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DAREnet

D5.3 – RDI Roadmap (V3)

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Abstract: Objective of D5.3 is to assess and prioritise the DAREnet Cycle 3 innovation opportunities and to develop the RDI roadmap version 3.

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PU   Public

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Glossary

Abbreviation / acronym	Description
2D	Two-Dimensional
3D	Three-Dimensional
4D	Four-Dimensional
CCC	Coordination, Command and Control
CMT	Community Management Tool
CP	Civil Protection
DMC	Dyke Monitoring and Conditioning system
DMR	Digital Mobile Radio
DNC	DAREnet National Contact
DoA	Description of Action (of the DAREnet project)
EUCPM	European Union Civil Protection Mechanism
EMS	Emergency Management Service
FEMA	Federal Emergency Management Agency [United States]
GIS	Geographic Information System
IO	Innovation Opportunity
ISO	International Standardisation Organisation
KB	Knowledge Base
PCP	Pre-commercial procurement
PFA	Psychological First Aid
PFA-CE	Psychological First Aid in Complex Emergencies
PPDR	Public Protection and Disaster Relief
PPP	Public Private Partnership
PSS	Psychological Support Services
RDI	Research, Development, Innovation
SOP	Standard Operating Procedures
SM	Social Media
SV	Spontaneous Volunteers
TWG	Topic Working Group
T&E	Technology and Equipment
UAV	Unmanned Aerial Vehicle
WP	Work Package

Executive Summary

The overall aim of the DAREnet project is to improve flood resilience in the Danube River region. One of the main activities is to collect needs of practitioners, to analyse identified gaps, to specify challenges and prepare initiatives for next steps, everything with a focus on innovation and the state-of-the-art in pre-defined areas.

The present document summarises the activities of the current 3rd roadmapping cycle that is **focused on TECHNOLOGY & EQUIPMENT aspects** and strives to filter and identify the most promising opportunities while assessing them from different perspectives that will allow a first selection of recommended innovation opportunities. For the assessment a scenario-based approach was applied that enabled the RDI topic working groups to base work on a fictive scenario.

The findings of the 3rd roadmapping cycle will inform and guide the activities in relation to the planned Danube Flood Resilience Innovation Competition (WP6).

Disclaimer: The opinions stated in this document are the result of the collaborative work within the DAREnet project consortium and are not necessarily in-line with the innovation strategies and aims of the individual organisations involved.

1. Introduction

The past has shown that in Europe, practitioners interested in the uptake of security research and innovation are dedicated to performing their duty and to focusing on their operation. In general, practitioners' organisations have little means to free workforces from daily operations, and to dedicate time and resources to monitor innovation and research that could be useful to them. They have little opportunities to interact with academia or with industry on such issues.

The DAREnet project reflects these gaps and is meant to support flood management practitioners across the Danube River region and from different disciplines to deepen and broaden their Research, Development and Innovation related collaboration (=RDI).

DAREnet is a multi-disciplinary community of practitioners, operating in a network of civil protection organisations, and is supported by a broad range of stakeholders from policy, industry and research. Together they are building a transnational and interdisciplinary ecosystem to foster synergies, innovation and its uptake.

The overall objective of the H2020 project DAREnet is to analyse future challenges and needs. In a next step gaps and innovation opportunities are identified with regards to flood and disaster management in the area of the Danube River basin. Therefore, a cyclic approach was chosen, as visualized in figure 1. Based on finding from previous cycles specific topics have been selected for separate cycles – the current one is focused on Technology and Equipment (T&E).

One of the key-results of DAREnet is a regularly updated RDI roadmap highlighting promising innovation opportunities to strengthen flood resilience of the region. The roadmap is the collaborative result of a systematic assessment and prioritisation of identified gaps, innovation opportunities as well as promising innovations, including standardisation.
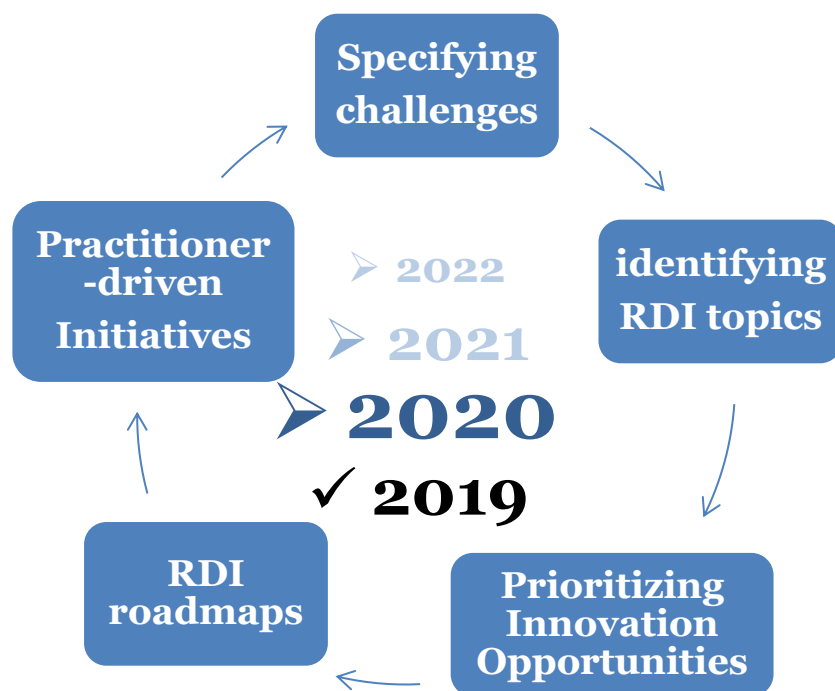

Figure 1: The DAREnet roadmapping cycle

This is the third edition of the DAREnet RDI roadmap. This document summarises the innovation opportunities or gaps/needs contained in the knowledge base (KB) and identified by the topic working groups within the DAREnet "RDI Monitoring & Knowledge Base" phase.

