** (by territorial, technological or environmental specifics), as well as any other particular local and national factors.

## Territorial Specifics Determine DPP Approach

National and regional **experience determines risk perception** and preparedness quite inevitably. While many anthropic factors are similar and require proven contemporary DRR measures, natural and complex environmental factors differ greatly over climatic, resource and geographical realities. Statistics and analyses of trends over the past few decades confirm that disaster potential and impact is growing everywhere but the types of events that define local experiences are based mostly on a country's **natural and environmental conditions**. Those come before cultural, societal and organisational paradigms, as well as the nation’s ability to use technological solutions efficiently.

Broadly defined – according to statistical data and even media reports – Asian nations are more commonly exposed to hydro-meteorological hazards such as floods and typhoons; they also have droughts and epidemics in some macro regions.

**African** critical events are related to a wide range of extreme natural phenomena: floods, droughts, earthquakes, cyclones; African countries also face relatively frequent epidemics and food security emergencies, the only continent which is notoriously exposed to the latter. Man-made threats such as terrorism are increasing in the past couple of decades as well.

**South and Central America** faces geological disasters with a certain frequency – Chile, Ecuador, Mexico and Costa Rica all have had to deal with volcanoes relatively recently. Mexico has suffered earthquakes damages. Hurricanes, floods and droughts are all regular hazards for this macro area.

**North America** most notably deals with hazards such as earthquakes, tornadoes and hurricanes, most notably the United States. California has frequent earthquakes, while tornadoes threaten the Midwest. Hurricanes from the Atlantic pose risks to the Eastern states. Characterised by big open spaces (facilitating weather event transitions), this continent is exposed to a variety of climatic and natural disaster risks. Canada is no exception, as its northern parts face regular severe winter storms. Ultimately, terrorism has risen to a new critical level of particular risk, especially since 2001.

**Europe** also faces a growing number of climatic risks – floods and heat waves mostly (the latter inducing fires in the same areas), as some countries report destructive earthquakes. Along with the **Middle East**, they have also had to face a growing terrorism threat over the same period, as integrated preparedness mechanisms require technological, organisational and even philosophical and psychological expertise in reducing and handling critical events. Events in Germany, England, Spain and Israel are only some of the visible cases. Emergency personnel has had to constantly update its methods, upgrade technology and re-evaluate mitigation and response procedures, as it is very hard to predict an onset of such an event.

*Figure 1. Number of serious disasters reported by continent and most hit countries (2019) – Centre for Research on the Epidemiology of Disasters (CRED).*

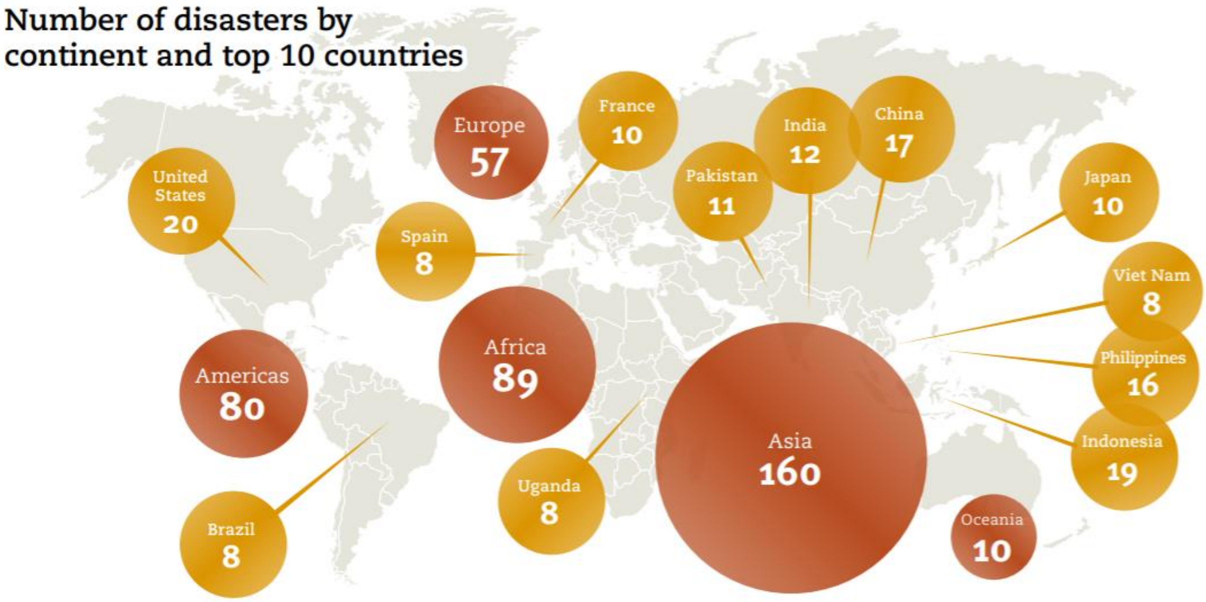
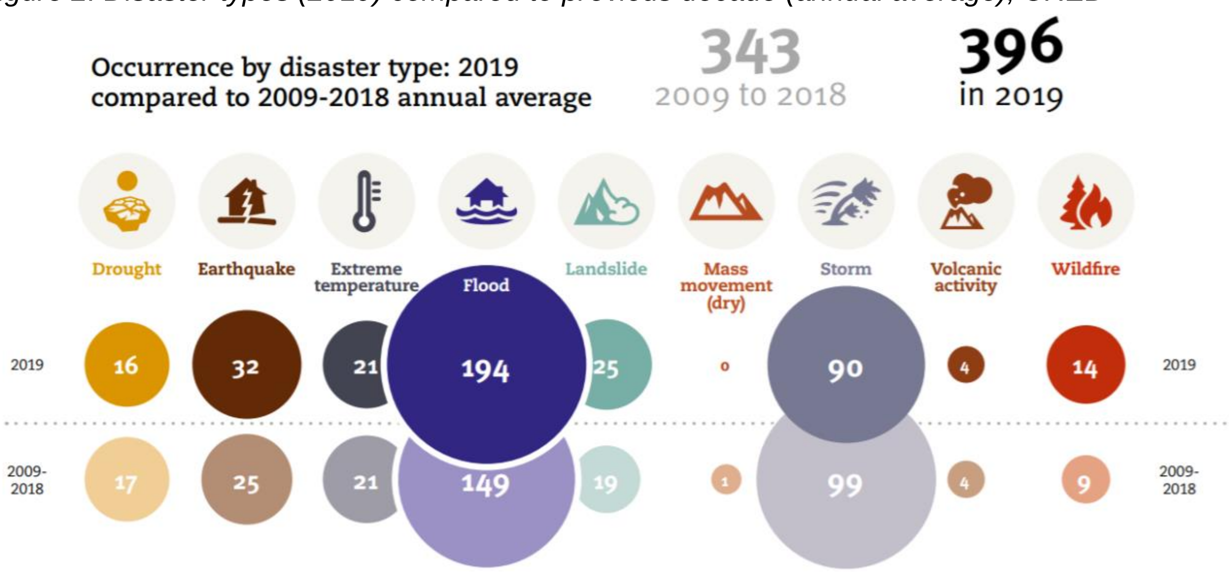



*Figure 2. Disaster types (2019) compared to previous decade (annual average), CRED*



We can see from the above statistics that significant disasters are spread out, more or less evenly by continent, affecting the entire planet. Larger countries report more important critical events. Evidently, for all continents and on an average base, the number of disasters has kept rising in the past decade, with 2019 surpassing the total average to date. Floods have been – and remain – the most relevant critical event, followed by various storms, extreme temperatures and geological disasters such as earthquakes and landslides (the latter often induced by flooding and sometimes by human activity).

Therefore, nations and macro-regions inevitably develop their DRR capacity and DPP management approaches as a response and according to their typical natural, climatic and most characteristic anthropic (human) activity for their territories. Natural (environmental, climatic, geological, etc.) risks, however, lead in importance, impact and influence on local DPP specifics.

According to a list of countries by natural disaster risk (known as the **World Risk Index**, calculated by the UN University "Institute for Environment and Human Security", UNU-EHS), **Bulgaria is in 52$^{nd}$ place** as an averagely threatened area, with a coefficient of 4.22% - equal to that of Australia and Just before Italy.

The latest data comes from the 2017 World Risk Report (WRR) and is published in collaboration with the German think tank (Bündnis Entwicklung Hilft, BEH), systematically considering a country's vulnerability according to its **exposure to natural hazards and risks**. The WRI includes 28 indicators based on globally available open data and serves to generate rankings and maps which allow for certain comparisons between countries. More importantly, the indicators influence the WRI in a weighted manner, as risk are considered higher where **societies** themselves result "**vulnerable**" and have less capacity to prepare, respond and rebuild.

As noted above, a crucial observation is pervasive in all reports and statistics – the frequency and severity of disasters has only increased over a single decade, let alone when compared to several decades ago. The UN has consistently reported a steady increase of disasters across the globe. UN agencies which deal with climate, security and recovery efforts have been insisting on more concrete measures and a global review of the reasons and mitigation steps, especially over the past 20 years (most notably in its 2004 International Strategy for Disaster Reduction, **UNISDR**). The Strategy has been established with a mandate to "enable all societies to become resilient to the effects of natural hazards and related technological and environmental disasters, in order to reduce human, economic, and social losses" (UNISDR, 2005).

Once again, as with the WRI index, the UNISDR reports reiterate the concept and methodological observations that the most severely affected regions and countries are those with low or medium income, or those which rank lowly on the overall scale of the **Human Development Index** (known as a composite index of life expectancy, education, and per-capita income indicators). Considering the generally even distribution of natural extreme events which we saw above, reports have been consistently placing the majority of more destructive disasters in **predominantly developing areas**. This is simply because they lack the capacity, experience, funding and know-how in the DPP sector. Subsequently, when disasters strike a developing nation, it also reports a high number of damages and casualties, and it is unable to rebuild in a fast and disaster proof manner for upcoming potential critical events.

The World Bank Group (WBG) also reports in its more recent summary findings that disasters continue to affect the poor and vulnerable the most. From 1998 through 2018 alone, WBG data shows that **91% of storm-related fatalities** were in low- and middle-income countries, even though these countries experienced just 32% of storms. This comes to confirm our above findings regarding largely **equal distribution** and emphatically **unequal impact**. Thus, disasters continue affecting all nations but in very different ways.

Numerous examples from developing nations and macro-regions corroborate these findings. The tsunami that hit **Asia in December 2004** (in the aftermath of an earthquake in the Indian Ocean) left nearly 230,000 people dead, according to the 2005 USAID report. This made it one of the deadliest disasters in modern history and it **changed significantly** the way in which countries in South-East Asia approach **tsunami preparedness** from that point on – including signs, procedures, national and local drills, equipment, etc. Yet, they do not have a lasting solution to a threat which is frequent and quite substantial when it comes to their buildings, logistics and overall land-use planning.

In fact, it is namely **unsustainable development** and inefficient land use planning which has rendered the losses from natural disasters so high in particular areas. When **spatial planning** is superficial and not based on data and long-term DPP, it does not allow for basic needs to be met, including local environment protection and potential upgrades to the DRR ecosystem, if and when there is the capability to do so. Hence, underdeveloped and underprepared nations tend to "focus their resources on issues [other than] disaster preparedness". They **deal with a disaster when it hits**.

On the other hand, the long-term effects of disasters in **developed nations** are felt more strongly in the **economic sector**. Although their economies are better prepared to absorb higher losses and their capacity to rebuild back are based on long-term planning and better financing, disaster-hit areas in developed countries suffer short-term economic impacts and effects on their local productivity more significantly.

The WBG 2016 "Shock Waves" report states that almost **75% of "unplanned" economic losses** are attributable to **extreme weather events**. Our own analysis on statistically relevant disaster impacts in Bulgaria's Black Sea region (in the previous study segment) have shown that **natural disasters lead** in every possible statistical way, both social and economic.

This is precisely why – increasing international cooperation aside – it is our intent and study purpose to look at more developed nations; those which **prioritise preparedness and mitigation, reinforce planning and prevention mechanisms**.

Without a doubt, the accumulation of related resources and overall wealth of developed nations has been allowing them to continue allocating funds to upgrade, improve and reinforce mitigation and preparedness measures. And then there is also the question of **efficiency**. Making up for some organisational and financial shortcomings is possible through **best practice mirroring** – this is undeniably one of the optimal and ethically advisable shortcuts to acquiring a more **sustainable approach** to **superior planning** and **efficient resource deployment**.

Unsurprisingly, countries which are **leaders in the field** and have been praised in reports and cooperation programmes for their exemplary DRR approaches (and actual results) are often the ones which fund, produce and disseminate **topical studies** aimed at **identifying hazard-prone areas** and **recommend appropriate DPP measures**.

Leading countries have elaborate **training systems**, established and regularly reviewed for optimal preparation of their disaster response teams. Everyone – from first responders to community volunteers – is able to easily access training so that they can quickly and efficiently respond in a crisis.

Furthermore, efficient DPP systems rely on **education and technology**, in order to develop advanced **early warning systems (EWS)** for the general public and to raise their population awareness in a shared and comprehensible manner.

Ultimately, vulnerability to disaster risks is multifaceted. In part, it is due to natural and environmental conditions. And then there are the anthropic factors with an even greater degree of complexity. Thus, integrated risk **vulnerability** is defined as a measure of **proneness to disaster** along with a society's ability to effectively **withstand or react** to adverse consequences ("proneness" in terms of the risk liability susceptibility and "coping" in terms of resilience and recovery, as some scholars have put it).

On one hand, fortunately, even as critical events rise in frequency and impact, **Bulgaria** and the **Black Sea coastal region** remain largely spared by the more destructive natural forces and scenarios. On the other hand – as we noted in previous study segments – there is much to be improved in our DPP systems, and there is much to be learned from the leading countries in the field.

Both the positive and negative features associated with the Bulgarian and Black Sea physical and social environments include the same determinants and variables which make the difference in other DPP systems – **land use planning, politics, economics, culture, psychology, engineering, technology use, institutions**.

No developed nation claims to have a perfect emergency management program, even those which are universally considered DPP leaders. In comparison, however, developing ones typically lack education, funding, and equipment to reduce their vulnerability. Bulgarian society needs to improve its **institutional efficiency, living conditions and weak warning systems** so that it can improve its overall DPP capacity and standing among its peers.

## Factors and Trends which Influence DPP Capacity Building

Certain environmental elements and anthropic actions and traits are **common** to most of the Earth's population, impacting similarly the risk profiles of an area. Others conditions are distinct – and where these outline a specific background for the Bulgarian Black Sea coastal area, we would attempt not to take them into consideration for our analysis, should they produce incomparable outcomes for both territorial risk profiling and DPP response.

However, there are certain global factors and trends which have altered the perception of DRR effects and needs, and they continue to exercise important systematic consequences on contemporary socio-economic ecosystems. In those, of course, we count our subject Region of reference. There are:

- **Relevant macro-trends** which influence DPP as a coordinated response;
- **Important positive developments** of global development which we have to loop up to;
- Finally, there are those that are **actually applicable** to the subject Region, separately from any analysed reference DPP frameworks

We also need to emphasise the fact that we are **not deliberating** most purely environmental factors and trends which affect our societies at present – such as global warming and other **climatic changes**. Those are at the foundation of any systematic and integrated risk profile of a given region but they do not alter significantly the socio-economic capacity of better developed nations to organise an efficient DPP system or a coordinated DRR approach. Most of the relevant impact factors – if not all – lay within human capacity, social organisation and reciprocal anthropic interaction with natural elements and manifestations.

## Urbanisation

This global trend is **pertinent to all societies** – better or less developed, more or less vulnerable to general and specific risks. While in principle it may be true that cities manage to avoid many disasters due to a better or more concentrated infrastructure, resources and response mechanisms, it is also true that urban areas suffer major losses and have a population concentration which worsens existing problems and creates new ones, out of pure scarcity of those same precious resources needed to optimise DPP.

Almost everywhere, population growth and fast urbanization tend to act as factors which increase disaster risks. As of today, about 55% of the global population lives in urban areas, with the Americas above 80% and Europe at 74% (Africa is the only continent where urbanisation is slightly under 50%). The UN has estimated that **more than two-thirds** of the world's total population will live in cities by 2050. The WBG "Aftershocks" Report expects these trends to put around 1.3 billion people and an estimated USD 158 trillion of assets at risk – considering **river and coastal floods** alone.

Quite simply, the increasingly high density of people, activities and assets make cities attractive but it also makes them extremely vulnerable to a wide range of natural and manmade risks and critical events. The environment, the global industrial chains and many social systems are already under a lot of environmental and economic strain as it is, and population density clearly worsens these effects.

As we noted above, this is a macro factor which affects practically all countries. Along Bulgaria's sea coast, Varna and Burgas districts have statistically more of an urban population compared to Dobrich district. In fact, within its urban settlements, **Varna city** alone reaches **74% of the total district population**, without even considering its largely urbanised outskirt areas and smaller towns functionally belonging to its hinterland.

Another WBG report, "Lifelines", estimates that general investment in more resilient infrastructure can provide a net benefit in low- and middle-income countries of up to USD 4.2 trillion in a midterm perspective, with **USD 4** in direct benefits **for every USD 1 invested**. Such investments are especially relevant for urbanised areas, as they can improve the quality and **resilience of essential services** – such as transport, water and electricity supply – and thereby contribute to more resilient and prosperous societies. Where there is larger population concentration, such an approach seems crucial.

The Bank's "Social, Urban, Rural and Resilience Global Practice" bureau insists that "rapid [urban] growth without efforts to **boost resilience** exposes cities to huge risk". Both **population growth** and **human migration** are on the rise. Along with known climatic changes, this sets the stage for critical events of dramatic proportions, "a tipping point for the safety of cities all over the world". Therefore, investing in resilience measures can contribute to a safer and more sustainable future for cities and their urban population.

There are, however, many **objective obstacles** that limit resilience investments, especially in developing countries and cities:

- **lack of local capacity** in planning, implementing and, crucially, **financing** resilience projects;
- common challenges in project preparation include **high up-front costs**;
- a profound **lack of confidence** on behalf of the private-sector – especially to co-invest and share responsibility for something which is not immediately beneficial.

Once again, these challenges are commonplace in regions which lack optimal or even sufficient-level DPP systems. Nevertheless, they outline, statistically and empirically, a much more frequent case in currently developing countries and macro-regions.

There are, fortunately, certain initiatives and approaches which **might help improve** such conditions and shortcomings. Local authorities and societies might:

- Institute a local **policy framework** which **encourages resilience**, for example, by passing and implementing modern and well-enforced building codes;
- prepare and/or favour a number of **investor-ready projects**, including by setting up a kind of a Public-Private **accelerator** system for resilience investments. Institutions have to

incentivise (make easier and more attractive) investors to fund resilience projects in their area;

- facilitate or prepare own **sectoral analyses** of hazards and specific risks, including project design and **delivery challenges** and **acceleration scenarios**.

## Build Back Better

The “Build Back Better” approach (BBB) has seen its establishment as a cornerstone methodology in approaching any recovery and restoration efforts in developed crisis management systems. The mainstreaming of disaster risk management studies and practices has led to development planning which aims at reversing current trends that see disaster probabilities and impacts still rising.

Essentially, when institutions or nations rebuild after a disaster (of any proportions), they need to do it **stronger, faster** and **more inclusively**. This has proven to reduce impacts on human lives, health and economic well-being by as much as 31%, cutting average global losses while reproducing its benefits locally. Such figures and estimates are provided by the Global Facility for Disaster Reduction and Recovery (GFDRR) in its partnership study.

Destruction caused by disasters paradoxically leaves territories not only with the need but also with the **opportunity** to build back better. The Sendai Framework for Disaster Risk Reduction (adopted in 2015), in its Priority 4 recognises reconstruction as an opportunity to build more resilient societies – and that does not imply only infrastructure but also DPP governance and procedures. Societies which prove to be prepared to make the best use of such unfortunate times are able to withstand subsequent critical events by better managing risks they face. They learn their lessons, e.g. locate buildings outside flood zones, design structures to resist storms; project and execute roads, bridges and electric grids that are able to endure severe weather. Overall, settlements may end up with a better quality of life and higher productivity, on top of being more disaster resilient. Above all, **efficient recovery** undoubtedly **reduces the impact and costs** associated with **future disasters**.

Intrinsically, the **recovery** process includes three main stages:

A) **Relief**, including search, rescue and medical care;

B) **Restoration** of basic services – water, food and sanitation supply; followed by energy, mobility and regular health care;

C) **Reconstruction** – a phase which looks at infrastructure: repair and replacement of buildings and equipment; as well as asset recovery for enterprises and households.

The last stage is the longest and most expensive one in territorial recovery. Although the BBB concept is intended as an integral part of the entire cycle, it is namely in the last stage that it provides the most added value and contributes to a more resilient society.