For the purposes of this DAREnet roadmap version 3, findings from previous project works identified "innovation opportunities" (IOs). Selected IOs were divided into groups and further elaborated based on the type of innovation opportunity as well as regional relevance, budget efforts, time constrains, usability and risks. At the same time the stakeholder groups have been envisioned to address the opportunities.

The third cycle of the DAREnet roadmapping process, same as the second cycle, followed a **scenario-based approach** focussing on technology and equipment aspects of diverse domains of flood management during the entire disaster management cycle. This document is based on the main findings and outputs from previous project activities.
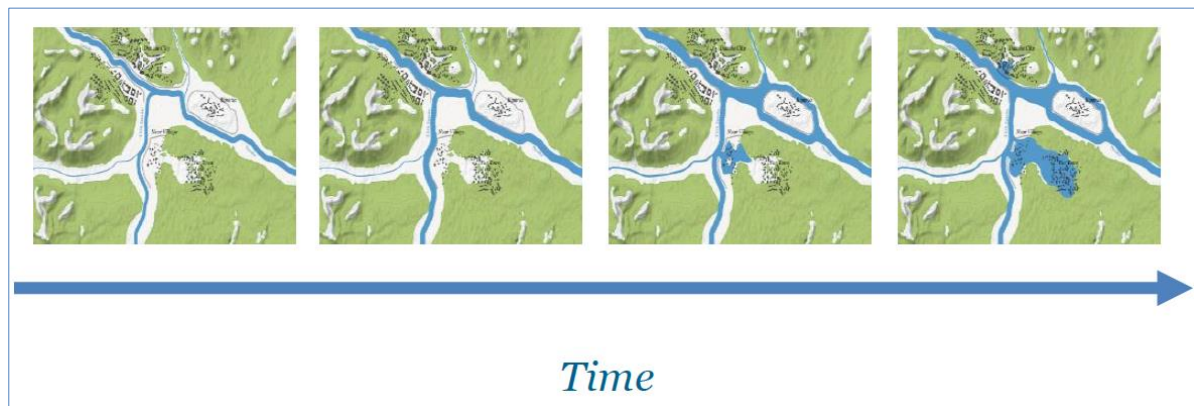
Figure 2: Phases of escalation in the chosen scenario.

The roadmap presented here also builds the base for the "DAREnet's Call for Practitioner Initiatives", leading to a portfolio of innovation ideas formulated by practitioners within and beyond DAREnet communities. These practitioner initiatives will be widely disseminated by the DAREnet project, promoting this essential project outcome to competent policy makers and funding programmes from national to European level, and aiming at their translation into concrete innovation projects.

2. Methodology behind the RDI roadmap

A total of seven concrete innovative opportunities were identified during previous project activities. These opportunities were entered into standardized forms (so called "Innovation Opportunity Sheets"), described and assessed from different perspectives and afterwards prioritized. Finally, based on these activities, version 3 of the roadmap has been edited summarising the work in the third DAREnet Cycle.

These innovation opportunities for the area of **technology and equipment** were assessed from the following perspectives:

- Classes of innovation types
- Practitioner needs (see 3.1)
- Level of maturity and reliability (see 3.2)
- DAREnet terms of reference (see 3.3)
- Other external factors (see 3.4)

With aim to collect as many contributions as possible, all identified opportunities have been made available to the DAREnet communities and external experts and subjects. Based on the results of these assessment steps, all selected innovation opportunities were finally prioritized within their group (i.e. in the aforementioned table 1 they are ranked with the most important/easiest to achieve being the first one of each group).

3. Innovation Opportunities

The following sections aim to provide a summary of the state-of-the-art of the Innovation Opportunities (IOs) of the 3rd DAREnet roadmapping cycle. The information provided regarding the subject of "equipment & technology" and related aspects aim to provide a basic description of each IO, compare them against needs of practitioners and formulate findings from this process. The input for the current roadmapping cycle originates from the findings of Work Package 4 (WP4). Based on this data a total of seven IOs (or topics/areas for innovations) have been identified:

No.:	Opportunity
1.	**Flood Protection Measures (Pre-installed protective measures), Levee Defense and Levee Control**
2.	**Water rescue and Boat operations**
3.	**Hygienic measures**
4.	**Securing evacuated areas**
5.	**Social Media handling**
6.	**Removal of flotsam/log jams**
7.	**Early Warning**

Table 1: List of Innovation Opportunities (DAREnet roadmapping cycle 3)

3.1.   Assessment against practitioner´s needs

Innovation opportunity 1: Flood Protection Measures (Pre-installed protective measures), Levee Defense and Levee Control

Levee and embankments are usually the main protective measures to protect lives and material goods. Compared to dams, levees are not meant for a continuous and long-lasting impounding. Therefore, the control of such structures is needed to identify weakening or possible damages as early as possible. These measures have become quite common in larger cities to ensure a nice riverbank without much visual disturbances, but also provide efficient flood protection. If a levee (or dam) is damaged or its structure weakened, it needs to be reinforced. Generally, building emergency dams could be summarized under this task. These activities involve often sandbags, however big packs and dedicated substitutes have been used more and more over the last years.

Existing solutions can be divided into two main groups, which are **solid and movable** ones. In many cases it is combination of both.

On regulated watercourses, a protective riverside is usually established as protection against 50-100 years old waters. The situation in the first-order stream is satisfactory, but it is far from being required given the potential risks posed by climate change.

As for the dams, especially reinforced materials and construction technology were used, which prevented their rupture, damage. Countries currently do not record damage to high dams. But they are at risk because number of these dams were built mostly more than 30-40 years ago. On the other hand, the system of alerting and warning people who exist in local communities just behind the dams, according to some respondents, is not effective and correct enough, but this is more related to "Early warning". Many areas are prone to flooding. The current situation is quite

problematic. It is necessary to focus on investment to be directed to the area of flood prevention. There are still some critical points when many devices are not in good, desired condition. Various protection areas and their effectivity lies on regular maintenance, bank strengthening and bottom cleaning. Regular monitoring of the condition of dams. If something happens, there is (should be) a service, supervision that responds immediately and prevents greater damage to structures and integrity. This is an opportunity for innovative technology and equipment (including materials and processes).

Specialized subjects/companies exist and are acting in the field of dams/levees monitoring. They are using various geophysical and geological methods, electromagnetic measurement of layer conductivity, resistance tomography method, digital measurement. Technical and safety supervision, observation probes-hydroboreholes, hydromorphological monitoring, ultrasonic measurement, limnigraph. Specific entities are responsible for solving problems related to the control water management and protection structures, as well as some departments in the local communities where these objects are located. Citizens are also responsible for reporting any damage if they have seen it. In both cases, there is room for using cutting-edge technologies.

Likewise, in many countries there is also a big national problem with the unknown owners of some large and several smaller dams, here the legislation needs to be amended. The flood risk management plan requires a comprehensive renewal, unification, and uniformity of conditions.

Number of good experiences have been identified. For example, in Novi Sad, a project was implemented to improve, strengthen the waterfront. The technology used is a stationary system, which can be reinforced with movable barriers. The result met expectations and the solution is effective. Similar experience comes from other cities also. Barriers are located along the Danube. Sensors and other early warning systems for floods are also used regularly. The government(s) has a website with various risks where anyone can access simulations and other important information about floods.

It is necessary to refrain from focusing too much on solid / concrete dams - dams are a thing of the past. They cannot be located everywhere and must be costly and complicated to maintain over time. There are a lot of another possibilities, which have to be taken into account. Protective levees, canals and reservoirs; dry polders; retention tanks; high-capacity pumps, monitoring stations and similar are already in use or at disposal. Room for improvements is mainly in technical level of available tools and in number of available solutions/equipment. Monitoring systems are not 24/7 in every single case (always).

A good and innovative solution is the use of portable barriers. They provide several operational advantages because they are mobile and can be used to divert water from the nearest river to make the dam, etc. Several types are available on the market.

Public water companies (first-line responsible subjects) have mobile dams at their disposal, but this is not enough in terms of needs and the size of the river basin. Significant problems are second-order flows, which are in the jurisdiction of local governments. A lot of them has already been done in the area of disaster prevention or reduction, but there is still room for improvements and the emergency sector has initiated, with local government management, more budgets to do so. In addition to moving barriers, during floods, sandbags are still filled as required, or water-filled barriers are used as well. At the same time, existing mobile barriers require technical intervention, which needs to be consolidated or maintained in good condition.

Other solutions for controlling and maintaining dams are, in particular, legislation, such as bans on material and waste management on embankments, motor vehicle crossings, planting trees on defensive embankments, it is forbidden to dig wells and trenches near embankments, as well as any damage to embankments.

Planning and decision-making measures are an important part of the measures. Such as: risk and threat assessment, measures in buildings, regulation of watercourses, retaining walls of buildings, prediction of natural disasters in the atmosphere, as well as the organization of surveillance, notification and warning systems. Some of the solutions to be used and to be respected are: to bring appropriate land use plans, not to build next to the rivers (floodplains), construct "flood resistant" buildings in risky areas, restoration of natural flow, construction of dams and defensive barriers. Recording can determine flood zones, which may be endangered by river spills. There is room for using innovative technology and equipment.

From the point of innovation potential, as mostly interesting appears to be remotely operated robots carrying the correct sensors; sonar technologies; satellite observation and satellite data transmission - modelling of the current state, drones. Sonar, warning information systems / warning SMS, map data. (These technologies most probably already exists on certain levels, but availability to practitioners is questionable.) The applied technology is currently based on the protection of the dam and some moving barriers, which are provided in specific cases. Citizens are becoming more aware of some scientific articles, which is encouraging. Mobile apps to report any possible issues are spreading. The involvement of ICT is wanted. This is a trend that needs to be supported. Basic principle is to maintain the flow of rivers in a natural shape and to avoid artificial interventions on the banks of rivers.

An example is a specific technology / device located in a river bed and, because the device is filled with water, it automatically sends data on the speed and amount / volume of water that will cause precipitation in a certain period of time. If the device is quickly filled with a large amount of water, a signal is automatically sent to the headquarters and warns of the potential risk of flooding.

As a conceptual approach, a set of measures can be applied. Stripes indicating the flood area around rivers. This will show the sites for the construction of dams and at the same time limit parking and other activities in the area. Mapping of the lowest points and directions of runoff at the regional, national and supranational level (this marking might be integrated in different mobile application to notify the users automatically). SMS disaster warning system. Integral and complex application with coordinates of problem points and places. It can be connected to all national monitoring systems. The system of management, traffic diversion and critical infrastructure in emergency situations is also important.