The UNISDR emphasises the proper use of recovery, rehabilitation and reconstruction phases to increase community resilience by "**integrating DRR measures** into restoration of physical infrastructure and societal systems". A comprehensive approach needs to enable the revival of quality human life, together with the economy and the environment.

This all-around concept has three vital qualities as cornerstone elements of every single recovery stage – rebuilding **faster, stronger** and **more inclusive**. These are easily explained by looking at the humanitarian aspect of reacting quickly and efficiently to societal emergencies; by understanding the above added future value of quality recovery in infrastructure and institutional governance; but above all by looking at those same costs and economic impacts which are suffered when recovery phases take longer. The below figure presents average losses experienced by some of the leading countries in terms of economic losses from disasters, should complete recovery take anywhere from one to five years.

***Figure 3***. *Average well-being reduction due to faster recovery: top 10 affected countries*


*The top point shows well-being loss associated with five years of reconstruction, the bottom point corresponds to a one-year period. Percentages indicate loss reduction in case of successful speeding up of recovery efforts.*

We can see that the United States and China lead in total net amounts, due to extended territories which are subjected to extreme events and disasters. But they are also among the leading ones in terms of potential efficiency, should they be able to reduce the recovery process. India leads in potential “savings” in case of a faster and more efficient effort but those numbers are comparable for most of the heavily affected countries. Japan and Italy seem to have existing recovery systems which allow them to come back strong even in the case of a longer recovery process.

In any case, even considered on a case by case basis, there are significant benefits in implementing a post-disaster recovery process which is stronger, faster and more inclusive for local societies. Naturally, those benefits are maximized if achieved together.

Exemplary challenges include managing acceleration at the optimal cost and time, not at the expense of quality (strong). And inclusiveness should not come at the cost of ignoring cost efficiency completely. But any sensible local and national government, infrastructure investors and financial bodies understands the message of **spending better rather than spending more**.

## Use of Innovative and Disruptive Technology – ICT, Big-Data, Media and Engineering Solutions

Technological solutions and systems are regularly used in everyday security operations as much as they are useful in DRR. Clearly, innovative processes and disruptive technology change the state of play and there is a healthy amount of competition in the security sector between leading producers, contractors, countries and defence treaties. When it comes to disaster risks and humanitarian efforts, more often than not, there is also a global sense of duty to collaborate, to share and help, even directly by conceding resources, equipment and specifically trained personnel.

Safety experts tend to divide technological solutions into three separate categories according to a basic set of criteria for each one:

- **Process technology***:* Implementation know-how for best practices, capacity building and knowledge-based social development;
- **Implementation-oriented technology***:* Implementation strategy that leads to tested and proven outcomes.
- **Transferable local knowledge***:* Traditional and reliable DRR know-how that is "indigenous" to specific regions but has the potential to be replicated with similar effects in other regions.

While these may not sound like technological solutions per se, those are namely the main types of innovative breakthroughs that mark the added value of some DRR practices. Each of those, in turn, has **contemporary technological applications** related to the sector, more or less disruptive in their own right. We are considering solutions both inherently innovative as a concept or in terms of application methods. Technological solutions come as a secondary and instrumental aspect, under each of the above three categories.

When we analyse advanced technology, most cases deal with **high-tech electronics**, **deep-tech and big-data computing applications**. Such technology may not be disruptive in another sector, as it has been tested and proven to do other tasks, unrelated to DPP. However, we have to recognise those solutions which affect positively disaster management and have been implemented with lasting success.

It is difficult to identify and bring out one or two particular technologies as examples in the sector, given the rapid expansion, scope and impact that many solutions have had in their own niches. On the other hand, some have markedly influenced our existence and daily culture, including safety and security, preparedness and reaction to disaster scenarios.

**Social media platforms** (e.g. Facebook and Twitter) and **messaging services** (e.g. are notoriously global successes that have all been applied in emergency events, with varying success. **Big Data** is implemented at a growing speed in security and safety solutions, **robots** and **Artificial Intelligence** (**AI**) remain largely experimental but much hope has been placed on machine learning for risky operations. Given the rapid evolution and intense competition in some of those subsectors, achieving larger-scale impacts requires perseverance, time and intensive investments in research and skills. However, that seems to be the way forward, as **drones** are almost universally exploited with greater frequency, while **Internet-of-Things (IoT)** solutions are increasing in application – i.e. sensors, trackers, warning devices and various connectivity platforms.

Technological giants have gained substantial **experience** over the past decade, and much of that has been **passed on** to horizontal and vertical stakeholders among **businesses, public institutions** and **citizens**. Average costs of such technological solutions continue to fall as they become more accessible and widespread. Currently, they are completely integrated – at least as **complementary instruments** – to older legacy technology, security and communication systems such as satellite imagery, seismometers or simple mobile text messaging. Together, they serve local authorities and DPP agencies in **detecting, monitoring** and **accessing disaster data**, as well as communicating with the public at various stages.

One sector where disruptive technology is expected to make substantial difference in the near future is disaster prediction. Artificial Intelligence (AI) solutions are intensively being tested for such a role, with improved algorithms and **Machine Learning** (**ML**) technology expected to provide important steps forward in the field. There is already ample evidence that AI can accurately **predict some disaster types** before they happen.

Still, disruptive technology applications today have a predominantly incremental effect in DPP, especially for countries which do not possess sufficient or sufficiently advanced solutions. Such technology serves to refine DRR activities and preparedness mechanisms – mostly by accessing and spreading critical information quickly and efficiently (including **Early Warning Systems, EWS**); by helping analyse and understand **disaster causes** and potential future developments, including **social phenomena**; by **assessing damage** (including upcoming economic impacts) and incrementing **digital databases**.

But truly disruptive technologies can and should do much more. They already improve situational awareness by providing the DPP community with clearer understanding of actual real-time processes – they are expected to contribute more in advance warning mechanisms which might help prioritise resources quickly and efficiently and reduce human suffering and economic impacts.

The below table presents the main types of advanced, innovative and disruptive technology that is currently employed or tested in the DPP sector (provided by the International Telecommunication Union (ITU), a United Nations specialized Agency for ICT.)

***Table 1.*** *Main categories of technology used in DPP (2020, ITU)*

| | Drones | Social Media | Big Data | Robots | AI | IoT |
|---|---|---|---|---|---|---|
| Urban | Dependent on regulations | Likely relatively high | Likely high | High | High | Yes |
| Rural | High except may not have supporting infrastructure for full functionality (e.g., 3G/4G mobile coverage) | Possibly low (depending on spread of ICT) | Possibly low (depending on level of financial inclusion) | Few examples | High | Subject to 3G coverage or installing communications system |
| Disaster phase | Response, recovery | Mitigation, preparedness | Recovery | Recovery | Preparedness | Preparedness |
| Costs | Medium | Low | Low | High | High | Low to medium |
| Complexity | Medium to high (qualified drone operators, establishing and interpreting data streams) | Low to disseminate; high to analyse and interpret | High (to analyse and interpret data) | Medium to high (to manipulate robot, interpret data and maintain the system) | High | Medium |
| Stakeholders | World Bank, NGOs, United Nations | Public, NGOs, government | Banks, UN | Government, private sector | Academia | Government, private sector |
| Regulatory issues | Air space regulation, data protection and privacy | Some countries have Internet filtering | Data protection and privacy | Ethics | Ethics, data protection | Data privacy and protection, environmental considerations |

## Leading Countries in the DPP Field

Being able to segment and identify the leading global actors (Nations) which define the state of the art in Disaster Prevention and Planning is an indispensable part of our study. With some exceptions, those are the countries that provide the leading examples and best practices in the field.

Undoubtedly, there has been a general and significant progress in the sector reported by numerous countries – from science-based decision making to science and technology advisory group and smaller-scale successful implementations with interesting scalable perspectives. Many good examples come repeatedly from a given macro-region – for example, the above-average Asian contribution to computing solutions from China, Japan, Malaysia or even the Philippines.

In terms of **applied science**, **China** is overall the **most prolific** in scientific output related to DRR and DPP (closely followed by the United States). **Japan** is the **most specialised** and also a very prolific country in terms of overall disaster science – such as research on management cycles and disaster sub-segments. **Indonesia** is among the most affected nations and is accordingly investing stably increasing amounts in **capacity building** and systemic initiatives. **EU** scientific citation impacts bring out the importance of the **UK, Italy, Germany and France**.

**Japan** alone has been emphatically relying on innovation and has published at least thirty relevant Innovations for DRR that include innovative products and approaches considered to be extremely effective. Most of those have already contributed measurably to reducing disaster risks in the country. Notably, there have been topical discussions and interesting publications by faculty and field experts coming from universities such as the University of Tokyo, Keio University, the local arm of the United Nations University, CWS Japan, and the IRIDeS centre of Tohoku University.

Japan is celebrated for responding brilliantly to critical events and preparing efficiently for future ones. An emblematic case is the 2011 earthquake and tsunami which served to establish a coalition of all relevant professional bodies and academic society under a so-called **Science Council of Japan**.

**Australia** and the **United States** are further examples of developed nations that have efficient and advanced emergency management institutions. The Australian national government has an emergency management program which focuses heavily on using **education to reduce vulnerability**. The USA is now requiring that communities develop **mitigation action plans** to address rising disaster losses. Their political and social reality requires them to also give attention to Weapons of Mass Destruction (WMP) preparedness.

Besides individual Member States' DPP programs, the **European Union** is notable for its **transnational projects and initiatives** that provide invaluable insights, cross-country comparative studies and aim to construct widely applicable toolboxes. We are providing some of those examples as a Best Practice below. And while difficult to call out one particular country for possessing a far superior DPP ecosystem, we can give the name the Swedish Emergency Management Agency (SEMA) which has been exemplary in answering societal expectations in terms of preparedness, training and effective coordination of the country's ability to respond to crises.

Developed nations are expected to face increased technological disasters, as computers have become integrated into every part of daily life. Other countries are continuing their struggle with repeated natural calamities as a leading cause of damages. However, both developed and developing nations are defined by their specific levels of **technological and industrial development,** as well as their **culture** as a way of handling critical moments, approaching **capacity building** and structuring their **institutions**. While people, businesses and institutions in both developed and developing nations continue to make mistakes leading to disasters or influencing local vulnerability, there are some **genuinely beneficial practices and systematic applications** which influence DPP capacity – and most of those come from the above-listed countries.

## Organizational Efficiency

Institutional efficiency and organisational structure are also defining factors in a nation's DPP capacity. Organisational efficiency can potentially have a critical (positive or negative) influence on overall effectiveness of local and national disaster organisations because it determines the speed, effectiveness and quality of response.

Among the main paradigms in this segmentation we have **centralisation vs. decentralisation** of services, capacity and decision making. Arguably, there are successful examples of both approaches.

**Bulgaria** has largely a **centralized approach** to its national emergency management, which is also the case in other institutional planning and response systems. While this provides a more distinct hierarchy, it often leads to **fragmented** and **reactive application** of DRR measures –

waiting for upper-level functionaries and command chain executives to apprehend, consider and communicate decisions down the operational chain.

Bulgaria's institutional and governance centralisation presents **remnants from former doctrines** favouring centralised planning in many areas of social and economic development. Part of a larger organisational tissue – even a mentality – it determines also some of the shortcomings of the national system which are seen in the Black Sea coastal region institutions as well (Varna, Burgas and Dobrich districts have relatively negligible capacity and ability to decide important interventions related to critical events).

The nation's Unified Rescue System (URS) has its articulation in terms of separate territorial independent units. However, they are often reporting to a central Coordination Office (a.k.a. **Disaster Headquarters**). And the more "important" the disaster turns out to be, the higher up the decision making goes. A practice which seems logical and almost natural, however it often disempowers local branches of government and territorial URS units. Quite frequently, even for less critical events (but with high media visibility) decisions are made directly from Sofia-based governance structures which would need at least a **better real-time situational understanding** and **enhanced data-based analytical reports** to be able to make better decisions than local authorities and field experts.

On the other hand, it is true that many other countries approach critical events in a similar manner, through national disaster coordinating councils, even when operating through various local agencies. Our object of analysis is and remains, however, Disaster Prevention and Planning – and it remains to be seen whether centralisation is predominantly efficient as a planning and governance approach. One thing is certain for the Bulgarian reality: while disaster planning may often be controlled by central governments, the capacity to focus on local risk reduction remains limited, and that is certainly the case with the Black Sea coastal area as well.

Where our system **lacks a comprehensive, organized, proactive, and participatory structure,** we need to identify **good examples that are replicable** in that perspective. And while country-specific actors, organisations, DPP management and activities may vary greatly, most **hazards, cultural aspects, historical perspectives, political objectives and current events** that influence DPP management are comparable.

## Categories of Innovative DPP Practices

A critical analysis of literature and case studies in the DPP field reveal certain principal categories which group best practices according to their organisational, scientific, technological or governance application and scale. We can segment these practices thus:

- **Scientific innovation in DPP** – Communities and institutions access, elaborate and exploit information related to disaster risks. Data-based decisions are justified and actionable. UN agencies (e.g. GFDRR) and the WBG encourage increased DRR information access and integration in decision making – including through better technological solutions and innovative applications. Those can further facilitate the understanding and management of disaster risks, improving subsequent reaction and societal resilience.

- **Resilient Infrastructure –** The absence of essential public services is severely noted in the aftermath of disasters. Restoration is just as essential as regular maintenance, financing and technical expertise. Resilient and efficient infrastructure integrates disaster risk management principles into its inherent design. The WBG "Lifelines" report reveals that disasters cost around **USD 18 billion annually** in in direct damages to **power and transport infrastructure** alone. Infrastructure disruptions produce subsequent and wide-ranging socio-economic costs, and a fundamental principle of DPP is investing into targeted resilience programmes which improve infrastructure performance (see the above example on USD 4 yield for every USD 1 invested). Strategies include increasing alternatives (redundancy); reviewing standards, methods, and materials; targeting improvements in response to climate changes.

Moreover, statistically, **9 out of 10 disasters are water-related**, creating **cascading risks** and effects through food, energy, urban, and environmental systems. Harnessing the power of natural solutions and "green" infrastructure – especially in the case of **sea transport –** may improve traditional infrastructure planning for our subject region. This will also generate services at lower total costs and boost regional resilience.

- **Scalable Urban Resilience** – Urbanization requires substantial and well-planned infrastructure investments to meet growing resource demands needed to ensure sustainable socio-economic development. Technological support to concrete and detailed information on urban risks (e.g. high-resolution insights according to layers of pertinence) provides the capacity to improve design specifications, especially those needed to build and support urban resilience. Having the capacity to plan for and mitigate adverse impacts of disasters and climate change means possessing the necessary technical expertise and tools to effectively plan for resilience; diversify financing sources to ensure that resilience investments actually are implemented; quite importantly, establish both local and trans-regional partnerships to support urban resilience objectives. **Spatial development**, environmental **threats to urban stability** and sustainable growth scenarios are comparable in that sense, and identifying best practices in this segment remains a prerequisite for our study.

- **Strengthening EWS – Early Warning Systems**, especially in the hydro-meteorological services segment, are essential in ensuring mitigation actions and preventing excessive negative impacts where possible. Mounting disaster costs have increased the need for accurate, timely, and actionable information on likely weather impacts and hydrological hazards. Hydrological and meteorological technical expertise and capacity building is essential to both governments and crisis management teams in providing a timely and adequate response to inevitable phenomena.

- **Financial resilience** – Natural disasters and hazards inflict economic damages which typically exceed available reconstruction and re-development funds. Financial instruments are indispensable in strengthening resilience of vulnerable regions and countries. Bulgarian institutions and businesses have both much to benefit from existing or innovative **risk financing instruments** on the market, as currently even standard insurances are underestimated and underused.

- **Engaging local society in resilience efforts** – This is a segment which is particularly beneficial for our study to explore and identify good practices. Bulgarian cities, including the coastal region, are lacking in non-governmental involvement and societal response to DPP policies and practices (partially because of the above-mentioned centralised approach). Local initiatives, socio-economic programmes, cultural and training programmes – all might bring closer local actors and citizens closer to the services needed to build up resilience, improve decision making and decrease inequality which might be generated as a result of critical events' impacts. Strengthening the overall societal resilience means also **including vulnerable groups** in community-led programmes and risk-management initiatives, **involving local experts** in DRM and urban adaptation to specific risks, delivering exemplary **communication and training** strategies.

- **Investing in response capacity** – This may not seem like an innovative or ground-breaking aspect of DPP. However, capacity building is arguably a continuing process, never static and always based on situational awareness. Disaster Risk Management is not an exception – first responders (fire, ambulance, police) and civil protection agencies need adequate, effective and timely support in terms of tools, equipment, communication and tech support, if they are to provide efficient relief to affected citizens and territories. Relying on outdated equipment, communications, power or other infrastructure adds failure risks instead of diminishing them. Changing urban and climate scenarios have brought improvements to DPP capacity, including specialised infrastructure, rescue equipment and innovative services. We will take an analytic look in an attempt to identify practical strategies and investment plans (often designed as a response to some specific risks and challenging events) that ensure civil protection authorities and first responders are ready for DRM and recovery operations.

- **Resilient recovery (Build Back Better)** – Disaster recovery, reconstruction and investment programs have a proven need to be guided by the BBB principle, even and especially where resources are scarce to begin with. Post-disaster damage and needs assessments are crucial, with superior planning and quality control all throughout the process of full recovery. Knowledge-based improvements are essential in developing and applying solutions by key DPP stakeholders. Capacity building in terms of planning for rapid recovery and preparedness for future disasters is just as pivotal as actual recovery efforts.

## Man-Made Disasters – Only Road Safety Included

A particular category is represented by the man-made (or anthropic) causes for disaster. Technical failures are also a result of something projected and built by humans, however such disasters are statistically and economically less relevant – advanced societies are better protected against them, developing nations are more impacted by natural events.

One exceptional group of man-made disasters are the **traffic incidents** which continue claiming lives and causing suffering, even though they are leading in terms of economic impacts or significant infrastructural damages. Road, railroad and air-traffic accidents are quite visible in all societies. **Road accidents**, in particular, are statistically most relevant – including in terms of frequency, injuries and fatalities caused. While larger logistic incidents are closer to the definition of real disasters, road accidents are serial small-scale critical events which are relevant enough to dedicate our attention particularly to **transport infrastructure** (and **regulation**) **improvements** which have proven to decrease systemic and participant vulnerability, as well as improve resilience in the passenger and logistics sector.

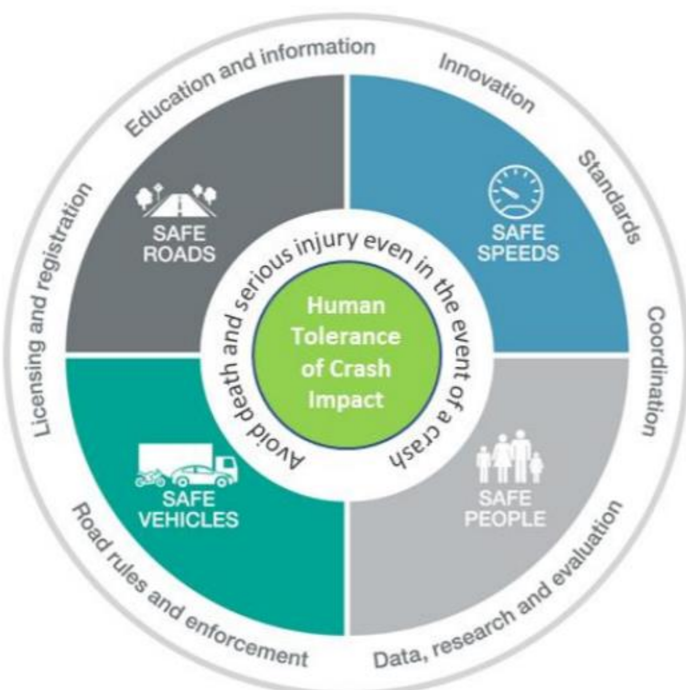
The International Bank for Reconstruction and Development (IBRD) publishes a Good Practice guide targeted at Road Safety investments, policies and standards. Its Annex on **infrastructure improvements** is especially relevant to our analysis, as these have been found to possess the greatest potential (and wide replicability) for generating lasting beneficial impacts on road safety. Moreover, recommended **policy interventions** (e.g. increased enforcement efforts) are segmented into those that are effective and sustainable, and those which are less so. Together, recommendations from leading road safety performance countries provide a set of proven and effective mitigation measures.

This is an area which Bulgarian national and regional authorities might find beneficial to explore in-depth. Many potential non-infrastructure mitigation recommendations (being less costly) are better directed at measures that have **compelling evidence** for having delivered road safety benefits. While certain road mitigation measures might be popular both with drivers and law enforcement institutions, these might report back mixed results or be less effective than what is commonly perceived. As with other good practices, road safety measures should be adopted based on an **evidence-based, data driven approach** towards actual risks (vs. potential ones) and reported lasting beneficial effects.

Recommendations are defined mostly through the perspective of reduction in Fatal of Serious Injuries (FSI, passengers and participants killed or seriously injured). Quite often, authorities go along with testimonials, popularity, third-party experts etc., while measures need to have proven their efficiency in the most substantial metrics, i.e. FSI.

The below figure represents the foundation of the Australian "Safe-System" Approach which we will explore in detail among the best practices below.

***Figure 4.*** *Principles of the Australian "Safe-System" Approach to road safety*




Aiming for a successful behavioural change in road safety (i.e. reduction in FSI) requires a review of infrastructural solutions, enforcement measures, as well as communication campaigns.

Developing a set of measures that are actionable as a strong general deterrent of risky behaviour is also described in the "Handbook of Road Safety Measures" by the Institute of Transport Economics in Oslo. Thirteen cornerstone measures of police enforcement and sanctions are segmented according to traffic law violations – speeding, seatbelt non-wearing, red-light running and driving under the influence of alcohol (DUI). Sanctions are mostly issued in the form of punishments, with some "rewards".

The below table reminds us that the **enforcement system** is generally three-fold:

• **Legislation**: Essential for approving an appropriate regulatory framework and penalties • **Enforcement**: Police officers citing law violators through fines, tickets and arrests; and • **Courts**: Case review, judicial outcomes carrying out sentences, dismissing charges or providing an in-between decision (i.e. reduced sentencing).

***Table 2.*** *Enforcement Measures and Effects on Road Crashes and Injuries, ITE Oslo*

| Measures | ***Effective***: Yes/ Mixed/ No | Impact on Road Crashes and Injuries |
|---|---|---|
| **Automatic speed enforcement** | **Y** | • Significant reduction in number of road crash injuries of about 16%, with a greater effect for fatal crashes than for others. |
| **Red-light cameras** | **Y** | • Side collisions, which are the target road crashes of red-light enforcement, were found to be reduced. • Found to lead to an increase in rear-end and total number of road crashes at junctions. |
| **DUI laws** | **Y** | • The two laws that have the greatest and best documented effect on road crashes are an increase of the minimum legal drinking age from 18 to 21 and a blood alcohol concentration (BAC) level of 0.02 for young drivers. |
| **Stationary and mobile speed enforcement** | **Y** | • Found to reduce crashes. • No effects on crashes when combined with general police patrolling. |

| | | |
|---|---|---|
| **Seat belt enforcement** | **Y** | • Found to increase seat belt use by about 20%. |
| **DUI enforcement** | **Y** | • Found to reduce road crash numbers, especially during the first months after the implementation of a new enforcement program or an increase in the amount of enforcement. Use of highly visible checkpoints where many drivers are tested, have been found to be most effective. |
| **Restrictions for DUI-convicted drivers** | **Y** | • Restriction for DUI convicted drivers includes license suspension, vehicle impoundment and alco-lock. License suspension was found to be effective in reducing road crashes while the license is suspended, but not after the license has been reinstated. • Vehicle impoundment was found to have greater and more long-lasting effects than license suspension, both among drivers who have a vehicle impounded and among drivers who are in danger of vehicle impoundment (e.g. because the license is suspended). |
| **Demerit point systems and license suspension** | **M** | • Demerit point system not found to reduce road crashes. • Warning letters and courses for drivers with critical numbers of penalty points may reduce the road crash involvement for respective drivers. • License Suspension was found to be effective only among drivers whose license has been suspended, and only while the license was suspended. • No effects were found on drivers in general or on drivers whose license was reinstated. |
| **Fixed penalties** | **M** | • Fixed penalties for non-use of seat belts were found to increase the use of seat belts. • No effects on speeding were found because increased fixed penalties for speeding. |
| **Treatment of DUI-convicted drivers** | **M** | • This includes educational measures with a focus on behaviour changes, and therapeutic measures with a focus on alcohol problems. Results from evaluation studies are inconsistent. • Educational measures may be effective in reducing recidivism among drivers without alcohol problems. Among alcoholics, education has no effect. • Treatment seems to be most effective in combination with sanctions. Some studies found increased crash involvement among drivers who had chosen treatment as an alternative to license |

| | | |
|---|---|---|
| | | suspension. |
| **Patrolling** | **N** | • No effects on road crashes found on most types of police patrols. |
| **Motor vehicle insurance** | **N** | • Stringent laws requiring liability insurance appear to have led to increase in road crash numbers. • Introduction of no-fault insurance and lower compensation limits also appear to lead to more road crashes. • Policyholders who have collision insurance have the same claims frequency as policyholders who do not have this kind of insurance. • Paying accrued bonuses in cash (reverse bonus system) has been found to be associated with a reduction of about 22% in crashes. |

Although a **national prerogative** in Bulgaria, these measures deserve a careful review by local and regional authorities as well, in terms of policies and practices that reflect what is useful and proven as producing a measurable impact. If institutions consider that cultural specifics and existing infrastructure does not warrant a direct application of the majority of such recommendations, an ad hoc study would help understand and apply some of them or alternative ones through a **data-based** approach.

One exemplary application of the **effectiveness of automated traffic enforcement**: As reported by several topical studies, automatic speed enforcement has an average benefit-to-cost ratio of 2.5. By comparison, the benefit-to-cost ratio of **point-to-point speed enforcement** is estimated between 7.4 and **12.5**.

Furthermore, **FSI reductions** are as high as **39%** through automated speed enforcement. For **red light cameras** alone, they have been found to significantly reduce crashes due to red light running – as high as 63% in New Zealand's largest metropolis, Auckland. At the same time, there can also be an increase in minor 'rear end' crashes where following vehicles had anticipated the preceding vehicle to run the light.

One important consideration – Automatic traffic enforcement should **not be used** as a **revenue-raising activity**. Studies report that this "blurs the line for the public as to whether governments use the device for safety or for fiscal reasons and may **harden attitudes** towards their use". As a counter-example, **Swedish** authorities only activate speed safety camera enforcement for about **10%** of the time even though the radar-based speed measuring system works continuously. This enables the Swedish Transport Administration to monitor actual vehicle speeds without drivers feeling they will be penalized for every minor speed violation. They ensure that cameras are positioned where they are required, and not only on major roads just because vehicles travel at higher speeds to **identify where there are problems on the road**.

## Twenty Best Practices Identified as applicable for the Black Sea Coastal Region

When analysing DPP good practices – both on a **systemic** level and in terms of concrete **applications** or tools – we have to keep in mind that there are also a **local**, **regional/district** and a **national dimension** to these solutions. Therefore, when accepting a particular policy or practice as beneficial and applicable to the Bulgarian Black Sea coastal reality, we also intend that such a replication might have to involve local authorities, district administration or national agencies and government ministries or departments.

Thus, we are evaluating both systemic and concrete interventions which are realistically applicable to the **Bulgarian reality**, part of which is the Black Sea coastal region of the country. This means also that a current distribution of responsibilities, jurisdictions, delegated functions and many other factors might **influence the potential effectiveness** and **efficiency** of implementation of most of these opportunities – and that for those parameters to improve, the pertinent stakeholders might have to adopt some changes.

In the below list of good practices, we will proceed from the **general** towards the more **specific** solutions; from an overall DPP approach and a systematic framework for beneficial conditions towards more circumstantial, narrow applications, including technical and engineering applications.

## 01 – A Culture of Preparedness

**Japan**

Following the above-defined approach in narrowing down best practices, we start with the nation which is universally recognised as a **global leader in disaster preparation** – Japan. In fact, it is indispensable to break down this nation's DPP paradigm into reasons, methods and certain exemplary initiatives which make its preparedness, mitigation and response establishment superior in many ways.

Put simply, Japan's all-around "**culture of preparedness**" is responsible for its leadership in the field. That, and of course some inherent regional conditions, **environmental specifics** and traditional **efficiency prerequisites** in a nation which lives on a delimited and exposed territory (mostly on three large islands), and lacks any significant natural resources to sustain its socio-economic well-being and growth.

It is said that Japan is sitting on a "Ring of Fire" – the submarine arc of seismic activity in that particular area of the Pacific Ocean. Consequently, Japan is one of the most **earthquake-prone** countries globally. This is one of the initial and principal factors which drives the nation to be the excellently prepared and equipped to handle earthquakes. Even in the past 100 years we might cite the 1923 earthquake and the 1995 Kobe disaster. In between, Japan suffered an almost complete destruction in many of its important areas during the two World Wars. And gradually, its society has learned how to be prepared and has been accumulating **cutting-edge knowledge, skills and equipment**.

This "readiness leader" marks its **Disaster Prevention Day** on September 1, and has done so every year since 1960 (marking the anniversary of the 1923 Tokyo quake). Japanese schools have regular evacuation drills, many even on the first day of classes. The country's leaders emphasize regularly the importance of "mutual aid" during critical events. An often reminded motto is "**Providing is preventing**".

Japan's **EWS** are, globally, the **most sophisticated**, especially in relation to earthquakes. Public and private entities take the initiative to organise **emergency drills**, simulate the transportation of "stranded" commuters one point to another. Linked closely to quakes' EWS, Japan's **tsunami warning service** has been set up in 1952. It consists of **300 sensors** around the archipelago, with **80 aquatic** sensors among those. They monitor seismic activity non-stop and the network is designed to **predict the location height**, **speed** and **arrival time** of **any tsunami** heading their coasts. Essentially, tsunami safety has been integrated a prerequisite for **coastal city planning** throughout Japan's territory. On the East coast tsunamis hit more frequently, and hence, hundreds of **tsunami shelters** have been built, including being **earthquake-proof**. Many of Japan's vulnerable cities have their own tsunami walls and floodgates to limit the waves from entering the river system inland.

Japanese buildings are also extremely well-made and engineered for earthquake impact. Since the early 1980's, Japan has **updated** significantly its **building codes and guidelines**, facilitated by earthquake science. The Kobe earthquake claimed more than 5,100 lives and prompted another national-level academic and technological review on earthquake safety and disaster management. The last thorough building code revision was in 2000 – mandatory checks were added to the specific requirements.

Local authorities and regional institutions have the resources, capacity and persistence of will to pursue greater preparedness than ever before. An example at hand is the **investments** made by Shizuoka prefecture in priority improvements between 1979 and 2009 alone – USD 4 billion dedicated to **improving the safety** of hospitals, schools and social welfare facilities. As a result, although Japanese cities are often shaken, they rarely suffer significant destruction, at least in the past 25 years. And in any case, whatever the extent of potential and occasional death and destruction, it would be much worse if not for Japan's "hard-earned culture of preparedness".

We will take a look at some of Japan's initiatives, measures and national or local approaches to preparing for earthquakes. Many of those are useful and valid for other types of disasters, as the DPP ecosystem is in place and always ready to respond.

### *1. Technology and Engineering in Play*

First and foremost, Japan permits and builds only **earthquake-resistant buildings.** Given the regularity of such events, all constructions should withstand certain levels of tremor. Rigorous earthquake-proof standards are set by law, applying (especially) to schools and office buildings where crowds gather. Even with older buildings considered, around 87% of Tokyo is earthquake-resistant.

Some structures employ **engineering solutions** that make them literally **flexible**, others are built upon a **Teflon-type foundation** which allows them to move along the shockwaves. Some even have "**inflated, rubber, or fluid-filled bases**" that absorb tremors. Ancient wooden pagodas have also provided earthquake resistance ideas in terms of construction approaches and shapes, having survived through the centuries.

Then come the **earthquake-resistant trains.** Japan's public transportation system is dominated by trains and the shinkansen (bullet) trains are the most characteristic ones, planned and executed for a foreseeable future. Safety measures include earthquake **sensors** that allow any moving train to be halted almost immediately. Consider the 2011 quake – there were dozens of high-speed trains moving at that moment. Every single one was able to stop because of the "pre-quake" sensors resulting in zero deaths or injuries during a **9.0 magnitude** tremor.

A final example in the category is provided by an impressive engineering system in the outskirts of Tokyo – the **Water Discharge Tunnel**. Built under a sports complex, it collects flood waters caused by all types of water-related natural disasters, mainly cyclones and tsunamis. Then, it gradually redistributes the water into the Edo River. When an earthquake is followed by a tsunami in the Tokyo area, the city is thus safe from any significant flooding threats. It cost the local government a lot of time and resources it has already paid off many times over.

### *2. Cross-over Preparedness*

**Smartphones** are everyone's pocket computers nowadays. In Japan, every device has an earthquake and tsunami **emergency alert system** installed. Linked to the sensors and high-tech systems that protect the majority of the territory, it is able to send a notification a **few seconds before** an impending disaster, giving citizens some time to seek immediate protection. The system notification persists (voice, vibration, etc.) until the earthquake stops.

Japanese **earthquake survival kits** are also not a straightforward matter of being equipped, rather than a result of the national systemic approach. Every household has such a survival kit stocked with **first aid** equipment, water and food **supplies**, face masks and gloves, insulation sheets, as well as other **survival tools** like torches and classic radios that **receive and broadcast** updates. Many stores even sell complete packaged sets.

### *3. Public Awareness and Training*

Probably the most relevant aspect – even and especially for countries with lesser financial capacity – Japan's public awareness programs are what really make a difference. **Immediate TV coverage** is ensured by all channels: official broadcasts ensure the population is informed and well-advised on how to stay safe. Event details, protection facilities and tsunami forecasts are all part of the transmission, giving time and valuable **support to citizens**.

Learning from the past is also deemed as essential as preparing for the future in Japan. Its **Earthquake Memorial Museum** is located in Kobe, a fitting place for a city which suffered more than 5000 deaths from the 1995 earthquake. The museum has an education centre, interactive displays and training facilities on disaster prevention, preparedness, protection and survival.

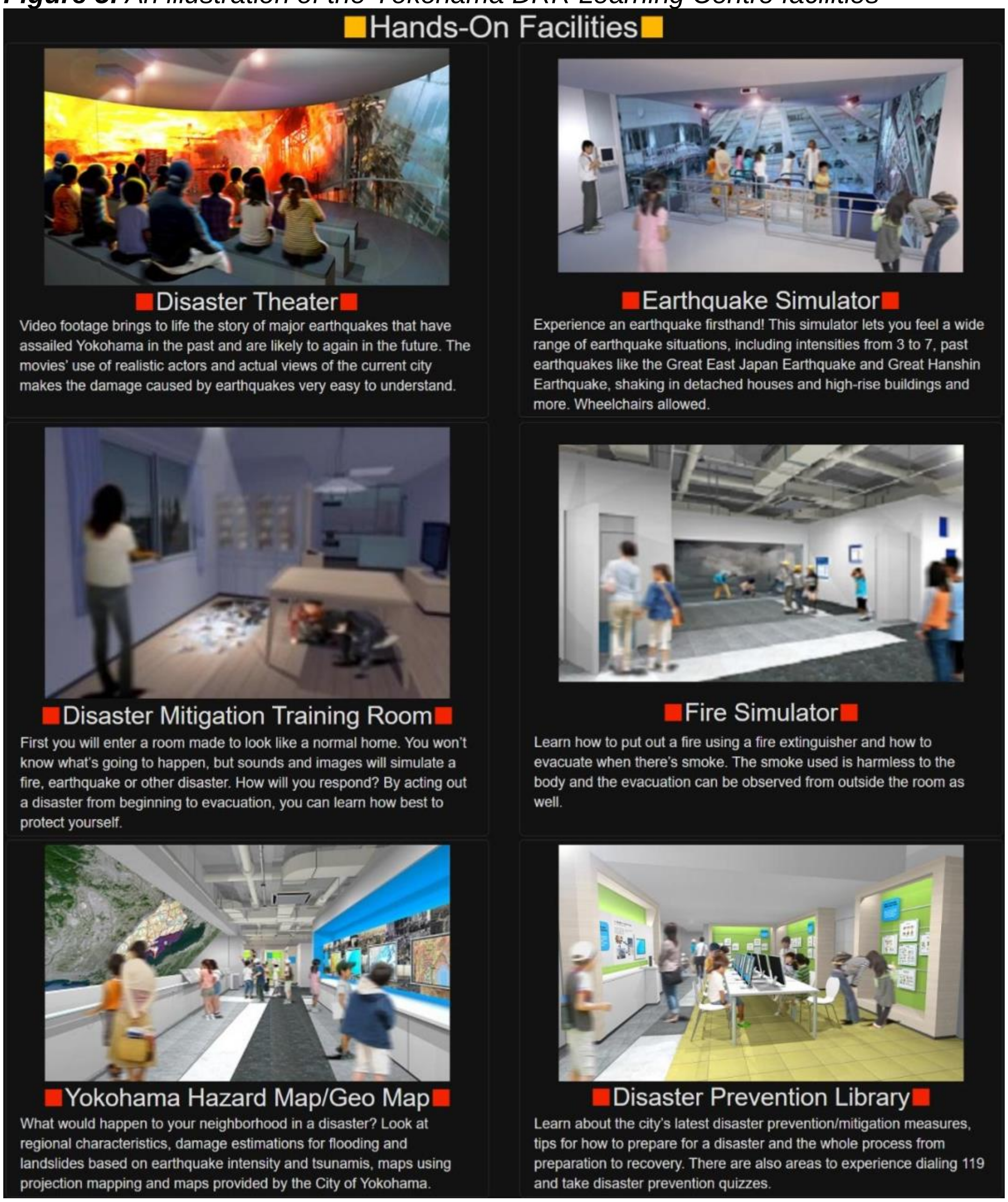
The country's stance on disaster **awareness programs** and quality **education courses** on disaster prevention runs much deeper. Many schools around the world hold occasional safety drills, with general-purpose procedures for alumni and staff. Japanese **schools** run them more often (some even once a month) and concentrate on quakes. It is from a very young age that children are taught the proper ways to seek protection and stay safe in a disaster-hit area. **Field trips** to fire departments include simulated situations, getting young citizens familiar with the feeling so that they react calmly and orderly during the actual event.

Two facilities in particular have an impressive capacity, experience and resources in providing coordinated DPP support and training and awareness programmes:

**The Tokyo Rinkai Disaster Prevention Park** is the central base of DPP operations in the Tokyo Metropolitan Area. Besides emergency response facilities (e.g. local disaster management headquarters), it houses institutions that compile disaster-related information and support coordinated emergency disaster measures.

**The Yokohama Disaster Risk Reduction Learning Centre** is an emergency response centre for critical events in the area. Built to improve citizens' DRR knowledge, it also stores emergency supplies and materials. Quite significantly, it has a number of **hands-on training rooms**, impressive **simulators** and **exposition areas** which provide a constant support to citizens with invaluable programs and daily activities.

***Figure 5.*** *An illustration of the Yokohama DRR Learning Centre facilities*



Some important conclusions are due, following the review of the above Japanese national approach. It is true that many of the above solutions might not be realistically applicable to the Bulgarian DPP reality and the Black Sea coastal socio-economic conditions. Having said that, many new-generation sensors are quite affordable nowadays, while other engineering solutions might be taken as guidelines (flood-channels, e.g.) and be interpreted through a more basic and cost-effective replication. Crucially, it is the overall approach that counts. Ultimately, lessons to be learned include:

- an enhanced understanding of the importance of **public risk communication and awareness initiatives** on DPP; those are largely replicable under certain conditions and scaling-down some of the intensity of preparation;

- regular **urban and community planning initiatives** that focus on DRR.

## 02 – A Flexible and Evolving National Recovery Policy

**United States**

The United States is also an unquestioned leader in the DPP field – especially in terms of high-tech equipment and cutting-edge solutions, as well as abundant security financing. The country's **particular (federal) structure**, sheer size and distribution of jurisdictions and responsibilities make it somewhat complex when it comes to management efficiency and longer-term planning.

Decades of experience and pursuit of higher security and safety levels – more recently related to human threats such as terrorism – have led the US to develop a largely **flexible DPP policy** on both Federal (national) and State levels.

**Initially**, the national DRR and response structures were built on the principles of federalism, leaving it a primary responsibility of **local and state** governments. Federal assistance supplemented larger and cross-state efforts. Some of the more significant disasters in recent US history have, however, demonstrated gaps in such a disaster policy – the **2001 terrorist attacks**, **2005 Hurricane Katrina** and **2011 Hurricane Sandy**.

Consequently, a process of **centralization of post-disaster** recovery governance has been carried out at both national and state levels. Fears that this would undermine local recovery authority have been countered by better efficiency and intervention capacity. For the size of the country – and some of the disasters it is subjected to – the approach is currently paying off, despite not having formal roots in many cases.