Preventive and control measures are the best solution to prevent the deterioration of dams. It is necessary to continuously examine the condition of dams, taking into account climate change. This may require changes in the size of the protective equipment. Changes in the structure of the territory of large cities must also be taken into account. For example, in the city of Sofia, the protective devices of some rivers have fallen during their construction outside the urban area and with the subsequent expansion of the city are already included in the urbanized part, which leads to the need to change their size. Known methods, which are not so innovative but effective, are the termination of gabion structures. Modern solutions for effective flood protection solve the combination of the application of structural measures / construction and strengthening of dams / with ecological solutions / etc.

Experience learned so far shows, that well equipped responders have better results and their response actions are more effective. There is direct proportionality, with better equipment having better results.

New trends and innovations should bring acceleration of intervention, targeted and controlled intervention, better overview of the current flood situation, better coordination of the deployment of forces and resources. Better synergies between all stakeholders. The benefit would also be more efficient management of lifeboats in the river information system, more successful evacuation of vulnerable and endangered persons. Important point is training, which have to included together with any new equipment and technology.

To be successful with introducing innovations it is important to consider also financing of actions, current state of related legislation, interconnection with legacy systems, bilateral and multilateral cooperation of units (of particular area), involvement of public and local communities into the whole process. Also standardization, especially in scale of international level.

Innovation opportunity 2: Water rescue and Boat operations

These sub-items refer to evacuations from flooded areas via wading with rafts. Rescuing of trapped people, for example in cars or pressed against fences. This task requires special trained and equipped teams.

Besides supplying trapped peoples, or evacuating them or simply rescuing them, also securing of driftwood, or tanks, etc. might be necessary. Additionally, driving a boat through flooded areas also bears high risks that are not comparable with ordinary water rescue operations, standing waves, siphons, or wires could pose multiple threats for boats and their crews. The focus is on technologies and equipment to facilitate and secure such operations.

The current situation in this area is aiming on hovercrafts, low-draft boats, amphibious rescue and evacuation vessels, inflatable rescue walkway and similar solutions. Based on the experience of the last few incidents, it appears that the amount of equipment is increasing and a well-planned evacuation could take place. The next step is to raise awareness that personal protective equipment and facilities are in place for areas that could be at risk from floods.

Emergency - crisis management in many countries has respectable resources for rescue from water and underwater. The teams are equipped with executive boats and other equipment. There are also specialized fire and civil protection units for water and underwater rescue, which includes top divers and people with a certificate for water and underwater rescue. They use boats that are specially designed to be strong enough and impact resistant. In practice, all available boats are used. Rubber boats with paddles, motor boats and basic protective equipment, especially life jackets, are used. Communication takes place via radio stations. As equipment used in water rescue operations are mainly: lifeboats, life jackets, floating ropes, diving suits, oxygen tanks, first aid kits, oars and many other equipment, but it is also important to have communication resources, GPS devices, their correct records.

But the current state is not sufficient in many cases and in perspective of material and technical equipment with regard to local conditions (terms of use, terrain fragmentation/rugged terrain, manipulation), possible pitfalls, universality of use in water/land (Solutions already exists, but are not at disposal – probably mostly financial issue, but also cutting-edge technologies have to be considered).

Topic of resources sharing should be open. This way financial sources might be saved. But it is more complex, because also responsibility and maintenance have to be considered. Aim is to make existing equipment available and activated as much as possible. This have been identified as one possible gap that could be covered by innovative approach. All the equipment should be divided equally in terms of critical infrastructure as well as endangered communities.

From the point of practitioners view, the boats need to be designed to make it easier to evacuate people, as well as highly (easily) maneuverable (technical design, materials, technologies...). They should have small draft, be solid (reinforced to avoid damage) and multi-purpose (floating bridges, hovercrafts, etc.). Gaps have been identified during rescue on wild water and in flooded objects. All the technology and equipment have to be robust and durable.

Concerning innovative aspect, effort should be paid mainly to using of modern materials and processes, from the design to the production, with focus to multi-usage of final products. Another promising area is using of remotely controlled devices such as UAV, UGV or UFV (unmanned floating vehicles). Last, but not least also surrogate solutions, such as temporary camps for example, definitely belong to this topic.

Innovative action in this topic could bring acceleration of intervention targeted and controlled intervention, better overview of the current flood situation, better coordination of the deployment of forces and resources. Better synergies between all stakeholders. Rescue services and other actors should constantly train for rescue operations in water and underwater. It is positive that these actions are starting to be planned in the annual plans of the various actors in the rescue systems. From the point of view of technology and equipment it can be special training canals, real exercises with real equipment, but also cutting-edge training/education technologies. Using of innovative tools should be aimed on reducing of practitioners/responders exposure.

For the successful deployment of products in practice, it is important to consider related training and preparation. Not only of responders, but, based on experience, of the public also. Cases happened, that people refuse to be evacuated, for example. Again, multi-level communication and collaboration of all stakeholders including communities is required. Last but not least, what needs to be taken into account, is the exaggerated confidence of people, that they can do it themselves. This can be supported with equipment but carefully considered at the same time.

Innovation opportunity 3: Hygienic measures

It is the hygiene what is an important aspect in situations of flooded area. Hygienic measures are important primarily for the responders, but ultimately for everyone who might get in touch with the water or when the water sinks the remaining mud. The water during a flood contains often chemicals, such as diesel, or gasoline, and often the sewage systems are also affected leading to spillages of untreated waste water. So, water can spread different diseases as well as hazardous materials, especially if places where such a material are produced/stored/used are flooded. Another aspect is provision of drinking water for people and animals in affected area.

Given the fact that flooding bears high hygienic risks, it is important to provide sufficient information to those affected, but especially the inhabitants which have to clear their homes from any debris and might get exposed to any contaminated material. Further, a fast recovery of the sewage and drinking water systems is critical to reduce hygienic risks.