The Federal Emergency Management Agency (**FEMA**) coordinates federal participation in **DRR, DPP** and **recovery** efforts in all domestic disaster scenarios. FEMA also administers **individual assistance, public assistance** and other mitigation grant programmes. Other agencies in play (with significant federal funding) include the Department of Housing and Urban Development (HUD), the Economic Development Administration (EDA), and the Department of Transportation (DOT). U.S. Congress may also supplement resource allocations, including by tax credits, grants and loans to help states and local governments finance recovery efforts.

Important financial support is provided by the **National Flood Insurance Program** (NFIP). Although in principle funded by flood-prone property owners, it is additionally funded by the government and is the largest disaster recovery program. Around 6 million policy holders pay close to USD 4 billion in annual premiums for **flood insurance**. Promoted and supported by the US Government, the NFIP provides **insurance settlements** for flood losses, and, more significantly, **post-flood recovery alternatives** via funds for buyouts of flood-prone properties. Further down our analysis, we will analyse other financial incentives and programmes from other countries, considered good financial practices.

**How the 2012 Hurricane Sandy changed the scene**

In October of 2012, Hurricane sandy hit hard much of the north-eastern United States, resulting in 159 deaths, immediate displacement of 26,000 people in 16 states; 650,000 homes damaged; long-term housing displacements for an estimated 200,000 people. It also led to serial power outages for millions, closed roadways, transit, rail, airports, and ports for extended periods of time.

FEMA led the recovery efforts, activating all support functions provided in its **National Disaster Recovery Framework** (NDRF), appointing recovery coordinators for the most heavily impacted states. A **Rebuilding Task Force** was established with a presidential order, and it consisted of representatives from all relevant federal agencies, as well as an advisory group of elected leaders from the most affected areas. Charged with supporting rebuilding efforts, in August of 2013 the task force published 69 **policy recommendations**.

Congress approved a USD 50 billion package of disaster assistance, mostly designated to **repair highways, railways, and public transport**, including USD 11.5 billion for FEMA programs and USD 5.4 billion for the U.S. Army Corps of Engineers to repair, restore, and rehabilitate coastal properties and to provide flood protection.

The role of New York City and State administrations was directed mostly towards the analysis of storm's i**mpacts on buildings, infrastructure, and people**; an assessment of city's **risks from climate change in the medium and long term**; and an effort to outline **strategies to increase resiliency**. Local agencies worked on recovery and rebuilding mostly with FEMA coordination and supervision.

**Notable recovery features** included a large-scale housing repair program, voluntary home buyouts and funding aimed at improving housing infrastructure. Mitigating future floor risks was at the foundation of all rebuilding efforts, especially in the seafront communities of New Jersey and New York.

Most importantly, innovative Federal, State and Local recovery approaches were established. The "**Rebuild by Design**," a design competition promoted innovation by developing **resilient construction plans**. A large seed fund was set aside for winning projects and the 6 multidisciplinary design projects that were designated as winners were transformed into actionable public infrastructure projects.

The "**Stronger, More Resilient New York**" plan included 257 initiatives competing to strengthen the coast and upgrade building stock, Critical Infrastructure and services. The city allocated consistent funding to make neighbourhoods safer and more resilient.

The State Governor launched the "**Community Reconstruction Zone**" Program enabling **communities to directly develop and propose recovery plans** focusing on damage, future threats and economic opportunities. Communities had their local committees, while the State provided them with planning experts, tools and guidelines. FEMA also provided assistance and supplemental funding for highly rated initiatives which went above certain limits. A total of 66 committees from 100 communities were successful in applying and realising their recovery projects.

It is evident that despite being a nation at the forefront of technological and security standards, the United States **did not have a unified approach** in place **for complicated, far-reaching and prolonged critical scenarios**. On the other hand, a higher degree of flexibility played to their advantage in recovery and restoration aspect, since they learned and built upon experiences from 2001, 2005 and 2012.

Continuing to seek an **optimal recovery model** requires situational awareness, (even empathy), expertise and responsibility, as well as financial mindfulness to national, regional and local fiscal stability. When the short-term priority was to speed up financing and reconstruction efforts, federal agencies overrode established mechanisms and allowed timely interventions along with due accountability.

A **multi-State** implementation of the **NDRF was first tested** after 2012 events. Task forces coordinated the larger federal programs but left much of the implementation on local and state institutions and associations – even planning and project development. Both ends of the spectrum came to the understanding that DPP and Building Back Better are essential in the broader context of necessary action on **climate change adaptation** and **long-term risk reduction**.

Despite successful recovery campaigns in such critical times, US authorities plan for further **systemic simplification** of the perceived fragmentation, aiming for a more **streamlined yet flexible approach**. A noticeably growing federal role in post-disaster recovery should be limited to general policy and funding. The importance of local leadership is paramount, especially in terms of DPP action plans and local priorities.

Notwithstanding a centralisation trend in some of the planning and priority setting (usually politically motivated by scale, visibility, etc.), the successful examples of decision-making and operational chains in New York, New Jersey – as well as Louisiana and Mississippi – provide

**good examples of bottom-up planning, policy, priority-setting, communication** and attention to local capacity and necessities. Put simply, national-level agencies have taken the lead when time and large-scale financing was of the essence, while state (regional) entities and associations were the driving force when sustainable long-term reconstruction was needed to plan for a more resilient future.

## 03 – Wildfire Control and Mitigation Planning via Satellite Imaging (and a parallel with EU's Copernicus Satellite Monitoring Services)

**Australia – EU**

Much has been written about technological innovations and their potential to change the way we view and understand our surroundings. With time, many such real-world applications have raised our hopes of achieving a greater societal resilience in the face of critical events and disasters.

**Satellite-based earth observation** is one of the innovations that managed to radically change our capacity to monitor the state of the Earth and make actionable plans about it. Public and private stakeholders are capable of monitoring the melting of glaciers in near real-time or the advancement of a meteorological phenomenon. Nowadays, satellite observation is considered essential information for a number of societal applications, including **disasters, energy, climate, agriculture, ecosystems, biodiversity, water** and **weather** scenarios and forecasts.

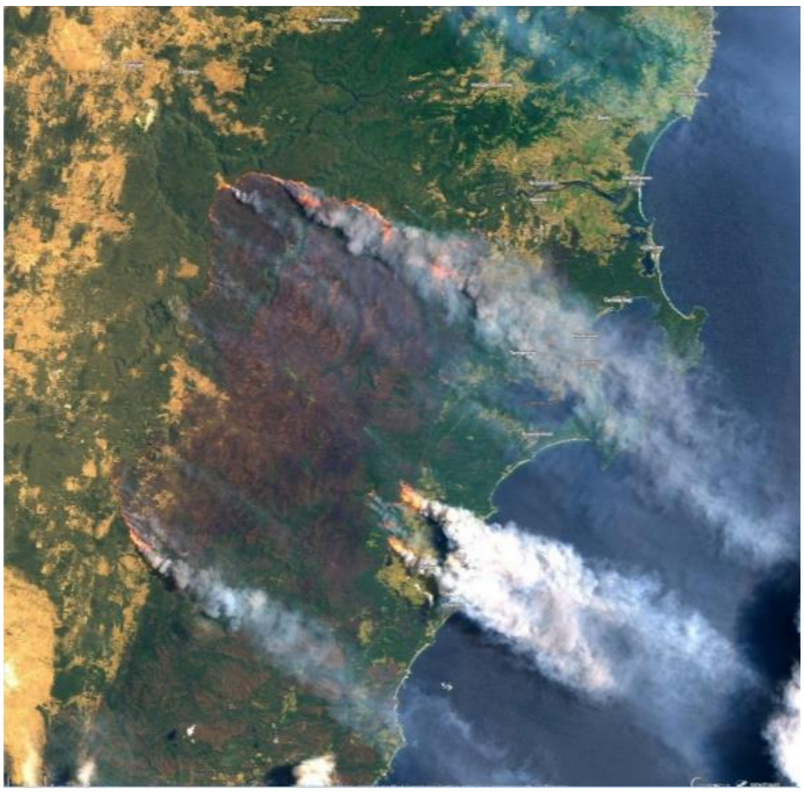
**South-East Australia** was hit by a series of **persistent wildfires** from June **2019** through **early 2020**. In total, about 19 million hectares of land were burned and 6000 buildings destroyed, including 3500 homes. There were more than **150 separate major fires** registered. The magnitude of the phenomenon was due to a combination of dry conditions, high temperatures and unpredictable winds.

Geoscience (an Australian Government agency) requested assistance from the Crisis Coordination Centre (CCC) of the Emergency Management Australia (EMA). The New South

Wales Rural Fire service was also involved. As a result of the cooperation and targeted exploration, more than **2000 useful satellite images** were provided to the ground teams.

An access to NASA (US) and Copernicus (EU) satellite imaging was obtained and used to **detect wildfires** burning in **remote regions**. When a new burning section was detected, the location was sent directly to local authorities, almost in real time or as quick as satellite overpass allowed it. The below figure shows some of the types of images obtained.

***Figure 6.*** *Clyde Mountain fire, 200 km South of Sydney (Sentinel2 imaging, Copernicus EMS), 2019*



Transferring such an approach to Bulgarian realities is quite a practicable thing to do and expect from DPP stakeholders. The number and importance of international **cooperation programmes and networks** our country is part of is more than sufficient to obtain **quality information** needed for emergency response and Disaster Risk Management.

First and foremost, there is the **Copernicus Emergency Management Service** (https://emergency.copernicus.eu/, **CEMS**). It provides **on-demand mapping**, with detailed information for selected emergency situations that arise from both natural or anthropic disasters.

**Risk & Recovery Mapping** from Copernicus supplies geospatial information in support of Disaster Management activities including DPP and DRR phases.

**Rapid Mapping** is another geospatial information service which provides quality feedback within hours or days of a specific request. It assumes vital importance in support of EMS in the immediate aftermath of disasters.

**CEMS Early Warning and Monitoring** is another type of integrated AI service which supplies critical geospatial information via continuous observation and **forecasts for floods, droughts and forest fires**.

All of the CEMS on-demand mapping services can be **activated through DG ECHO**'s Emergency Response Coordination Centre (ERCC). As a Member State participating in the **Union Civil Protection Mechanism** Bulgaria is entitled to such support via its Authorised Users and National Contact Point. More importantly – "except for sensitive activations" – the majority of mapping products are available online on a "**full, free and open basis**".

Another important service provided by Copernicus is the **Land Monitoring Service** (https://land.copernicus.eu/pan-european, **CLMS**). The European Environment Agency (EEA) produces a number of important and regularly updated **datasets**:

- Land Cover datasets;
- High Resolution Layers;
- High Resolution Phenology and Productivity;
- CORINE Land Cover inventory (CLC and CLC+);
- European Ground Motion Service.

While dataset acquisition priorities are set by the European Commission, this is done with the contribution of MS such as Bulgaria (via the Copernicus Committee). EEA complements such datasets with Copernicus Marine Environment Monitoring (CMEM) and CEMS, to create integrated products.

The CLMS is an incredible high-technology service which provides critical multi-layer tools that Bulgarian DPP stakeholders should use more intensively. Together with the Joint Research Centre (JRC) the EEA provides such geographical information since 2011 and can be used to **advance digitisation protocols** throughout the country, not only the Black Sea coast. Land cover statistics and actual status are merely some of its benefits – it can in fact be used to track important changes in forests, water cycles and energy variables.

**CLMS product categories**:

- Systematic biophysical monitoring
- Land cover & land use mapping
- Thematic hotspot mapping
- Reference data
- Ground motion service

The above can enable a series of pragmatic **DRR applications** and **DPP** mechanisms, namely in the **fields** of:

- Spatial and urban planning
- Forest management
- Water management
- Agriculture & food security
- Nature conservation and restoration
- Ecosystem accounting
- Mitigation to climate change

All of the above have a direct or traceable influence on DRR capacity and disaster resilience. Australia is just one of the countries which have embraced such opportunities, as satellite observation can help tackle both policy and response challenges.

Besides natural hazards and critical events, employing these tools in a knowledgeable way can help address deficiencies in **human activities** which pose additional risks to our surroundings – e.g. non-regulated **building developments**, **land use**, **industrial activities** and **environmental threats**.

## 04 – Investing Heavily in DRR to Avoid Recovery Expenditures

**Indonesia – Philippines**

We already illustrated the WBG argument that investing USD 1 in quality reconstruction, namely in resilience infrastructure, saves USD 4 in future disaster damages for vulnerable areas.

Expanding this line of reasoning there are additional consideration that emphasise the importance of **targeted investment in mitigation and preparedness**. Disaster Risk Reduction (DRR) expenditures are various in nature, as they include tangible resources, infrastructure, human know-how and technology. However, few would argue that they don't have a proportional influence on resilience and mitigation capacity (some experts even go as far as asserting that "**DRR saves $7 for every $1 invested**").

Shifting the focus **from disaster response to DRR and preparedness** is also our objective area of analysis. Prompted by international campaigns and influential cooperation frameworks which promote such an approach, some countries have concretely deployed it as a practice over the course of the years.

**Indonesia** is a prime example of a country which needs to prevent disasters rather than aim for recovery optimisation – such is the **frequency and intensity** of some critical natural events over the island country. Investing in DPP systems for the country (and its neighbouring archipelago of the **Philippines**) was a conscious choice, in their relentless pursuit of **lasting mitigation** measures.

Reducing risk levels in the region often means **allocating much higher amounts** for the same activities and interventions than needed in many of their international counterparts. Being **extremely disaster prone**, both countries have bet on DRR as a result of their past experiences and repeated struggles with disasters.

The government of **Indonesia** invests about **2% of its budget** into DRR (around USD 1 billion) for every fiscal year with a general **upward trend** of funding. The majority of the money allocated to DRR is being used for physical disaster risk reduction.

The **Philippine** government has its own DRR and quick response fund. More importantly, it requires **local governments to dedicate 5% of their revenue** to DRR and management – with a ratio of **70% for prevention**, mitigation and preparedness, and 30% is dedicated to response. The DRR allocation is multifaceted and includes risk-**mitigation infrastructure, equipment**, stockpiling of emergency relief **supplies, training, planning**, capacity including, information elaboration, **education and communication**, as well as **risk transfer mechanisms** from leading countries and stakeholders.

Accordingly, other countries and regions (or simply stakeholders) which have been heavily affected by disasters in the past, need to understand the importance and cost-effectiveness of DRR. This means not only **actual recent events** but also proven **potential dangers** and **targeted investments** in that segment. If a region is flood-prone or landslide-prone, it should dedicate more of its **attention and resources** to prevention rather than post-event recovery efforts. Both because needed resources might be higher, and because the conditions and phenomena might and will probably re-occur again.

Naturally, it would be an oversimplification to claim that a linear increase in DRR investment projects reduces damage and impact. There are some **intangible societal qualities and factors** which influence the desired efficiency and effectiveness. For example, an increased overall DRR awareness (population and institutions) is essential in improving effectiveness of measures planned and undertaken.

DRR cost-effectiveness also depends on some long-term complex approaches such as **education, policy,** and **planning** initiatives. While precise calculations methods are not available, studies in DRR cost-effectiveness focus namely on a series of factors which prove "**increased awareness**" of DRR importance in local, regional and national DPP efforts. Institutional awareness translates into targeted investments, where possible, corresponding to policies dedicated to population priorities and overall resilience.

Further **research** is needed to **quantify the correlation** between DRR investments and socio-economic resilience. Any findings might be theoretical at first, as empirical experiments between protected and non-protected territories with identical risk factors are unthinkable. However, motivated investment proposals and research results all need to be delivered in an **understandable and convincing** manner for policy and decision makers, as well as the local population.

## 05 – A Wide, Flexible and Diversified Coverage of Financial Incentives

**Australia**

Australia is not only at the forefront of DPP, it is also a country which is efficient and innovative in **post-event support** to affected areas and communities. This naturally means ensuring a sustainable financing approach to both private and public recovery.

The country's Natural Disaster Relief and Recovery Arrangements (**NDRRA**) serve as a guidance for all Government and local reconstruction efforts and financial assistance to state and territory governments. The provided support is **not intended as a disincentive for insurance** or disaster mitigation – quite on the contrary. States are encouraged and formally required to explore and promote a range of insurance options and assess available options on a cost-benefit basis.

The Australian economy is well-placed to access the main financial markets. Naturally, raising funds for **ex-post financial disaster recovery** remains consistent with an efficient cash management and public finance balance.

The **Disaster Recovery Allowance** (DRA) is aimed at all hazards (natural and man-made) and serves to provide individual support to those affected by critical events. Standard waiting periods are waived (in the context of social welfare regulations), as the Government has the discretion to authorise direct DRA payments. Particular evaluations precede DRA activation, including the classification of the event as one of national impact or especially affecting certain areas or industries. Another way of determining actual needs is the correlation between the event and a loss of income.

**Disaster Recovery Payments** (AGDRP) also cover a multitude of hazards and are provided in the form of one-off transfers. Without evaluating personal means, it allows families to access funds provided a certain relevance of the event, its "unusualness" and other parameters.

Some of the **innovative elements** include **mobile payments** and other fintech solutions. Employing services such as Mpay or M-PESA, payments are channelled through **mobile networks** which have enabled access to the identified financial services – even for people who **don't have access to regular banking** services.

An estimated 2 billion people around the world are "**unbanked**" – remote rural settlements or simply poor communities are prime examples. The number of those with mobile phones is much less. Thus, payments can be made for utilities, services, goods, enabling millions of financially vulnerable people to access financial tools. In the context of DPP, it helps affected individuals access cash payments after a disaster and make transactions locally. This, in turn, **facilitates early recovery** and re-investment.

Such small scale transfers are also **beneficial to local businesses** and the social ecosystem within affected communities. Transfers are also safer and more mainstreamed within the disaster aid sector, rather than being dispersed and inefficiently distributed via external channels.

On a side note, **fintech solutions** have drastically improved the way people access goods and services through direct payments via mobile phones – even and especially among tech-savvy and better educated population groups. **Direct mobile payments** can provide incentives to access diversified energy sources and mobility solutions (e.g. pay as you go models for consumption or logistics). It might enable those with a low credit score to access loans and financial tools to re-build their livelihood after disasters.

Furthermore, it may allow payments when bank systems are down or infrastructure is damaged (roads, ATMs, etc.). Integrating mobile payments and fintech solutions into DPP is neither costly nor complicated, yet it ensures **real-time access** to liquidity for disaster affected communities and **better accountability** for financing entities at all phases of disaster management.

The Australian Government also employs a mixture of the following disaster management financial tools:

1. **Dedicated contingency reserves** for disasters – including multi-year roll-over disaster reserve funds;

2. **Insurance policies and incentives** – promoting and enabling the transfer of risks and compensations against damage (especially related to **Public assets** such as buildings and **infrastructure**);

3. **Contingent credit arrangements** with particular financial institutions – in line with public and private incentives to diversify risk, **preferential credit conditions** to recover and rebuild might be arranged beforehand;

4. **Catastrophe bonds** or other types of catastrophe-linked **securities or derivatives** that provide an alternative more of risk transfer.

Naturally, determining the optimal combination of financial tools, payment means and public resource redistribution mechanisms is entirely dependent on the country or region which will be applying such solutions. Determining the appropriate financial strategy for managing disaster costs is just as important for well-developed economies as it is for developing ones. Innovative financial tools and channels can be employed independently or in a combination deemed more beneficial to affected communities, formal donors and public finances in general.

The Australian approach is a perfect example of how a mixture of insurance incentives, mobile payments and simplified direct allocation of funds receives favourable responses from DPP stakeholders, the population and third-party financial experts.

Longer term financial needs, such as those for the reconstruction phase, may be better served by other types of products, including traditional insurance and reinsurance, depending on the circumstances.

## 06 – Seismic and Building Codes

**Japan – Italy**

Japan was already discussed in view of the country's overall DPP efficiency and culture of preparedness. Another country which faces some common vulnerabilities to those of the Japanese territory is Italy. Both nations face frequent earthquake risks and (with the difference in subsequent tsunami developments) both have had to adopt **stringent seismic codes** into its **building approval procedures**.

The Italian experience with introducing tighter building codes is more or less similar to that of the Japanese. Both countries have long ago come to the justified conclusion that building structures that are resilient to ground shaking are crucial in **mitigating damage from earthquakes**. Hence, seismic codes are designed to protect human lives and property from earthquakes and collateral damage.

After the Messina Straits earthquake that killed 80,000 people in **1908**, the Italian government issued its **first ever seismic code**. It stipulated that the **seismic ratio** (seismic acceleration divided by the gravity acceleration) should be set at 1/12 for the first floor and 1/8 for the floors above. Authorities have revised the code several times significantly since then. The current one covers the entire territory of the country.

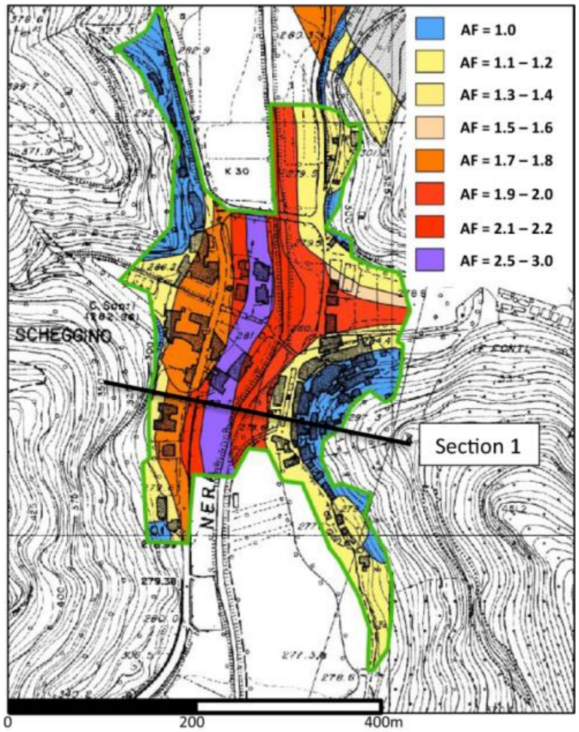
The Great Kanto earthquake in Japan killed more than 100,000 people in 1923. The government introduced a seismic code in **1924**, which was in fact the **first nationwide seismic code** in the world. The current version aims at ensuring human lives are not threatened by any scale of earthquakes. Regulations specify that buildings should "withstand a lateral force equal to the building's weight". With such seismic codes, human loss was limited to minimum (~200 people) even during the **Mw 9.0** Great East Japan Earthquake in **2011**.

**Seismic Micro-zonation** (sM) is one specific approach employed by earthquake-prone nations. It is defined as an "assessment of local seismic hazards by **identifying the zones** of a given geographic area with **homogeneous seismic behaviour**".

The **Italian** practice of seismic micro-zonation involves the sub-division of a potential seismic or earthquake-prone area into zones with respect to geological and geophysical characteristics. Parameters and features of the territory include ground shaking potential, **liquefaction susceptibility**, **landslide and rock fall** hazard, earthquake-induced **flooding** and much more. In general terms, seismic micro-zonation provides an estimation of the **response of soil layers** under earthquake excitations. This leads to a better prediction of the variation in earthquake manifestations on the ground surface, including impacts on building and infrastructure.

Seismic hazards at different locations within the macro-area can correctly be identified provide the basis for exact micro-zonation and **site-specific risk analysis**. This, in turn, can **facilitate earthquake damage mitigation**. A complete micro-zonation map includes data for existing buildings and infrastructure and aids greatly DPP and contingency planning procedures of disaster response stakeholders.

***Figure 7.*** *Seismic micro-zoning map ("Approaches, results and applications after the 2016–2017 Central Italy seismic sequence.")*




The **first attempts** of seismic micro-zonation in any urban area (industrial or residential) were carried out in **Yokohama in 1954**. Local authorities considered various zones and corresponding soil conditions in an attempt to design **seismic coefficients** for different types of structures located in those zones.

Today, seismic micro-zonation requires an all-around **multi-disciplinary approach** with major contributions from the experts in geology, seismology, geophysics, geotechnical, structural engineering and planning. Not only do they help identify sub-surface condition, but they **overlay data** on buildings and other infrastructure (i.e. roads, water, electricity, gas pipelines, etc.) to **illustrate the vulnerability** of those very same buildings and/or infrastructure. An extraordinary yet pragmatic tool for developing risk reduction plans for earthquakes, landslides and beyond.

Micro-zonation is only one of the possible tools, albeit essential. It does not help reduce losses (human or economic), unless **used for planning** followed by consistent **implementation, monitoring and control**. While the first step may be costly and slow – including challenges of obtaining verifiable data its adoption is a measurable scientific foundation for **better building codes** and **land-development regulations**. Moreover, when properly done, it provides a good overview of potential damages which can in turn be used for **communication strategies** that lead to long-term **behaviour change**.

Furthermore, incorporating seismic criteria into acting building codes and permits influences positively all stages of DPP – **mitigation, preparedness, response and recovery.** Potential fatal outcomes (deaths), negatively affected communities and economic losses are tackled extremely **cost-efficiently** through a rigorous design and application of up-front regulations and requirements for any and all infrastructures, especially those built in zones of proven or potential land instability. Those are essential prerequisites for any contemporary land-use permits and urban development plans.

Besides the human side of potential injuries and personal economic losses, the protection of public and private assets from earthquakes is rather a straightforward priority. While it is true that a certain level of capacity and technology is needed, social and environment impacts are minimal and replication is based on comparable best practices in the field. Government agencies and related institutions might implement such advanced building codes without increasing excessively administration costs – by simply **replicating a successful set of seismic codes**, based upon **relevant engineering and geological research** of local and regional specifics.

Introducing and implementing building codes needs to go hand in hand with desired behavioural changes. These are not purely seismic codes – they are also closely related to **landslide risks**, as well as **unregulated urbanisation and building practices**.

The issue is especially relevant in the **highly urbanised coastal area** of Bulgaria's **Black Sea region**, especially within and around resort complexes and recreation zones which contribute much to the region's economic growth.

It is never too late to develop and implement improvements in building codes and regulations. Some countries have revised their building codes according to the **surveys of damages** to buildings by major past earthquakes. Resulting changes have strengthened societal resilience to earthquakes.

Many **developing countries** face difficulties in introducing and **enforcing** seismic codes. Government organizations, especially local governments, need to develop **legal systems, permission procedures,** and **institutions**. Many do not have enough capacity and resources, such as skilled experts and finances. **Public awareness** activities are also needed in cooperation with the private sector, especially aimed at house owners and developers that need to apply seismic codes to buildings.

Both micro-zoning and improved building codes are replicable and applicable as approaches and tools in the Bulgarian reality and the Black Sea coastal region. They are already used in some urban development procedures, yet their current penetration and quality have not managed to affect positively **urban planning, building permits, monitoring and preparedness mechanisms.** Building codes are rarely established or properly enforced in many local realities. And our subject area of comparative analysis continues having to face challenges with landslides and un-regulated urbanisation which have translated into problematic land-use around Golden Sands and Kranevo, as well as disaster scenarios in Asparuhovo (2014).

## 07 – Seismic Risk Management and Emergency Preparedness Project

**Turkey**

We turn our attention to the Turkish experience in the same field. After the **1999 Marmara earthquake** which claimed 17,000 lives – and with the long-term objective of strengthening preparedness and accelerating recovery processes, the Government of Turkey started implementing a **seismic risk management** and **emergency preparedness project in 2005**.

The initiative focused on strengthening the **effectiveness and capacity of provincial and municipal public safety organizations**, mostly in and around Istanbul. Measures ranged from improvements of public awareness and institutional capacity, to the modernization of emergency communications systems (including the establishment of an emergency management information system) and the expansion of existing emergency response capacity.

As per the **building back faster** principle, the central Government prepared a National Response Plan which assigned specific responsibilities to provincial directorates to prepare **response plans at the local level**. These response plans defined stakeholder groups needed for an efficient response, comprehensive of the private sector.

Information management databases and decision-support systems were established, including a complete inventory of construction firms, their detailed capacity and equipment in major cities. The objective of an integrated **digital emergency management system** was to improve institutional **ability to mobilize resources rapidly and effectively** at all levels. Examples include a jump-start debris removal procedure and reconstruction algorithms in a pre-arranged and well-coordinated manner.

Preparing **contingent financing instruments** was an additional step to help authorities strengthen their ability to respond to shocks quickly and effectively (e.g. World Bank pre-approved credit lines immediately after the declaration of a national emergency). During critical events and conditions, accelerating effective recovery is crucial and ensuring that reconstruction starts as quickly as possible has lasting humanitarian and economic effects.

The Istanbul Seismic Risk Mitigation Project (**ISMEP**) helped strengthen critical public facilities to better withstand the shock of earthquakes and supported measures for **enforcing building codes** and **land use regulations** in the Metropolitan City of Istanbul. ISMEP had **extended benefits on the country** in acquiring know-how, financing and coordination mechanisms to be able to mitigate some of the largest disaster impacts and improve its DPP and emergency response capacities.

ISMEP consisted of three functional parts which complement one another:

- Emergency **preparedness in the aftermath** of earthquakes – risk mitigation on individual, family and institutional levels altogether enhance preparedness capacity;
- Priority **mitigation interventions** on seismic risk vulnerabilities of **high priority public buildings** (e.g. schools, hospitals) – this part involves inspection, monitoring but also retrofitting and reconstructing;
- Increasing **institutional** and **technical capacity** – e.g. building codes enforcement in participating municipalities.

ISMEP was Turkey's first (major) risk mitigation project and it involved an upgrade in **communication** and **IT systems**. First responder institutions and local units were supplied with equipment and vehicles.

Altogether, almost a million persons were trained through direct awareness raising activities. 235 thousand in the Istanbul area became Safe Life Volunteers. Large-scale training and communication campaigns were supplemented by e-training modules, while ensuring the replication and sustainability of the **Safe Life Training Program**.

Pilot municipalities received ISO 27001 Information Security Management system certifications. Building permit procedures were improved and digitised. The resulting traceable and transparent e-infrastructure ensured quick and efficient building permit protocols.

Last but not least, 1175 public buildings were reinforced or reconstructed to be earthquake resistant. DPP plans and protocols were thoroughly inspected and upgraded in dozens of schools in Istanbul and other major cities.

Such a DPP and safety overhaul of the national preparedness system is not easy or cheap to implement. However, a comprehensive review of national and regional DPP elements might lead to a targeted initiative aimed at their improvement.

Many of these practices exist in Bulgaria as well, although they are not up to the necessary standards. Urban development plans do exist yet they are not sufficiently digitised and actionable.

Institutional and technical capacity at the regional level is scarce. Flexible preventive funding for mitigation and rebuilding is not ensured, leaving communities to prey on Central government intervention much too often. Most importantly, national awareness campaigns and local community trainings and resource availability is well below international standards when compared to leading examples.

Turkey's push to improve DPP over the past 10-15 years have made it one of the leaders in the field, including exemplary initiatives such as the "Safe Schools Program", implemented and promoted by the United Nations.

The above major DRR initiatives made a difference in the lives of ordinary people by promoting a preparedness and response culture. Many public and private Turkish organizations were transformed and began offering their disaster management services in different regions around the world.

## 08 – A Highly Integrated and User-Friendly DRR Reference Database

**Australia**

Australia keeps being mentioned as a leader in DPP for a number of good reasons. One of those is its ability to creating, maintain and update a highly integrated DRR reference database which is easy to consult by all citizens and stakeholder groups. Such a dedicated site (or an App) needs to comprehend all-level viewpoints and competence levels.

A prime example is provided by the Government of Queensland. Its **Prevention, Preparedness, Response and Recovery Disaster Management Guideline** ("the Guideline") is available online here:

*https://www.disaster.qld.gov.au/dmg/Pages/DM-Guideline.aspx*

The platform is extremely well integrated and **complete** on the subject, **yet general** and with wide applicability through **well-segmented resources and sections**.

As the local government agencies point out, the scale and impact of Queensland's weather events make it the **most disaster prone state** in Australia. Local and District **Disaster Management Groups** and the Queensland **Disaster Management Committee** play a vital role in managing and responding to disasters and supporting the population through critical events.

The aim of the Guideline is to "provide **flexible, good practice suggestions and advice to those responsible for implementing disaster management practices."** The Guideline is based on legislative responsibilities but provides practical guidance and support to citizens and their link to State institutions, key factors and DPP mechanisms.

Disaster management in Queensland is based on four principles:

- comprehensive approach
- **all hazards approach**
- local disaster management capability
- support by the state group and district groups to local governments.

These are all evident in the Guideline outlook and functionality. The "all-hazards" approach assumes that the functions and activities used to manage one event are likely to be **applicable to a range of events**, whether natural or caused by human activity. Shortcuts assigned to stakeholder and disaster types are **plain and unmistakeable**.

***Figure 8.*** *The Queensland Emergency Risk Management Framework*

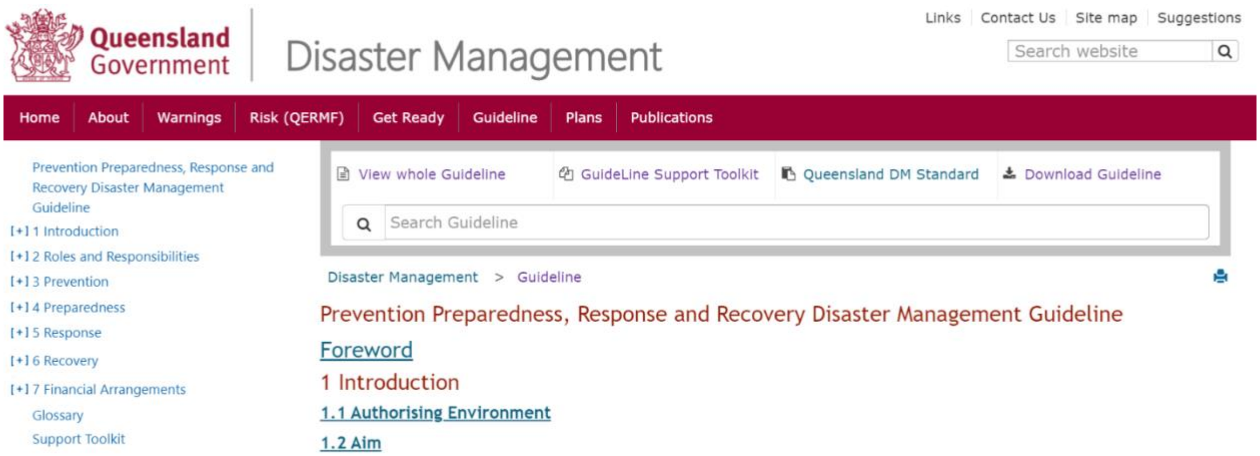

Disaster contexts and specific risks are not altering the foundation and functional basis of the Framework. As a result, this illustrative interactive Guide has been developed to **provide guidance** to local, district and state disaster management stakeholders with regard to their functions, obligations and legislative requirements under State and National laws and regulations.

The Guide outlines a **comprehensive end-to end process** for steps to be undertaken through each of the principal disaster management phases – specifically addressing roles and responsibilities of disaster management stakeholders, prevention and mitigation strategies, preparedness arrangements and considerations for planning, the activation of response arrangements, the recovery process and financial arrangements. It paints the **full picture** from whatever angle a user looks at it and it places its **ease of use** at the forefront.

The Guide is enhanced by **a practical toolkit** that ensures that various disaster management stakeholders are fully supported in the planning and management of disaster management requirements. These tools range from **contacts** and **responsibilities**, to **risk maps**, **chain of communication** and segmented **risk type** tools – **all in one place**, thoughtfully selected from, including communication considerations such as the **choice of words** when facing a certain situation. The tools also include **manuals** for management, operational and **civic groups**, as well as **checklists** and **templates** for various stakeholder types and situations.

While Queensland's guide places policy and planning in direct context with practical and citizen-centred measures and support tools, always with a preference for pragmatic applicability of what is made available to citizens and experts.

***Figure 9.*** *Screenshot of Queensland's Interactive Disaster Management Guide*




Queensland **Fire and Emergency Services** (QFES) is the agency tasked with creating and maintaining safe and resilient communities. It has a legal prerogative of minimising the impact and consequences of emergencies on people, property, environment and economy. QFES illustrates cooperation bases with various stakeholders and recognises critical relationships in the roles all societal factors perform. It has presided over the creation of the Guide with the help of many institutions and civil groups.

The toolkit items are mostly non-mandatory – these are **manuals, reference guides, forms, templates, maps, diagrams, handbooks** and **links** to related publications and institutions. They are referenced neatly throughout the document and can also be accessed from State Government web resources.

There are many features which make the Queensland Guideline an excellent practice with optimal replication potential: The **pragmatic aspect** and **quick consultation** selections; the **ease of access**, **navigation** and **functionality**; its **completeness** and the added value of segmented **stakeholder perspective**.

Bulgarian Municipal and District Disaster Protection Plans have proven mostly useful for institutional use, much like the longer-term Disaster Prevention Programs and Plans. They are also compiled with Unified Response System units in mind, which are already professionally familiar with regulations and planned measures.

A **user-friendly platform** directed mostly towards **citizens** is something which has to be better developed and offered to the wider public – both in Bulgaria and the Black Sea coastal region in particular.

## 09 – Emergency Transport Management

**Austria**

Austria is exemplary in its Emergency Transport Management (**ETM**) procedures, illustrated optimally as adopted by the **Austrian Railways** (Oesterreichische Bundesbahnen AG or **OEBB**) and their natural hazard management. The OEBB approach offers an integrated mechanism dealing with natural hazards and any other emergencies related to transport operations in their segment.

The Austrian railway network are comparable in quality to neighbouring European countries (e.g. Germany) yet proportionally **more prone to natural hazards**. This is mainly because they are frequently located in the Alps, the highest mountain range in Europe. Large **temperature gradients** at different **altitudes** worsen the conditions created by abundant water coming down from the mountains – snow **avalanches**, **torrents** and fast rising **floods**. In addition, **rocks** and **debris** fall down steep mountainsides. About a third of the 6000 km railway tracks are located along deeply incised alpine valleys and several high alpine passes.

Austria's inner alpine railway network is highly relevant to cargo and passenger transportation. Its importance to the inhabitants and the economy of alpine regions is fundamental and still growing. Considering the growing number of extreme weather events (EWE) due to climate change, maintaining and improving the railway network reliability is a challenging task.

The **OEBB** is the primary operator of the Austrian railway infrastructure. It needs to plan accordingly and mitigate the impacts of EWE through precautionary measures.

The **methodological approach** is based on a three-step process. It was carried out to identify **vulnerable sections, operations** and **features** along the entire railway network. The three successive levels of analysis and actions are characterized by the increase of scale or geographical resolution. Vulnerable sections of the railway infrastructure are defined by track identity and a kilometre mark.

The first stage (**level I**) is an overview of **homogeneous sections** of endangerment (on a scale of 1:25.000). The geomorphologic processes are distinguished into **nival** (snow), **fluvial** and **gravitational** processes. Furthermore, **hazardous potential** is derived from observed geomorphologic process activity and the usage of protective structures. Such potential is ultimately segmented into **four categories of relevance**:

A) **High**: Sections where **near-past losses** related to EWE occurred and are still not adequately secured.

B) **Medium**: Sections with existing but **presently inactive** geomorphologic processes (e.g. avalanche zones covered with trees). This category is still lacking sufficient protective structures.

C) **Minor**: Overprinted proof or no evidence of hazardous potential is currently found. Still, considering existing topography and morphological inventory, the possibility of future hazardous processes cannot be excluded.

D) **No relevance**: Absence of any relevant processes.

The detailed study found that around 3/4 of the entire railway infrastructure in Austria are not exposed to geomorphologic processes or are sufficiently protected; 10% show a minor, 13.1 % a medium relevance. Only **1.9 %** was characterized by **high relevance** and **vulnerability**.

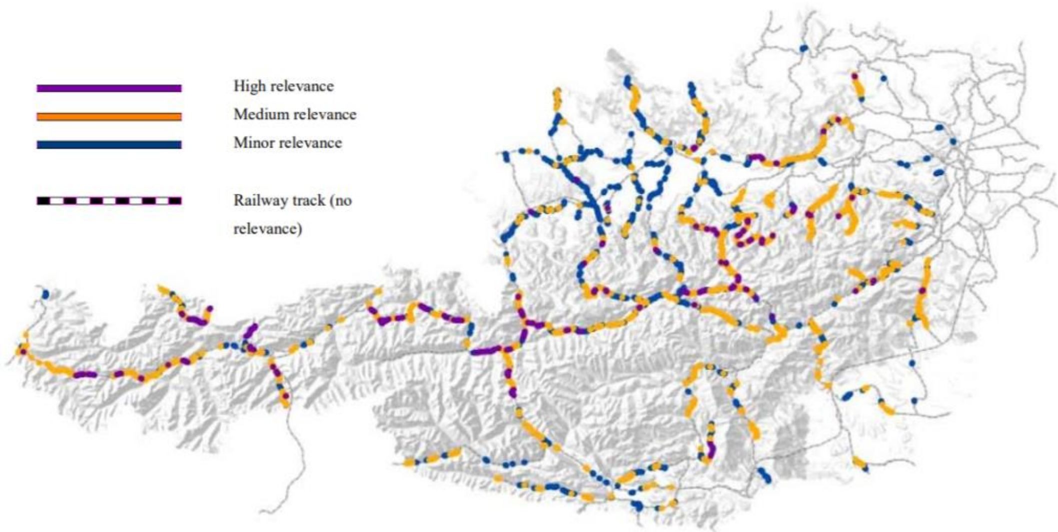
The **second level** involved subjecting vulnerable sections (from Level I) to a more accurate and specific assessment. This part is conducted on a scale of 1:5.000 and included only sections with **high and medium relevance**. The **high resolution** allows for every single hazardous process to be described **in detail**. Railway infrastructure exposition and its capability of retaining measures is analysed and **overlaid** with relevant **geospatial data**. The result is qualitatively interpreted in order to ensure the consistency of datasets in terms of **high-priority areas**.