Solutions covering these issues are modules and equipment for the purification and treatment of drinking water (water purification modules - high-capacity mobile water purification device-water treatment by reverse osmosis system, cleaning and disinfection of wells), oil and hazardous substances separators. Analyzers for the presence of dangerous substances in water. Mobile control chemical laboratories. CBRN teams, Hazmat teams. It is important to take into account that there is no waste treatment system in case of flood and even under normal circumstances, some water supply systems are disrupted.

Crucial stakeholders are networks of public health institutions. Due to the area of their work, their primary interest is the identification of suitable technologies and solutions. But the role of the volunteers for example (like Red Cross) is also recognized in these activities. The hygiene package is most important for first flood response activities. Water from specially designed containers is used as well as water purifiers.

There are means of disinfecting flood-affected areas, as the water caused by the flood also carries various contaminated materials / particles and spreading them widely. In following period of time, it is necessary to clear the area, provide disinfection and decontamination, water purification using various filters and pumps. There is also real danger of water pollution - groundwater and surface water, so this have to be treated as well.

Specific measures are taken during prevention and preparedness phase (planning), especially for points/areas with high risk, such as: Water and sanitation plans at the regional level; Communication campaigns; Clean water supply (in bottles); Recovery plans (wells); Biochemical analysis of water; Debris removal.

Final effectivity of response action is directly proportional to number and quality of available equipment and technology. The second crucial aspect is trained personnel. It is necessary to increase the efficiency of machines for the treatment of contaminated water and to build capacity in this area (number of devices, to increase total purification capacity, to implement system of sharing of these capacities and of course, to consider suitable system of training).

From the perspective of preparation and preparedness, appropriate risk assessments and construction plans for industrial facilities and factories should be carried out to avoid possible blue spots. Water supply system is one of the most important points and appropriate care have to be taken to it, whether it is regularly inspected and maintained, and how the water supply is restored in a short time if it is interrupted.

In addition to equipment and specialized teams, the population must be educated on how to deal with such situations (how to evacuate yourself, family, pets, use bottled water, eat canned

food, ventilate the area and thus speed up the drying of the area, to recognize some symptoms of the disease, how to use available equipment, how to prepare simple solution, etc.).

What should innovation activities bring into this topic are solutions based on cutting-edge technologies. Detection of hazardous substances, ecological neutralizing substances, mobile purifiers, long distance laser gas detection; mobile drinking water treatment plant - water treatment by reverse osmosis system; oil product separators. Determination of the degree of pollution and confirmation of purity and safety. Sensitivity of the devices plays important role, because measurements affect directly health and lives.

There are some environmentally friendly technologies, but the question is how to prevent the spread of toxic material all around. Sometimes it's almost impossible. There is no magic technology that prevents the spread of cyanobacteria in surface water for example. There are specially developed pumps that are more efficient in the process of recycling polluted water. It is very important to educate and legally impose on citizens and legal entities the obligation to dispose of all types of waste, then to develop a waste management system so that waste is not affected by floods. Develop hygienic sanitation facilities that can help in the event of the spread of infection, as well as the capacity of drinking water in the event of water supply interruption and contamination. What needs to be improved in terms of equipment are water filter pumps, water pumps that provide shelter to people severely affected by floods. The process should include mass citizen-centred training, together with a platform to compare needs and resources freely available to citizens. Hygienic measures request great capacities for treatment. Automatic systems should in a loop of RDI.

To date experience indicates, that there are never enough capacities, especially in cases of more extensive floods. Mobile control devices serving as drinking water purifiers and treatment plants and mobile separators of hazardous substances, submersible walls, mobile water purification device – these are tools recognized as suitable. A lot of problems have been reported in this area. This only confirm the urgency of the subject. Positive results have been recognized from using of mobile app (Team Österreich – volunteer management system / platform).

Prevention and preparedness are crucial. This includes technology and equipment also. Focus has to be given to training of operating staff and education of the public. Solutions should be targeted at all people whose homes are contaminated (is expected that will be contaminated) and have nowhere to stay until sanitation is carried out.

Innovation opportunity 4: Securing evacuated areas

The evacuated perimeter needs to be secured against plunderers. But there are also other aspects – what if livestock stayed there, what if wild animals are in the evacuated area. It is possible that also different groups of responders could be a threat for abandoned property, respectively it is important to ensure, that responders will not be blamed in case of thefts or damages. It is also securing of property itself, especially critical infrastructure, and its features. Specific attention should be paid to cultural heritage.

In most countries, it is the role of the police or the army, in specific cases by another security units (municipal police, private security services). They have to use different methods, while using ICT it can be a combination of surveillance with different electronic devices, as well as regular patrols in the endangered area. Important part is informing the population about measures already taken as well as about next steps.

The crisis management sector is looking after affected population and has in stock necessary material and technical equipment. It also includes equipment for several specialized units for the care of evacuees. These units do not have a professional status. These are specialized civil protection units composed of reserve personnel, but with the necessary professional training. Evacuation provided by local authorities and the national level is included only if larger evacuations are met, taking into account the criteria and priority set by law.

Legislation and founders in law enforcement structures, such as police, gendarmerie and border police, pay well on this issue. The legal framework is a very important part of preparedness.

In the event of a disaster, rescue teams, fire brigades / services and local authorities react first. Lifeboats and evacuation helicopters, rescue helicopters, various mechanisms are used to control and mitigate the disaster.

The gaps from the view of practitioners have been identified in using of independent (remotely controlled) surveillance and monitoring systems, related communication systems, integration of these systems with technologies and equipment currently in use (legacy systems).

It is important and necessary that all steps are planned in advance and on the basis of trust in the police. This could be supported by ICT tool.