The second stage also involved the **mapping of endangered areas** and **active processes**. This allows for a comprehensive evaluation, even subsequent, of the hazardous potential of geomorphologic processes. All areas are distinguished into **starting** zones, **transport** zones and **deposition** zones. Existing or projected proof of geomorphologic processes and activities within every zone are described.

Finally, digital mapping was complemented by current process activity, railway track exposure and usability of existing protective structures. Any identified protection deficiencies – for analogous or homogenous sections – is deemed as a concretely established necessity for further structural risk reduction measures.

The below figure illustrates an example of Levels I and II (segmentation and overlay mapping) in the OEBB investigation:

***Figure 10**. Level-I analysis, OEBB.*




*Source: Austrian Federal Railways Infrastructure*

***Figure 11.** Investigated Section under Level II – the Semmering pass; OEBB.*

*Source: Austrian Federal Railways Infrastructure*

The **Third level** represents the final step of the integrated project. Based on a quantification modelling of identified dynamic processes, the dimensions of organisational and structural **means and methods to be adopted** were derived at this stage. Only a few pilot areas were completed with the identified safety and prevention interventions but work continues.

Finally, the OEBB is combining a **rapid alert system** with the **map of natural hazards** and **meteorological data**. The so called INFRA.weather system is a "meteorological information and warning system" provided by a private operator but customised for OEBB railway network needs and specifics. The system provides a polygon-based map of the Austrian railway system with the most important upcoming weather events in terms of storm, flood, and snowfall. Implementation of **real-time monitoring** for the **highly relevant sections** and the integration of numerical models in order to **predict the impacts** of natural hazards on railway infrastructure is also foreseen.

Ultimately, based on this approach, several **new developments** were made possible:

1. A rapid alert system as a combination of natural hazards map and meteorological data

2. Real-time monitoring of sections of high endangerment

3. Integration of numerical models for the prediction of magnitude and scale of natural hazards in terms of destructive forces impacting the railway infrastructure.

The methodology represents breaking new ground for ETM investment in DPP of natural hazards, specifically those based on **long-term planning instead of ad hoc measures**.

## 10 – Geographical Information System on Natural Hazards

**Switzerland**

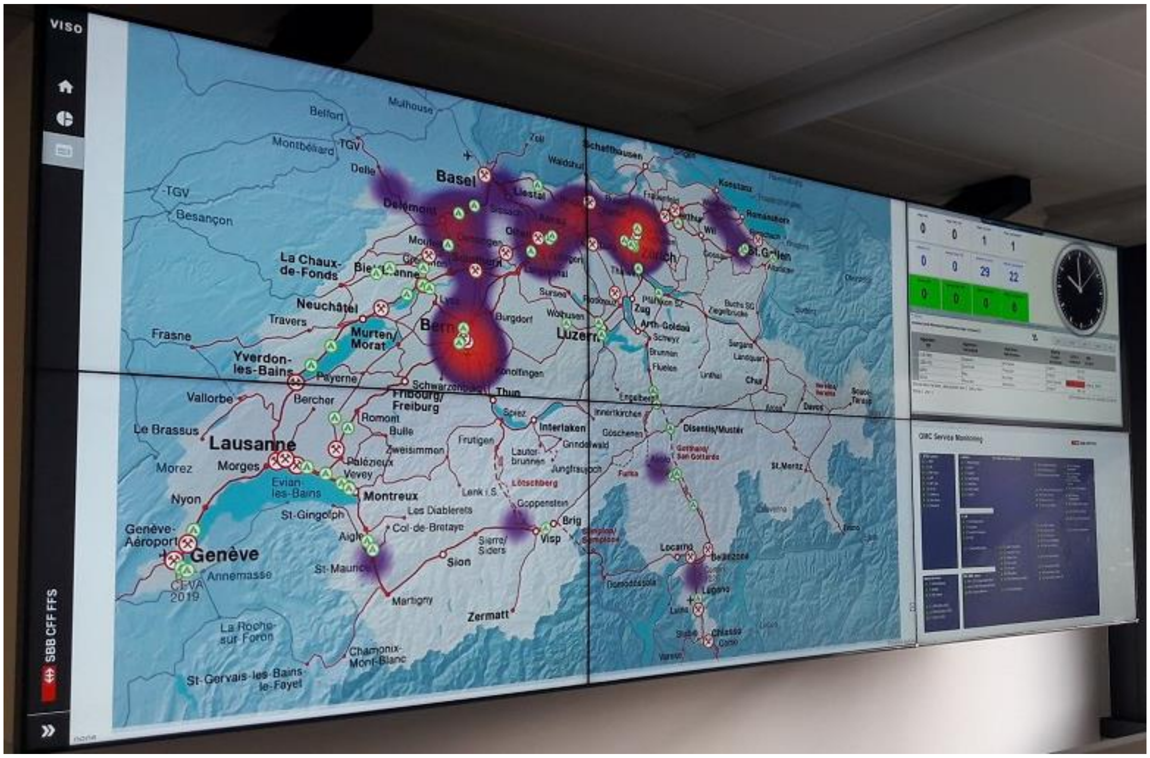
Switzerland's railway system and connected infrastructural network is also subjected to similar risks and threats. The alpine topography and weather makes it prone to natural hazards such as floods, landslides, rock falls, storms, icings and avalanches. The national railway operator – Schweizerische Bundesbahnen, SBB – has commissioned an efficient **Geographical Information System** (GIS) which goes a long way in projecting, managing and implementing DPP on natural hazards.

**Outdated archives and databases** were creating the problem of an unmanageable amount of reports and information on relevant events, both current and past, directly related to railway infrastructure safety and efficiency. SBB needed a “central nation-wide web-based system” and such a system was finally implemented in January 2008. It was called “**VISO**” and provided outstanding improvements to **spatial and temporal monitoring** of natural hazards and their relation to DPP installations and main infrastructure.

The VISO system consists of a layer on infrastructure **malfunction reports** in relation to **natural risks** (DERI-NR) and a Geographical Information System component (**WebGIS** NR). With the help of DERI-NR all natural events relevant to the Swiss railway infrastructure are gathered, processed and documented in real time. Since this is a web-based solution, all events and corresponding attributes (e.g. losses; category, impact and intensity) can be directly entered into the system and forwarded to the responsible person. Furthermore the geographical aspect of the natural event is based on attributes such as track identity or kilometre mark of the affected section within the railway network of SBB as well as the GIS coordinates.

The GIS NR represents the spatial event data and additional data layers such as hazard maps, potential damage in terms of number of trains and passengers, measuring points (weather conditions in general, snow) and protective structures. The precise positions of natural events recorded in DERI NR were projected on the SBB railway network by dynamic segmentation. GIS NR is capable of depicting the event attributes within the map. Conversely, events selected in DERI NR can be localised by GIS NR (Meier, 2010).

***Figure 12.*** *Malfunction visualization on the video wall in the Technical Operations Centre*




*Source: Esri.ch*

## 11 – River Engineering

**Japan**

Every country has developed particular and specific methods and technologies for flood prevention and water resource management. They reflect the nation's capacity and level of economic development, in most cases at least. More importantly, they are tailored to the area's **natural, topographical** and **hydrological conditions**, as well as notable or projected risk factors. Often, however, indigenous (traditional/local) technology has its objective limitations of a purely scientific nature. Advanced economies and well-equipped DPP stakeholders manage to look forward into a **long-term sustainability** of a measure and develop innovative responses and systems.

Japan's economic and industrial development experienced a significant systematic re-organisation after the Meiji Revolution in the **late 19th century**. The country began introducing successful western **technology solutions for river engineering**, aimed to prevent floods and develop a sustainable approach towards water resource management. In turn, other countries such as neighbouring China and even Mexico, started introducing "western" river engineering with the exclusive support of Japanese experts in the field.

Dutch engineers introduced the **scientific approach** of river engineering in Japan. Johannis de Rijke, a Dutch engineer, came to Japan in 1873 and stayed for 30 years. He was engaged in flood prevention in major rivers throughout the country, including Yodogawa River and Joganji River. The new methods emphasized on **managing sedimentation** in upper stream and river channels, promoting **water transportation**, and formulating **plans** at a river basin scale.

While Japan had constructed flood prevention facilities throughout its history of nearly 2,000 years, experts developed their technology based mainly on **experimentation**. The Dutch, on the other hand, have had to confront water level issues for centuries, even under normal everyday conditions, without critical weather phenomena in play. Thus, the Dutch engineering teams guided their Japanese colleagues in developing **monitoring stations** to collect hydrological information essential for **river planning**.

Together, they produced the first guidebook on surveying and designing of river facilities. They also introduced the concept of designing **flood volumes** as a basis for planning **facilities of flood prevention**, such as **dykes** and **service channels**. Consequently, based on these concepts, the Japanese experts developed their topical technology additionally and currently use the approach on a **large scale**.

**Figure 13.** *Levee Breach Experiment of Chiyoda Channel, Japan*

*Source: Water (ISSN 2073-4441) open access journal*

Water basin engineering is intended to affect positively flood DRR, precisely in terms of flood mitigation. Know-how and advanced technology is used at a large scale and in a preventive manner. Japan introduced **advanced water basin risk analysis** – and followed up by **cutting edge technology**.

Following through with such an approach requires, naturally, **consistent investment** costs: examples include **long dykes** and impressive **dam infrastructure**. Furthermore, some of potential technology to be employed involves complex management plans and safety measures, including **secondary environmental** and **social impacts**. Therefore, there are some important challenges to be overcome, considered and taken account for. An expert adoption of scientific knowledge, data analysis, structural engineering and financial management is indispensable for such interventions.

Other countries have also taken advantage of advanced river engineering. We mentioned **Mexican** engineers which received Japanese and American training and managed to implement **dam** and **irrigation** projects throughout the country.

**China** founded **training institutes** based on European and American models in the late 19$^{th}$ and early 20$^{th}$ Centuries. Earlier, they used to receive technical advice from foreign colleagues, including Soviet engineers for constructing dams and river structures in the 1950s.

More importantly, engineering firms, NGOs, research institutes and Universities from the **Netherlands** are the ones delivering technical solutions to both developing and developed countries. **Japan** has the merit of **promoting present-day river engineering for flood mitigation and DPP** on a **nation-wide scale**. It has also promoted the approach and supported training engineers, mainly in Asian countries, including Indonesia and the Philippines, mostly as official development assistance.

Ultimately the focal point in such an approach is that no matter how difficult and costly, it is still cheaper and less traumatic than massive post-disaster reconstruction efforts, or at least repetitive cases of such critical recovery scenarios.

The Black Sea coastal area needs to concentrate efforts on identifying critical and vulnerable zones, no matter what the scale – urban context drainage channels or riverbeds and extended dam coverage areas – and then invest in preventive water basin engineering to avoid repetitive flooding problems in such vulnerable areas.

## 12 – Rainwater Harvesting Technology

**China**

There are many methods employed around the world to tackle water scarcity. Most include saving and collection techniques but essentially they are part of larger preparedness mechanisms – both addressing water management (throughout the annual cycles) and especially drought preparedness.

Moreover, many case studies confirm approaches which have been very effective in reducing **life losses** and reduction of number of affected people, especially in terms of **health impacts** which **droughts** can have on vulnerable communities.

**Rain water** is an essential part of human life and has been for centuries. One of the direct relevance of rain water is rain-fed **agriculture**, which is still a common practice in most of the developing countries. However, rain water is increasingly becoming the source of **drinking water** in water scare areas, both in **arid climate zones**, as well as in **coastal zones** where **safe drinking water** is becoming an increasing problem due to increasing **salinity** and other **freshwater scarcity** problems.

In many arid areas, **rain water harvesting** is practiced on a household level and homemade systems. It has becomes a key source of drinking water for many families. Modern day rain water harvesting system is based on the same old basic principles, with some inputs from the improvements in the slope of the roof and the water collection structure – better and more appropriate **pipes** and **retention tanks**.

Some zones with perennial water scarcity issues use rain water harvesting systems also as part of **public building codes** – including schools, offices and government facilities. Rain water harvesting is also an integral component of **green retrofitting** of private buildings in many arid cities.

In **coastal areas**, rain water harvesting is also found to be effective for wider community usage, and rain water from neighbouring house roofs is collected together in larger tanks to be used by 4-5 families together. This has helped solving drinking water problem in coastal communities where **salinity** and **arsenic** (in underground waters) are perennial problems for safe drinking water. Ultimately, rainwater harvesting systems are very effective in reducing water stress, effectively decreasing water related **health issues**.

***Figure 14.*** *Rainwater Harvesting for Household Needs*

**China's biggest water challenge** is meeting the needs of its large and often crowded population. Although it accounts for about 22% of the World's population, it controls only **7%** of Earth's **freshwater** resources. This stress on China's water resources continues as the population continues to grow, albeit less rapidly than a few decades ago.

Similar to other large nations (e.g. Brazil), its water resources are **not evenly distributed** throughout its territory. **Northern China** is home to 40% of the nation's population and **two-thirds** of its **farmland**, yet it has access to only **19%** of the country's water resources. In an effort to provide northern regions with sufficient water, China has been diverting waters from the Yangze River to the Yellow River. This will not be sufficient to reach the enormously important Loess Plateau and its fertile lands.

Since the 1990s, the government strategy was **switched** towards **water harvesting**. Collection systems have been heavily incentivised and implemented. Following a drought in 1995, the provincial government of Gansu commissioned a rainwater harvesting and reuse project called "**121-Project**". This project's name makes reference to its goal – every family should have at least two rainwater collection cisterns for every acre of agricultural land. Within a year of the project's implementation, 1.31 million people had benefited from access to water for domestic use.

***Figure 15.*** *Rainwater Retention System for Agricultural Use*

Chinese **rural inhabitants** have benefited from **government funded** programs that allow them to capture water during the rainy season and store it for later usage. This has reduced losses in the agriculture sector in arid areas and improved significantly **health and sanitation issues**.

**Coastal areas** have benefited in a more limited way from agricultural applications (e.g. vegetable garden). However, it has been extremely cost effective for household needs, as it uses **simple technique** and has achieved **large penetration and replication**.

Adopting such approaches on a certain scale requires **behavioural changes**; otherwise the level of effectiveness decreases significantly. For the Bulgarian reality, this can be widely applied in suburban areas around the highly urbanised coastal zones, overcoming washing and agriculture challenges.

Additionally, installing **water retention systems** might help manage water flows safely by accumulating large water volumes during excessive precipitation and **not allowing soil liquefaction** and the creation of conditions floods.

Especially in south-east Bulgaria and the entire Black Sea coastal region these would be consistent and realistic benefits.

## 13 – Use of Drones for DRR and Situational Management

**United States**

Drones are any flying devices (or vehicles) which do not have a human occupant. When they operate without any human intervention – even remote piloting – they are classified as robots. The American (and not only) **unmanned air vehicles** (**UAV**s) were initially developed for **military** use. They have since evolved and made their way into other fields such as aerial photography and package **delivery**.

UAVs can fly places manned aircraft cannot. They can also fly at **low altitudes**, overcoming **lack of visibility** and deliver **higher resolution** images than satellites. The first consistent and documented use of drones for disaster recovery was after Hurricane Katrina in **2005**. Them, roads were blocked by trees and small drones were deployed to search for survivors and assess river levels.

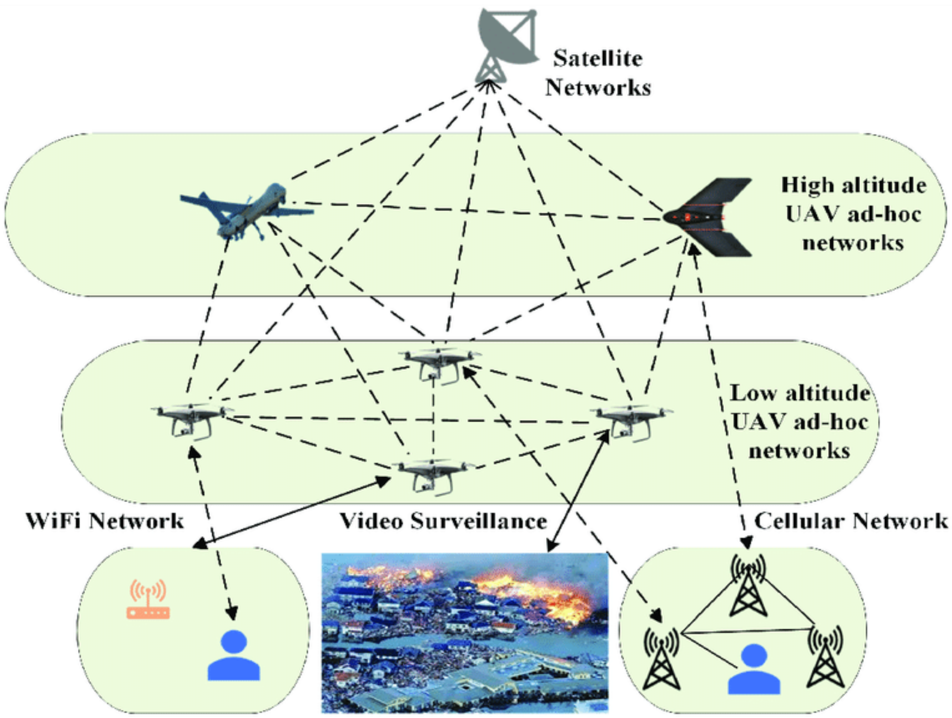
Following the success of those initial missions, UAVs began being used for different disaster phases. These include:

- **Preparedness**, e.g. filming volcanic activity in order to determine warning levels);
- **Response**, e.g. delivering equipment to locations with damaged networks; or functioning as a relay communications tower between a base station and an affected area;

- **Recovery**, e.g. delivering blood (massively used in several African countries), medical supplies and equipment in a consistent and even long-term manner after a disaster.

Examples include some impressive UAVs which **streamed live video** to ground operators and Coordination centres which use the images to determine event location and intensity. Crucially, they are used to **find people** and property that are at risk after a critical event. Damage assessment is also essential in evaluating recovery scenarios.

***Figure 16.*** *Link-up alternatives between high- and low-altitude UAV used in DPP*



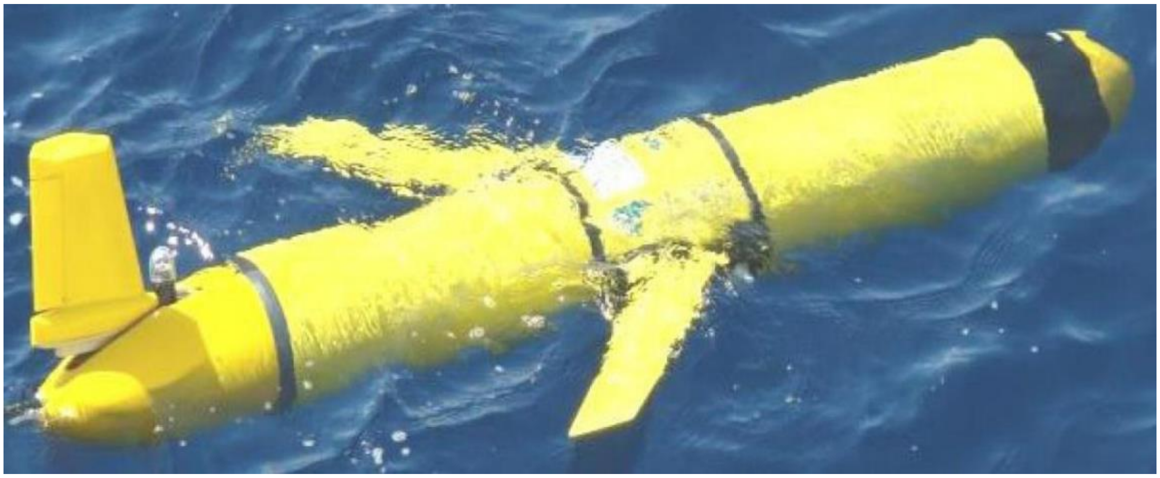

The American experience has been **exported**, expanded and affirmed as a fundamental DPP tool. The **Pacific Drone Imagery Dashboard** uses data from both satellites and drones for creating maps for disaster preparedness, response and recovery. In an effort to facilitate crisis management, UNICEF collaborated with the Government of Malawi to create a **drone corridor**, allowing the private sector, academia and others to experiment with UAVs.

DPP stakeholders have also begun using underwater drones, known as **Unmanned Underwater Vehicles** (**UUV**). They help measure storm intensity and direction and help predict upcoming vulnerabilities and disaster developments. One key difference between UUVs and airborne drones is that GPS does not work underwater, so UUVs are **tethered**, limiting their range.