Last but not least, it is necessary to improve the technical equipment used to secure the site. In addition, it is necessary to make the most of information and communication technologies in the process. Information and education aspect have to be included. Security capacities should be strengthened in the case of the provision of critical infrastructure and all other equipment to prevent theft and damage. The problem with evacuating the population is the refusal of the population to evacuate or not to recognize the danger in which they find themselves would be eliminated. The organization of security in vulnerable zones should be improved and the likelihood of similar and similar situations occurring being reduced.

The speed and reliability of the information flow of information, the predictability of the ongoing event is important psychological trainings and trainings for rescuers and intervention teams combine with the preparation of citizens - communities in endangered areas.

Innovations could be focused on monitoring systems that is activated only in the event of floods or other emergencies linked to safety and rescue services. Digital technologies are now available and can be combined. It is necessary to make full use of GIS and other software tools.

It looks that great potential is in using of drones to monitor, locate and track and search for lost people. It is possible to place temporary or use permanent camera systems on objects to control theft or looting. Find and support research and development of technical measures to inform a large group of people quickly and accurately, technical solutions to obtain an overview of the state of the evacuated area (eg evacuated people vs. people still there), simulation and forecasting system together with trained experts in the field of first contact. A system of comprehensive national and transnational emergency accommodation for flood-affected countries seems to be possible effective tool as well.

Based on experience, inspiration might come from insurance companies and private agencies providing very satisfied services in this area.

With regards to expected added value coming from innovations, it could be property protection; identification of the violation of the law / measures; controlled intervention; accompanying benefits might be control of the evacuation and rescue process, evidence of crime in the event of looting, etc.

The police and the army must be well equipped and must plan these activities in high-risk areas in cooperation with other stakeholders, so that the safety of people and the property of the population is protected after the evacuation and rescue. As well as public safety in line with the security for search teams. The use of information technology would increase the efficiency of all services in this area. Improve the safety of evacuated areas and better preparedness. Securing areas could be less demanding on human resources and save resources for other elements in the operation.

Important aspect is securing of conditions in evacuated are and places, where this people are placed. The possibility of a sharp rise in the prices of basic foodstuffs and water in shops and markets in the affected areas must be eliminated. In such situations, this must not be allowed and anyone who violates it should be held accountable to the relevant institutions.

Innovation opportunity 5: Social Media handling

During the last couple of years, the importance of self-organized activity of the public as well as the relevance of possible false information becomes obvious. Another aspect of social media would also be crowd sourced information gathering and the effective integration in situational awareness management. In other words, social media is a potentially valuable source of information, but it needs to be carefully considered and processed. Both aspects might be challenging for the responders and represent great potential.

This is still a bit of an unknown area. Responsibility depends on the way of communication and the strategy of using the tools. There is room for improvements from many perspectives. This topic can be split into two main parts, which have to be considered separately (different approaches are expected):

1) providing information towards public (informing through social media – number of different activities have been realized here and are rising),

2) using of information captured on social media (exploitation of what is available on social media).

As most important channels have been selected Twitter and Facebook, but latest trends have to be taken into account. At the same time, social media accounts of "official subjects" (police, FRS, etc) as well as information from another ones (unofficial, personal, different interest groups) should be considered (mainly for collecting of data from civilian population). Relevant role has also public media (televisions and radios). Appropriate source of information might be online cameras systems. In some cases/countries, there are also mobile apps, which partially covers this topic (Team Östterreich – Austrian Red Cross app.) Indications that social media are actively observed by editors, specialized staff and/or by artificial intelligence engines have been identified (Austria and Germany).

It is obvious that knowing the situation is one of the most important prerequisites for a successful response. The information is therefore crucial. No matter where they come from. However, it must be verified, accurate and up-to-date. The gaps from the view of practitioners have been identified in coordination and unified management of the flow of information in contact with social media; fruitful and timely information to the public in order to prevent misinformation and thus the spread of panic; identification of the target group - to which the information is to be provided; assumption of the situation after the publication of the information; coordinated, targeted, truthful and up-to-date management and information sharing.

Concerned to exploitation of the content available on social media in case of emergency situation is big question mark. This need has not been identified in the most of the Danube countries so far. It is more on theoretical level. However, some good indications of actions in this area have been identified (Virtual Operation Support Teams – VOST). Practitioners are aware about trends of photographing the spot and sharing data by individuals as well as they understand it as possible source of useful information. It is obvious, that there is great potential and that it is closely linked to technology (and equipment). Again, crucial is education and training of experts providing these works, including practitioners. The risk communication theory is developed but it looks that it is failed recently. Uncertainty is the worst enemy of social media handling (so this is the gap as well).

Innovations could be focused on validation of captured information and on preventing the spread of misinformation. Innovation should be focused on unified current information system. Use of the content available on social media by practitioners is currently more principal question. As soon as this will be approved by decision makers, it will be possible to discuss technology and equipment.

One of very concrete point is tool for confirmation of status on site. It means that practitioners (respectively another reliable sources) can verify a confirm if situation based on data from social media is true or not, respectively what is the difference and that this can be done as soon and as quick as possible. Live broadcasting of online situation and conditions using modern CCTV systems can be considered as innovative opportunity as well.

Above mentioned findings are confirmed also by number of experiences. Negative ones related to spreading or rumors which affect the public response, while good experience comes from sharing the positive example of human kindness.

The brief conclusion may be that more effective communication towards public means better interaction also with affected people and creates conditions for efficient response and after response actions. Collecting information from SM might enable practitioners to be better and more accurate informed about situation on site, to better model and forecast the development of the situation, to ensure evidence about extent of damage, etc.

Innovation opportunity 6: Removal of flotsam/log jams

Floods usually cause a lot of flotsam, which ranges from litter left in the flood plain, to entire trees, or even cars or houses. Besides obvious destructive effect of cars and houses although smaller flotsam can be a threat to infrastructure located at the stream. Particularly, log jams at bridges could cause problems and require fast actions. If not removed, these log jams could lead to further flooding due to the raise of the water level at the jam, or even lead to a failure of the affected bridge. For this scenario equipment and technologies for the removal of log jams should be in the focus. At the same time equipment and technologies to prevent such situations.

Technology and equipment in this area are known and used. Work machines, excavators, floating work machines and bulldozers are mainly used for the removal of accumulated waste and logs special technique for working on a watercourse; walking diggers, heavy equipment of army if needed. Specific technologies designed for the collection of residues and their disposal in specific areas.

It is the activity of water managers and rescue services, who are connected with this issue. There are state capacities for this purpose, but also a growing number of legal entities and entrepreneurs (for activation is necessary to have prepared specific procedures). The available mechanisms are various construction machines (excavators, cranes, various transport tools for the disposal of alluvium and waste, tractors …)

Deteriorated permeability of the river bed due to irregular cleaning and clogging is one of the main causes of floods. Problems arise mainly from human activity. But this is question more for prevention.

The gaps are manifested in the fact that the state (local government) does not have sufficiently developed capacities for heavy equipment, but relies primarily on legal entities and entrepreneurs who have such mechanisms that are not always ready and able to participate in cleaning operations.

From the point of view of innovation together with technology and equipment, the actions should be focused on design of related constructions, e.g. better permeability of bridge structures so that alluvium does not accumulate under them. This will help the flood water to cross the bridge without any problems. It is important to note that it is common for waste to be handled far from the site of the rivers, and this have to be considered as well. Mechanisms and auxiliary material should be lighter, but more powerful and environmentally friendly. Open point is how can technology and equipment help and cover related aspects like legal, financial, organizational, logistical and other issues. Innovative technology and equipment should solve topics of prevention and preparedness, also. Because these are the ones that cause situations of flotsam/log jams mainly.

Added value of innovative activities should be increased infrastructure protection, waterway protection, protection of water endangered areas, water collection for further use, respect for the aquatic environment. Increasing the practice of recycling and also the reconstruction of landfills after major disasters that comply with all hygienic conditions. Continuous education and training to perform these jobs, the use of modern equipment and technology.

Innovation opportunity 7: Early Warning

This addresses any equipment, technologies and systems to warn the public and the authorities in a timely and precise manner. Particular attention should be paid to early warning of people with special needs (disabled, illiterate, non-native speakers, etc.).

These are mainly technologies for efficient transmission of information and equipment for sending and receiving them. Attention needs to be paid to the way of interpretation of information to different target groups and specific people.

Current situation is, that Main needs are covered. Room for improvements are related to specific areas and specific target groups. Core is warning system of civil protection (sirens). Other possibilities are mobile devices; warning SMS - basic information, mobile apps, emergency package; radio broadcasting; warning information systems (these systems are not used on whole territory of Danube countries – a national approach would be desirable).

Currently, in a lot of European countries are in use integrated systems for alerting the authorities and population in real time, receiving and processing the data coming from multiple observation sub-systems (surface meteorological and hydrological sensors, DOPPLER radar, satellite sub-systems, etc.) and a lot of types of equipment. The main benefit is relevant for the nowcasting activities, allowing the early detection, surveillance and prediction of severe meteorological phenomena and related hydrological ones like flood. These systems includes a quasi-real time dissemination component of the meteorological information, so that the local authorities and the other users could be promptly informed about the occurrence of severe meteorological events, being able to take, in time, the necessary steps to avoid disasters and damages.

People, the population in general, often registers phenomena that they do not recognize as a significant early announcement of events. This information needs to be shared in the right way with the competent institutions, because they may be crucial as early warning and signalizing the occurrence of danger in time. There is a need of a timely and clear warning about the upcoming flood. The warning should be expressed in a way that persuades people to take appropriate actions to reduce the damage and costs of the flood. Very often the information is limited only to information about the precipitation, and the information about areas where there is a risk of floods is not included.

Main aspects which are recognised as gaps by practitioners are network coverage, security - privacy protection, protection against data misuse, early and targeted warning. From the point of view of innovative actions and ongoing trends a number of new solutions are appearing, information and communications technologies are expanding rapidly, a lot of applications are under development. Joint approach on different levels is required. As main tool has been identified mobile phone / smartphone.

Use of social media resources, where everyone can find themselves in the role of a reporter on the spot and be the initial information is important for the identification / early warning of danger. The trend is to follow the reactions on social networks, and this is live mechanism that has been developed should be used to the maximum. Weaknesses of the system are the obsolescence of the way of monitoring innovations in the field of data and information exchange. ICTs and social media are proved as the fastest way to initiate human reactions in emergencies. Special focus should be given to specific target groups – disabled people, elderly, persons with different disabilities etc.

The weak points of technologies and equipment currently in use are that there are a lot of people who are not educated to use this technology or do not have adequate technological support. Also, educational and financial constraints have to be in minds of policymakers. It was visible in the on-going organization of e school related to the COVID-19 pandemic, for example. On the other side, good practice comes from applications like RO-ALERT (Romania).

The message turns the scientific predictions into a non-special language information about the specific risks for the threated area (the comprehensibility of the information for the average, maybe specific, user is very important). People from affected area must be not only informed for the upcoming threat, but also to receive convincing information what exactly must do in order

to protect themselves and their property on-time. People have to know how exactly to limit the risks.