Still, the most popular UUVs are big enough (about 2 metres) and carry sensors that are able to measure ocean **currents**, **heat**, **salinity** and **density**. Such devices were used during Hurricane Florence in the USA in 2018. Sensors measured the ocean **heat fuelling the hurricane** and transmitted data to the National Weather Service and the crisis coordination centres.

Such data fills in gaps left by satellite images and greatly improves disaster modelling (in this specific case: hurricanes). The data also enhances forecasting the intensity and route of the hurricane, as the sensors measure **surface salinity levels** to determine how much water from **rain** (or rivers) is **mixing** into the ocean.

***Figure 17.*** *UUV used for DPP and situational management*



**Bulgaria** is probably the only country without an air rescue system. Government authorities have been postponing the purchase of even medical helicopters for a long time and the topic comes up after every major incident which involves casualties. The vehicles need to be appropriately equipped; therefore it is not an easy or cheap task.

While airborne ambulances are not so imminent, UAV and UUVs are much cheaper and usually piloted by earth-based units. Even smaller UAVs, commercially available drones, would be a step forward in the evaluation, planning and prevention approach of the URS units, local and regional institutions and DPP stakeholders.

The **Black Sea** coastal region has the chance to pioneer this affordable yet advanced and efficient method in providing both its **land and sea DPP** programmes with the benefits of unmanned airborne and underwater vehicles.

## 14 – Crowdsourcing Tools for Disaster Management Platforms

**Australia**

Once again, Australia is providing us with an exemplary mode of handling certain DPP and post-disaster initiatives. With the current level of wide-spread smartphone usage, **crowdsourcing** allows obtaining of **real-time** and **local information**. This technology allows the **pooling of citizen contributions** (knowledge, data, media, etc.) on critical features, conditions and factors influencing disaster impact and evolution.

Examples include the location of evacuees; the precise needs of disaster-affected communities; the location of affected natural resources (e.g. contaminated water sources); as well as the identification of vulnerable areas, at-risk of future disasters.

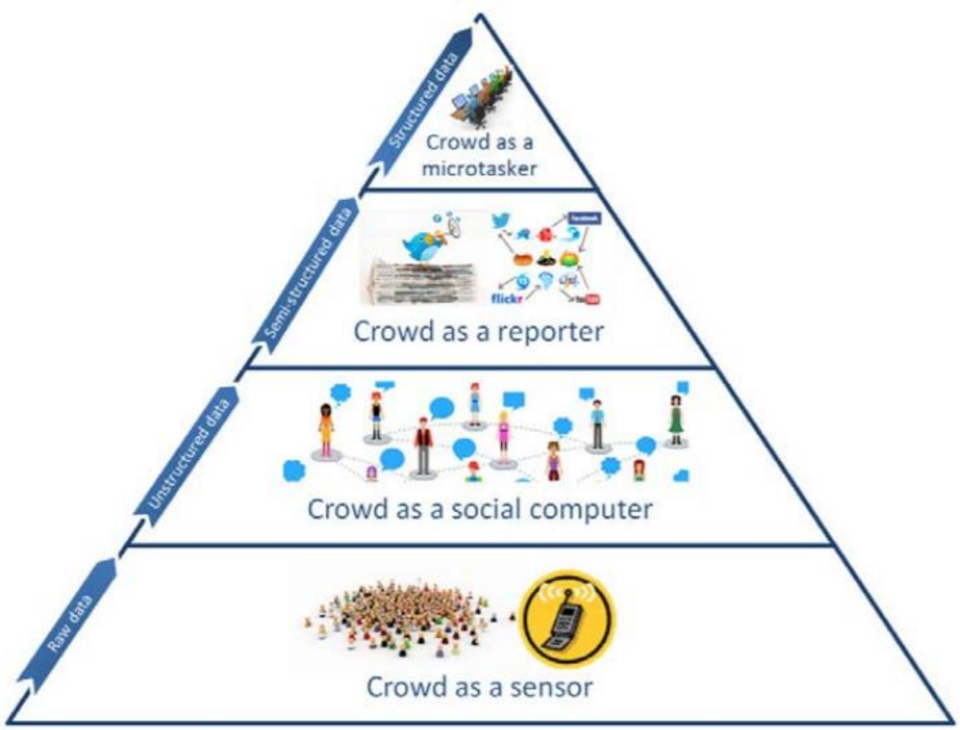
Crowdsourcing is an emblematic form of **citizen science**. Participatory mapping initiatives are gaining popularity and recognition within the DRR community. Furthermore, crowdsourcing allows disaster **responders and authorities** to access actual real-time local information. It allows for a more efficient analysis of infrastructural risks at the local level where adequate institutional data is not available.

The key is the **voluntary contribution of data**. Crowdsourcing requires an above-average sense of awareness and responsibility. It is already a global phenomenon and is applied on a smaller scale in many local initiatives, without even formalising it.

The approach has initiated behavioural **changes in the DPP** and aid sector as well. It is applicable to almost any type of disaster – natural or man-made – and almost any stage of its development (Prevention, Mitigation, Preparedness, Response, and Recovery).

Mobile technologies and social media have transformed the landscape of EMS and DPP services and the related public sector. It has enabled disaster affected citizens to produce real time, local information on critical events. Social media use during and after disasters produce thousands of photos and messages (e.g. on Instagram, Twitter, Facebook). The growing interest on how to **leverage social media** for disaster preparedness, response and management has been around for a number of years. Platforms and tools sometimes help, in other cases compromise safety and recovery operations. **Making sense** of a vast amount of crowdsourced data for emergency management and response is also a difficult task. Yet, these initiatives are exploited readily by multiple stakeholder groups: governments, companies, NGOs, volunteer and technical communities.

***Figure 18****. Crowdsourcing roles based on user involvement and level of data processing (Source: RMIT University, Melbourne)*



In **Australia**, the Government Crisis Coordination Centre (CCC) acts as an all-hazards management facility supporting protective security, counter terrorism, pandemics, and other natural hazards. It has recently started to monitor **social media as a new source** of data from which crisis coordinators can obtain awareness of developing situations.

A number of digital volunteer organizations (e.g. Standby Task Force, Humanity Road, Open Crisis) have integrated social media monitoring in their workflows when cooperating with large humanitarian organizations in disaster relief operations.

Two different technology approaches to disaster management can be identified:

- **Data oriented**;
- **Communication oriented**.

Data oriented approaches rely on intensive **aggregation, mining, and processing** of unstructured data sourced from different social media (i.e. Twitter, Facebook, Instagram, etc.) to generate **early alerts**. An example of such approach is namely the Australian Emergency Situation Awareness (ESA) system. ESA is a platform for emergency situation awareness which captures and **analyses messages** from different sources. It does not replace existing procedures and information sources but provides **additional data** with many **potential applications**: pre-incident activity, near real time notification of incidents or community responses and movements as a result of an emergency warning. In ESA's experience, this approach has proved to be faster than other traditional meteorological warning systems.

Moreover, whereas crowdsourcing relies on societal resources to produce, aggregate or filter original data, there are certain **automation tools** that are able to make use of information retrieval techniques to **analyse publicly available information**.

Analysing disaster risk information from macro-level data limits the analysis of the impact at the local level. When the crowdsourcing of local data is **integrated into risk reduction** analysis and plans, it can prompt further local actions based on local risks. Another important impact of crowdsourcing in risk assessment is that the process itself becomes a way in which participating communities learn about their risks, as well as an important **channel of communication** – both between same-level stakeholders and up and down the institutional chain. In the Bulgarian social and virtual reality, Facebook is used extensively by all age groups, while Instagram and Twitter by younger users.

## 15 – IoT Sensors for DPP

**Brazil**

**Internet-of-Things** devices and systems **(IoT)** are not new to safety, security and disaster management scenarios. IoT has the potential of saving lives through Early Warning systems integration, as well as other important monitoring and planning uses.

The deployment of multiple sensors for monitoring the conditions that could trigger disasters is crucial for remote areas and problematic environments. Developments in **cloud computing**, broadband wireless networks and the new generations of sensors and data analysis tools have led to the emergence of powerful, integrated and real-time systems. The inherent nature of such device use is referred to as the IoT environment.

Disaster management is an ideal case for IoT applications since sensors can send alerts about **potentially dangerous** indicators and conditions. For example, tree sensors detect if a fire has broken out by testing **temperature**, **moisture** and **carbon dioxide** levels. Ground sensors detect earth movements that signal earthquakes or other instability (landslides) in vulnerable areas. River levels are also monitored by sensors for possible flooding.

One approach to IoT is the integration of sensor data with a range of other information for a multi-faceted understanding of and response to disasters. After serious landslides in April 2010 that killed more than 50 people in Rio de Janeiro and left thousands homeless around the prefecture, the **Rio de Janeiro Operations Centre** was built in collaboration with IBM, by the end of the same year.

It has become an exemplary case of IoT sensors in use. This particular DPP unit is part of the City Hall structure, and although it was built a decade ago, it is still considered as a state-of-the art intelligence centre on a global level. The Centre manages complex city environments, incidents and emergencies around the entire prefecture by monitoring of **various data streams** generated around the city: **security** cameras, **rain** gauges, **traffic** signal data and traffic controls, **electricity** grids, GPS-equipped **public transit** vehicles and **social media** feeds.

The Centre monitors the extended urban territory 24/7. Critical incident preparedness includes **landslides** and **flooding**, while other sensors contribute to data feeds about **weather**, **traffic**, **police** and **medical services** in real-time. They anticipate problems and put defences in place to mitigate their impact. A weather and integrated event forecasting programme can **predict emergencies** up to two days in advance.

If an emergency occurs, **communities are alerted** via social media, conventional media channels and SMS. In high-risk areas, sirens are also used to evacuate the population. By coordinating all these activities, Rio de Janeiro has integrated most of the daily city **management** and **monitoring** functions **in one single command and control system**.

***Figure 19**. Rio de Janeiro Operations Centre.*

IoT technologies can’t stop disasters from happening, but can be very useful for disaster preparedness and planning (namely, DPP), including prediction and early warning systems (EWS). In this way IoT can **compensate for a poor infrastructure** that puts developing and emerging countries in a particularly **vulnerable position**.

The sensor monitoring of forest fires is a suitable illustration: sensors on trees can take measurements that indicate when a fire has broken out, or there is a strong risk, e.g. temperature, moisture, $CO_2$ and CO levels. If there is a **critical combination** of these parameters, EWS alert the population and request help. Firefighters arrive, having been acquainted with **more detailed information** about the location and spread of the blaze.

Other IoT applications are also potentially useful for DPP and EMS: microwave sensors that can measure earth movements before and during earthquakes; infrared sensors that can detect and measure floods and movements of people. These devices are **neither expensive nor difficult to procure, set up and exploit** and might be extremely useful to Black Sea regional DPP units and national URS teams.

IoT innovations are in a way an alternative means of one-way (passive) communication. They could help both with **preparedness and community resilience**. Wide deployment of IoT-enabled devices could bring benefits in terms of data network resilience in the face of various disasters. **Internet connectivity** in Bulgaria is above average and urban communication systems are well-prepared for such functionalities. IoT devices could enable communication services (e.g. emergency micro-message delivery) in case conventional communication infrastructure is out of service or is not completely efficient in real-time situations.

## 16 – Artificial Intelligence (AI) and Machine Learning (ML) in DPP

**United States**

High performance computing systems and networks are essential for DPP institutions of a certain level (national and regional). Artificial Intelligence and Machine Learning have advanced to the state where they are highly **proficient in making predictions**, as well as in the identification and classification of **factors** and **indicators**. Below are some of the categories of beneficial uses of AI and ML employed by DPP units and institutions in the United States.

1. **Processing information**. First and foremost, AI is used for data processing such as image recognition of satellite photos to identify critical objects such as damaged buildings, roads or flooding. **Multiple data streams** can be combined, unreliable data is removed and heat maps are generated. One example is what the US company Maxar (formerly Digital Globe) provides as **open source software** for disaster response. The software "learns" how to recognize buildings on satellite photos. Following the Nepal earthquakes in 2015, humanitarian and relief groups used pre- and post-disaster imagery, crowdsourced data analysis and ML to identify locations affected by the quakes that had not yet been assessed or received aid.

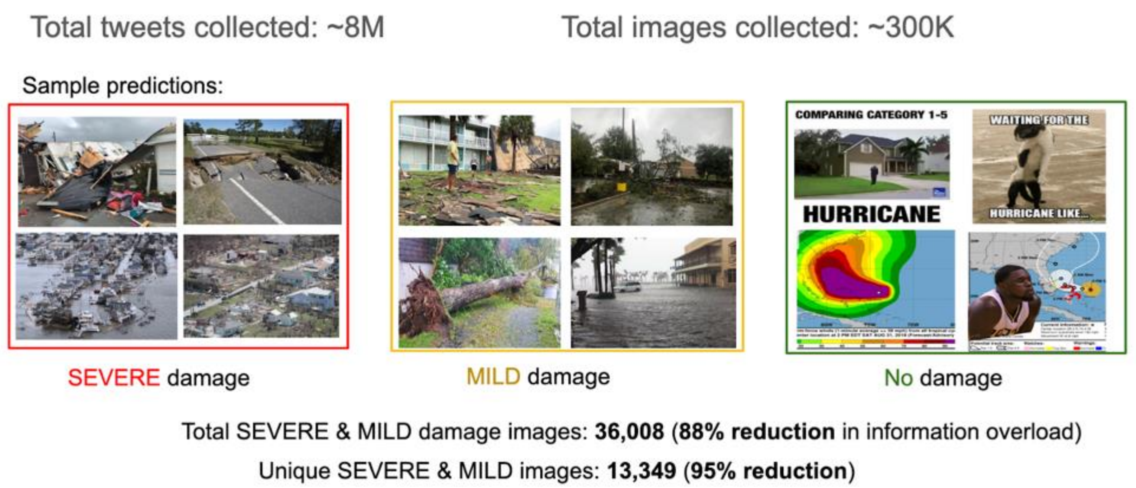
2. **Emergency calls**. During a crisis, **call centres** are often overwhelmed. In addition to voice calls, emergencies are increasingly reported by **text messages and social media**. AI and ML are applied to cope with the volume and different types of calls. In the USA, a system called Watson (developed by IBM) is used for speech-to-text recognition at emergency call centres since 2017. The text is input to analytical software that **guides operators** on how to respond to the call.

3. **Social media analysis**: Real-time information from Facebook, Twitter, Instagram and YouTube can be analysed and **validated by AI** to **filter** and **classify** information and make predictive analysis. The Artificial Intelligence for Disaster Response (AIDR) is a free and open source

platform that filters and classifies social media messages related to emergencies, disasters, and humanitarian crises. AIDR uses ML to automatically process tweets and other messages in real time. The software collects data based on **hashtags** and **keywords**, and then uses AI to further classify them by topic. The open software is free for those who work in crisis response. (*See illustration below*).

4. **Predictive analytics**. AI is also used to analyse **past data** to predict what is likely to happen in the event of a disaster. Optima Predict is a software which processes information from emergency response systems to **optimize ambulance routes**. The data can be integrated into online dashboards so that EMS and para-medical personnel can respond in real time in a more efficient manner and times.

***Figure 20.*** *AIDR processed images in real time (Hurricane Dorian, 2019)*




*AIDR was the Grand Prize winner of the 2015 Open Source Software System Challenge. The platform filters and classifies social media messages related to emergencies, disasters, and humanitarian crises. AIDR uses both human and machine intelligence to automatically tag up to **thousands of messages per minute**.*

## 17 – Disaster Prevention Communication and Telemetry System

**Japan**

We have already illustrated some of the main aspect of Japan's preparedness culture, in addition to technological and societal solutions to DPP optimisation. Its **disaster prevention radio** (**Bosai musen**) and **telemetry system** are additional exemplary features which deserve a more detailed analysis.

A **telemetry system** is used to monitor various disaster situations such as earthquakes, volcanos, floods, and environment as well as to operate DRR facilities on a real-time basis. The **disaster prevention radio system**, Bosai musen, aims at sharing disaster information with local residents. Even by relying on just these two methods, the private sector and ordinarily people can prepare for disasters by obtaining real-time information.

Telemetry and Bosai musen systems have contributed to measurably decrease the number of casualties, affected people and communities by sharing disaster information locally. Nowadays – especially in light of our replication purposes – the **cost** of similar systems has decreased significantly because of **ICT advancements**. Social and environment impacts are minimal and implementation is user friendly.

Still, a certain level of capacity and technology is required to operate the system. While these systems are useful for evacuation and response, using disaster information for actions on the ground is still a challenge. Risk communication with local communities is key to efficiently reach out for a coordinated response and trigger an orderly public behaviour.

Bosai musen and telemetry were significant improvements to DRR efforts and DPP status of communities. Relevant stakeholders can collect real-time information on disasters and DRR facilities through the telemetry systems. Real-time data remains essential in issuing **early warning** and **evacuation orders**.

Ordinary people can also access such information on the weather, rivers, and volcanos via a dedicated website or a locally/nationally popular App through their personal mobile devices, staying informed and ready to react in the event of disasters. Other stakeholders can get a better overview of the disaster scenario via Visual and Big Data. Technological solutions to telemetric challenges include optical fibre, Closed Circuit Television, climate radars and many other (see sensor list above in Case 15).

For local authorities and communities which cannot rely on wireless systems, the Japanese example from the 1960s is an illustration of an efficient monitoring without the full range of contemporary IoT applications and devices. The original system ensured monitoring of water and rain gauges directly, subsequently reporting the findings to relevant organisations on the telephone. Staff was then safely operating DRR facilities of pumps and gates from offices through telemetry systems without having to stay on site.

Thus, operators avoid facing risks of disasters from floods and tsunamis. In turn, local governments are able to issue disaster information, warnings, and evacuation orders through the Bosai Musen system. It started operating in Japan even before telemetry, in the 1950s and consists of central stations at government offices responsible for sending out messages and information throughout towns or individual receivers and households via radio and loudspeakers. Naturally, these messages can still be transmitted today with the help of advanced ICT means, even if an automated system is not available (e.g. the Brazilian case study) or AI and ML systems are not in place to filter and transmit relevant info up the communications chain and down towards the general population.

With time, the **Bousai system has evolved** in a **communication strategy**, a collection of standardised messages and preparedness rules and warnings to families and communities. The resulting disaster prevention manuals and handbooks prepare the population to recognise disaster-related messages in critical times and know how to react accordingly and in an orderly manner.

*__Figure 21.__ A Bousai musen Disaster Prevention Manual based on classic standard imagery*


## 18 – Using Social Media Feeds and Two-Way Messaging in Emergency Scenarios

**United States – Japan**

The above classic communication systems are still applicable today as an approach – and even a replicable solution – in many rural areas, including for training and communication campaigns. We shift our analysis towards more contemporary best practices in communication strategies and tools.

**Twitter** is a renowned messaging service where users can post 280 character messages (called "tweets"). Users register for the service and download the App, unless they use if from a computer. Unlike text messages, registered users can follow other users' tweets. "Cards" are used in the form of photos or **links** to videos and other media that get around the character limit. A crucial feature of Twitter is the **hashtags** (#) which aid quick search and recognition of tweets on a specific topic. For example, the keyword #hurricane locates all tweets containing the keyword hurricane. The drawback is that multiple hashtags can be created by different organizations during a disaster, making it difficult to know which one to use.

Twitter has also implemented the **Alerts** feature, aimed at improving its service during disasters. Alerts are **sent instantly** as either tweets or converted to regular text messages. The Alerts service was launched following the experience of the Lifeline project in **Japan**. It involved major public safety organizations as participants, including the Tokyo Metropolitan Government and Fire Department, and the Osaka Police.

Relevant Twitter **channels** publicised three hashtags to be used during the flood, depending on the nature of the tweet: **#Help**, **#Rescue** and **#Volunteer** for citizen groups to help agencies on the ground. A variety of information was shared in a well-targeted manner, including helpline phone numbers, updated train schedules, weather forecasts, relief efforts and safety tips. This helped to magnify **critical messages**, organise relief efforts, assist government agencies, warn the public and provide information in real time to citizens trapped in the floods.

Experts have looked at the role of Twitter during disasters, primarily flooding, hurricanes and typhoons. Most studies deploy **Big Data analysis** to examine the type of tweets and what they are used for, rather than their effectiveness during the disaster. Therefore, the goal is primarily to investigate how **Twitter is used to improve planning** and achieve more **effective disaster communications**. This includes understanding who are the most **influential tweeters** (i.e. biggest number of followers or retweets) or categorization of tweets.

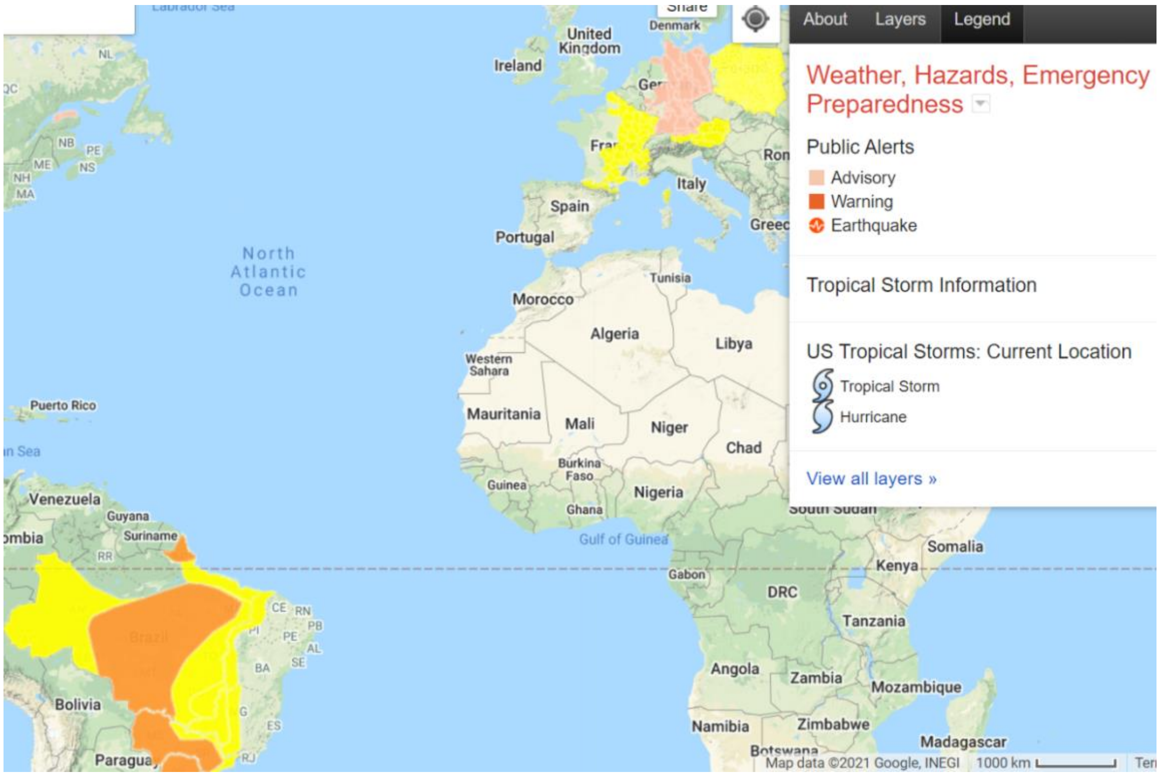
It has to be underlined that in the Bulgarian case, Twitter is probably not the optimal social network media, as it is not the most widely used and followed. Facebook is a much more suitable one.

**Facebook** is also relevant for disaster relief, given that it is the **largest social media** platform in the world, with 2.2 billion users (as of mid-2018), equivalent to roughly 30 per cent of the world's population. It has a Crisis Response service (*www.facebook.com/crisisresponse/*) which is also focused on segmenting messages for optimal real-time communication and resource planning.

In addition, Facebook has a **Disaster Maps tool** showing where users are located, moving to and whether they are using the **Safety Check feature**. The Disaster Maps tool has been used by relief organizations to identify where Internet connectivity required restoration in **Puerto Rico** following Hurricane Maria, and where respiratory masks were needed during the Southern California Wildfires (in 2018). The maps are particularly useful for examining mobile cellular **network coverage**, cell phone battery charging and **population movement** during a disaster.

**Google** has also created a **Crisis Map** (*google.org/crisismap*) for users to help locate critical emergency information. The maps feature **satellite imagery** and relevant information such as the **weather**, **flood** zones, **evacuation** routes, **shelters** and **power outages**. Users can **zoom in** on specific events (see map below). Despite the best of intentions, Crisis Map mainly shows the situation in the United States and some of the more developed countries. Users can **request to add layers**.

***Figure 22.*** *Google Crisis Map outlook (google.org/crisismap)*




Most of the networks and best case uses come from the services provided by the **US digital giants**: Alphabet (Google), Facebook and Twitter. The latter has probably been most ably used by both institutions and communities during disasters. It has also triggered the use of other applications to assist with critical events, including collaboration and sharing of **resources across platforms**. A suggestion on Twitter can prompt the creation of a Google spreadsheet to be shared for crowdsourcing information about **useful tips** used by the public, police and local governments.

## 19 – The Austroads "Safe System" Assessment Framework

**Australia**

The Australian "**Safe System**" Approach presents a "hierarchy of treatments" and data-based methods that can be used both in support of road safety **policy** and actual territorial

**interventions**. The Safe System is based on a long list of different types of potential crash scenarios and is evaluated on quantifiable indicators related to **Fatalities and Serious Injuries** (**FSI**). The implementation of the system involves:

• Adopting "**primary**" **solutions** which eliminate FSI occurrence; or

• If primary solutions are not feasible due to objective limitations (e.g. site, budget), "supporting" solutions are to be applied as the next safest option.

The highest possible **priority** amongst supporting solutions is assigned to interventions that **allow future Safe System solutions** (e.g. road surface marking with audio-tactile delineation installed with adequate width to allow a future wire rope barrier).

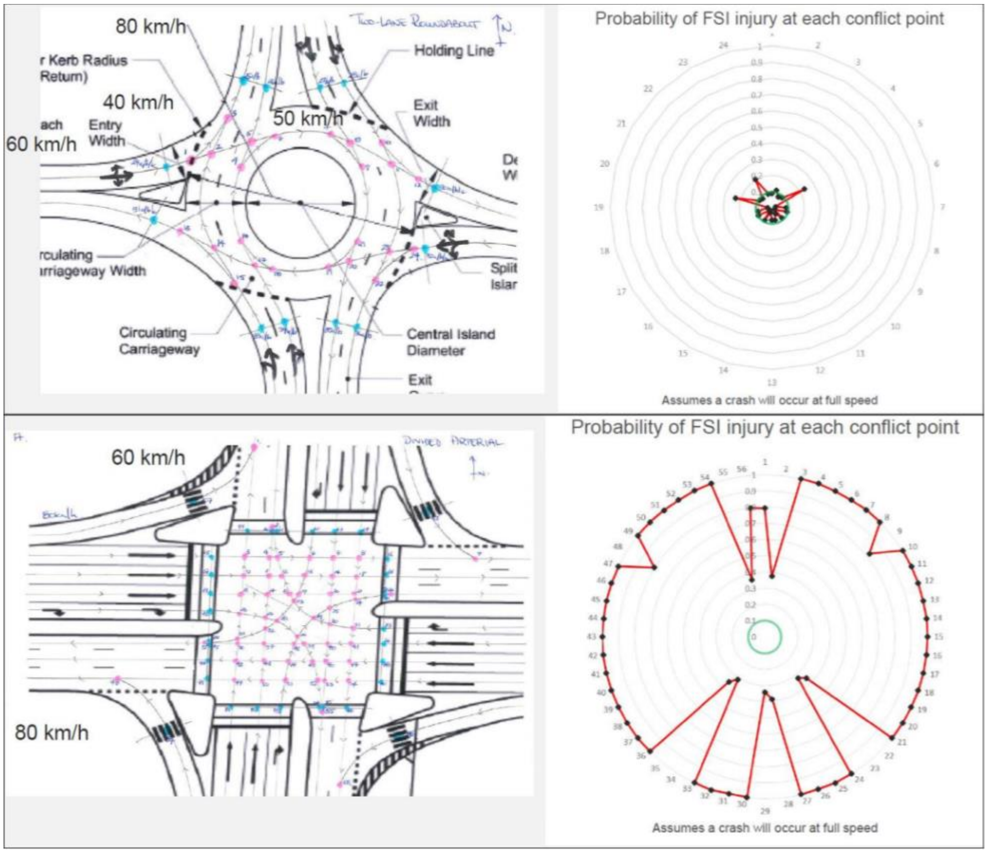
Safe System assessments focus is on reducing FSI by reducing the energy arising from a crash. This principle of **energy reduction** benefits is illustrated below. It considers FSI likelihood of having a **roundabout** compared to a **signalized intersection** at the same location.

Roundabouts serve to reduce vehicle speeds when entering an intersection, as well as eliminating the possibility of two vehicles **crashing at a 90º angle**. This alone reduces significantly the crash energy. They also have the advantage of reducing the number of conflict points – from 56 to 24; again, see below figure – thereby, again, reducing the probability of a crash.

For the **standard intersection**, **45** of the 56 conflict points have a probability of **100%** of an **FSI** in a serious crash. By comparison, the **highest** probability of an FSI is **25%** for the **roundabout**, with almost **all conflict points** having a statistical FSI probability of **10% or less**.

Naturally, this approach has been also adopted by many other countries which have appreciated the data-based justification of the roundabout superiority in terms of safety and FSI probability. Notable examples in the EU include Italy and Slovenia.

*Figure 23. Roundabout vs signalized intersection on Vehicle-Vehicle Crash FSI*




Note that this figure is from Australia and is based on vehicles **driving on the left**. It illustrates a high-speed context of road lane distribution – such as an urban boulevard or ring road; the focus is on vehicle-vehicle crashes. When there are many **pedestrians** and/or **cyclists** involved, an intersection with traffic lights or other controls may be safer.

A **conflict point** arises where the two movements intersect. They are represented by the pink dots in the above Figure. The above quantifiable studies have done in a similar manner by other reputable institutions and leading countries in road safety standards. They have all come to similar conclusions.

The entire hierarchy of the Safe System interventions is presented in the below table (*Based on the Austroads report AP-R509-16: Safe System Assessment Framework, with additions*.)

| Area of Concern | Primary Safe System Intervention | Supporting Interventions | | Other Opportunities |
|---|---|---|---|---|
| | | Compatible with Future Primary Options | Does not Affect Future Primary Options | |
| **Run-off Road Crashes** | • Flexible roadside and median barriers<br>(or equally/better performing future equivalent) • Very high quality compacted roadside surface, very gentle to flat side slopes & exceptionally wide run-off areas<br>• Very low speed environment & limits<br>• Road engineering to limit speeds | • Wide run-off areas, with well-maintained shallow drainage and gentle side slopes<br>• Wide sealed shoulders with audio-tactile edge line<br>• Lower speed limit | • Non-flexible safety barrier • Consistent design along the route (i.e. no out-of-context curves) • Consistent delineation for route<br>• Skid resistance improvement • Improved super-elevation • Audio-tactile centreline<br>• Audio-tactile edge line • Vehicle activated signs | • Speed enforcement<br>• Rest area provision<br>• Lane marking compatible with in-vehicle lane-keeping technology<br>• Electronic stability control in vehicles<br>• Intelligent speed adaptation in vehicles |
| **Head-on Crashes** | • One-way traffic • Flexible median barrier • Very wide median • Very low speed environment/speed limit<br>• Road engineering to limit speeds | • Wide median<br>• Painted median/wide centrelines | • Non-flexible barrier provision • Lower speed environment/speed limit • Ban overtaking<br>• Skid resistance improvement • Audio-tactile centreline • Audio-tactile edge line • Roadside barriers • Consistent design along the route (i.e. no out-of-context curves) • Consistent delineation for route • Overtaking lanes | • Speed enforcement<br>• Rest area provision<br>• Lane marking compatible with vehicle-lane-keeping technology • Electronic stability control in vehicles<br>• Intelligent speed adaptation in vehicles |

***Table 3.*** *Hierarchy of Interventions (Austroads Safe System Assessment Framework)*

| | | | | |
|---|---|---|---|---|
| **Inter-section Crashes** | • Grade separation • Close intersection<br>• Low speed environment/speed limit<br>• Roundabout • Raised platform<br>• Other road engineering to limit speeds | • Right-in/right-out, protected acceleration and deceleration lanes where required<br>• Ban selected movements • Reduce speed environment & limits | • Redirect traffic to better/safer intersection<br>• Turning lanes with sharp turns to limit speeds • Vehicle activated signs • Improved intersection conspicuity • Advanced direction warning • Improved site distance • Traffic signals with fully controlled right turns • Skid resistance improvement • Improved street lighting | • Speed cameras combined with red light cameras • Intelligent speed adaptation in vehicles |
| **Other Rural Crashes** | • Low speed environment<br>• Road engineering to limit speeds | • Reduce speed environment/speed limit | • Variable message signs/managed freeway systems<br>• Skid resistance improvement<br>• Turning lanes • Overtaking lanes<br>• Improved sight distance/conspicuity • Improved delineation • Improved street lighting | • Speed enforcement<br>• Intelligent speed adaptation in vehicles |
| **Pedestrian Safety** | • Separation (footpath &crossing point)<br>• Very low speed environment, especially at intersections or crossing points • Road engineering to limit speeds | • Reduce speed environment/speed limit • Pedestrian refuge • Reduce traffic volume | • Pedestrian signals • Skid resistance improvement • Improved sight distance to pedestrians • Improved street lighting<br>• Rest-on-red signals | • Speed enforcement<br>• Intelligent speed adaptation in vehicles<br>• Pedestrian safety sensors in vehicles |
| **Cyclist Safety** | • Separation (separate cyclist path)<br>• Very low speed environment, especially at intersections • Road engineering to limit speeds | • Shared pedestrian/cyclist path<br>• Cyclist lane • Reduce traffic volumes | • Separate cyclist signals at intersections<br>• Cyclist box at intersections • Skid resistance improvement • Improved street lighting | • Speed enforcement<br>• Enforcement of other regulations • Intelligent speed adaptation in vehicles |

| | | | | |
|---|---|---|---|---|
| **Motor-cyclist Safety** | • Separate motorcycle lane (e.g. on freeways) • Road engineering to limit speeds | • Shared motorcycle/bus/taxi lane (e.g. on freeways) | • Consistent design along the route (i.e. no out-of-context curves) • Consistent delineation for route • Skid resistance improvement • Motorcycle-friendly barrier systems | • Speed enforcement • Enforcement of other regulations • Intelligent speed adaptation in vehicles |

To illustrate further the **replicability** of the Safe System approach – in another country and context – we provide a Case Study from its implementation in **Argentina**.

The World Bank Group financed Argentina's Road Safety Project. As a standalone road safety initiative it had most of the **essential elements** of the **Safe System approach**. The results have been promising primarily due to the project's focus on strengthening and sustaining the road safety management capacity in the country by using the **Lead Agency Model** (in Argentina, this was the National Road Safety Agency, ANSV). The implementation authority oversaw policy review and infrastructural works, taking mostly a pragmatic approach to recommendations made by the experts' panel, and implemented initiatives that were critical to transitioning the country to a Safe System Approach over a period of **seven years**.

Partnerships with local and regional governments were crucial for funding cost-effective road safety interventions, building capacity – all led by the Federal Council for Road Safety. The Safe System approach supplied the necessary tools to collect road safety data. Additionally, the project helped the ANSV promote a sustainable framework for policy and projects, for which ANSV remains accountable to this day.

In addition, the initiative helped ANSV implement many elements – admittedly, most of which are traditionally present in EU and US road transportation ecosystems:

- National drivers licensing system;
- Road safety communication and education campaigns;
- Delivery of training and workshops;
- Protocols and guidelines for improving first responders' speed and efficiency in case of emergencies; and,
- Mechanisms to strengthen the capacity of traffic control and road police.

In terms of enforcement, traffic police working with the ANSV carried out over 180,000 inter-jurisdictional operations throughout the project lifecycle. Police units and associations also created

**educational campaigns, trainings and workshops**, and well as a **road injury information system** for use in 50 hospitals.

Finally, the Safe System project established the National Road Safety Observatory which maintains and analyses data to generate information on crashes, contributing **human factors** to crashes, and **infrastructure safety**. Currently, it generates and elaborates data for all of Argentina's 24 provinces. The project also created an **incentive fund** to implement road safety policies and projects with the aim of working with and through local and regional jurisdictions to devise road safety.

## 20 – The European Road Safety Decision Support System

**Trans-National – EU**

Considering the importance of creating policies and implementing infrastructural improvements based on data and thorough analyses, there are also European examples which provide best practices in the field. Even better, there are transnational initiatives which have involved experts under EC-funded consortia.

The **SafetyCube Decision Support System (DSS)** is an exemplary European Road Safety DSS which has been produced within the European research project SafetyCube (funded under Horizon2020; *https://roadsafety-dss.eu/#/measure-search*) Its primary aim is to support **evidence-based policy making**.

The SafetyCube DSS provides detailed **interactive information** on a large list **of road accident risk factors** and related road safety **countermeasures**. The SafetyCube DSS **fact-sheet** is available for download but more importantly, the DSS platform features interactive resources which can be consulted, filtered and explored by topic, context, type of event and corresponding measure. A **Quick Guide** on using the DSS is also available, with instructions on how to browse the system, make a search and further refine the results. (*A full recorded webinar on is also available on the site*)

***Figure 24.*** *The SafetyCube Decision Support System – main data categories*


SafetyCube (an abbreviation of Safety CaUsation, Benefits and Efficiency) is an EC-funded research project in the domain of Road Safety. The project lasted between 2015 and 2018 but has left excellent **tools** and volumes of **quality support information**.

As per its goal and functional mission, "the primary objective of the SafetyCube project is to develop an innovative road safety Decision Support System (DSS) that can enable **policy-makers** and **stakeholders** to select and implement the most appropriate **strategies**, **measures** and cost-effective **approaches** to **reduce casualties** of all road user types and all severities in Europe and worldwide".

The topics and explored sub-segments included:

Behaviour Law and enforcement;

Education and voluntary training or programmes;

Driver training and licensing;

Fitness to drive assessment and rehabilitation;

Awareness raising and campaigns Infrastructure;

Traffic flow and Traffic composition;

Formal tools to address road network deficiencies;

Speed management & enforcement;

Road type Road surface treatments;

Visibility / Lighting treatments;

Horizontal & vertical alignment treatments – Superelevation / cross-slopes treatment;

Lanes / ramps treatments; Median / barrier treatments; Shoulder & roadside treatments;

Delineation and road markings at road segments; Sidewalks treatments; Cycle lanes;

Traffic signs treatments at road segments;

Driver information and alert Interchanges treatments;

Junction treatments and Rail-road crossings (including Traffic signs treatments at junctions and Road markings at junctions);

Traffic signals treatments.

## Conclusions

Drawing conclusions from such a wide array of approaches, initiatives and measures is not an easy task. Nor was it the main objective of the study, as it had to identify leading best practices in the DPP and DRR fields. However, there are some **essential conditions** and requisites of successful and efficient interventions in the DPP sector.

Most leading solutions – whether on a system level or regarding a specific intervention – have begun with a **bottom-up analysis** of basic **needs** and current **shortcomings** of targeted DPP ecosystems. Essentially, tackling poor management and governance of infrastructure and systems is key. Put simply, a poorly-maintained infrastructure asset cannot be resilient and it has to be identified as such.

**Institutions** also need to be **resilient**. Profound political changes and economic challenges also need to be addressed at a local and regional level. Critical infrastructure assets and systems need to be identified and managed correctly, regardless of narrow social interest or current pressures, so that resources can be directed toward CI and essential DPP needs.

**Resilience** should be included in all public **regulations** and **incentives**. Financial incentives can be used to ensure that the full social costs of infrastructure disruptions are accounted for.

Encouraging service providers to go beyond just meeting mandatory standards is always useful, hence public-private partnerships in the DPP field are usually beneficial.

Access to **better data, tools, and skills** is indispensable to building lasting resilience. It improves **informed decision making**. Some of the above examples of digital modelling for urban needs and land uses are inexpensive yet critical to direct public policy, private behaviour and investment decisions.

**Flexible and innovative financing** schemes can supplement some of the shortages. The right kind of financing at the right time is key; just as the access channels and affordability of credit. An example: resources needed to support regulators and consider natural risks at early stages of infrastructure design are negligent compared to the funds needed to repair and recover in the aftermath of a disaster.

Making the **best use of technology** is also indispensable in improving disaster management capacity and the entire DPP ecosystem. Disaster response organizations must systematically manage information from multiple sources and collaborate effectively. They can reach out to the private sector, NGOs, citizen science (crowdsourcing) and IoT solutions. Their ultimate mission is to assist the population, mitigate damage and help communities rebuild. A growing number of responders and governments increasingly rely on ICT systems that can streamline knowledge sharing, situational analysis and DPP collaboration.

Inevitably, Governments will dedicate more resources and funding on disaster risk reduction and prevention, including medicine, research and global crisis control (especially in light of the crisis-overwhelmed 2020 and the continuing Covid-19 pandemic). The importance of best practice implementation and international cooperation is paramount to overcoming such challenges in the most effective and efficient manner.

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