Early warning procedures and instructions should be clearly edited, and audio and visual notifications should be made so that everyone can see and hear. Perhaps one of the innovations can be the use of drones with audio instructions, then the involvement of civil protection units in notifying residents who, for some reason, do not have access to information means and live in rural areas where no warning system has been developed. With current urbanization it is hard to create one system. It has to be a complex system for early warning which will incorporate several smaller systems.

Also, bad experience has been recognized. Despite new technologies have been developed on early warning, there are many shortcomings, mainly regarding the accuracy of warning and sometimes, malfunction of the systems. Experience generally says that the sooner a phenomenon is registered, the sooner one reacts and the consequences are less. Citizens who are informed in a timely manner react better and more organized.

As main risks, or weak point, have been identified legislation, financing, privacy policy, protection against data misuse, GDPR. The risks relate mainly to the lack of adaptability of these systems to the socio-economic and political environment. Flood forecasting and warning systems often fail because the links in the chain are malfunctioning or incomplete. One weakness in a system that otherwise contains excellent components can cause overall system performance to be unsatisfactory. A successful system requires sufficient integration of components and cooperation and coordination between several institutions. Digitization is not enough; there is a need to build trust between policy makers and the population. Construction of warning and alarm systems and connections to the population associated with greater and more frequent public education.

Analysis of gathered survey contributions

Each Innovation opportunity has been commented on by various experts/practitioners. Their contributions were provided in 7 cells, based on 7 different questions, for each occasion (except for the first, where 2 more were used). Together, it was collected 346 partial contributions.

IO	Que. 1	Que. 2	Que. 3	Que. 4	Que. 5	Que. 6	Que. 7	TOTAL
1	12	25	11	6	6	8	5	73
2	9	9	7	7	6	7	2	47
3	8	7	7	7	6	4	5	44
4	9	7	7	7	6	6	3	45
5	7	8	7	6	4	6	3	41
6	7	5	6	6	6	4	3	37
7	12	11	10	8	7	6	5	59
TOTAL	64	72	55	47	41	41	26	346

*Table: Number of practitioner contributions*

It is possible to analyze the number of individual contributions, assuming that interesting topics are commented more often. Taking into account this assumption, the most important are IOs 1 and 7 and the less important is IO 6. Particular results are visualized in graph no. 1.

From the concrete perspective of innovation potential, it is the question 3, which is the most relevant. Counting number of contributions only to this question, the most important IOs are again 1 and 7, the last is IO 6. Particular results are visualized in graph no. 2.

Analysis of the number of the particular contributions was considered, but it had an auxiliary function.
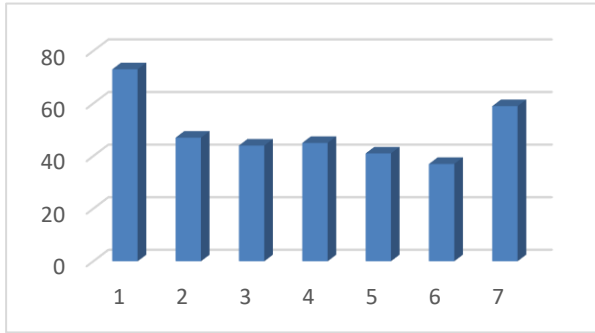
Graph no.: 1
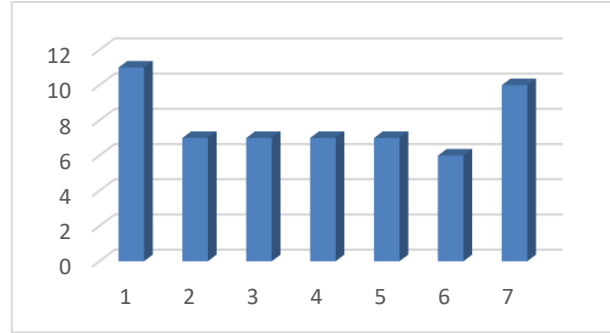
Graph no.: 2

Summary of assessment against practitioner needs

Final numerical rating of identified Innovation opportunities, after consultations of stakeholder communities and based on relevance for practitioners is as follows:
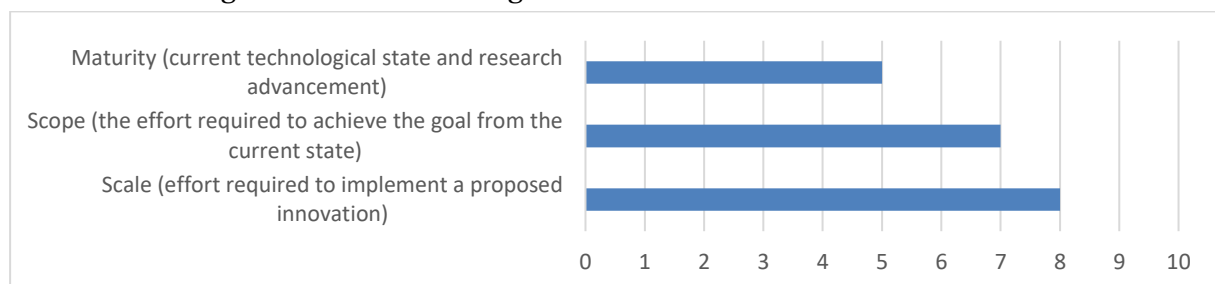
No.:	Opportunity	Rating
1.	Flood Protection Measures, Levee Defense and Levee Control	10
2.	Water rescue and Boat operations	9
3.	Hygienic measures	10
4.	Securing evacuated areas	6
5.	Social Media handling	7
6.	Removal of flotsam/log jams	8
7.	Early Warning	10

3.2.   Scoping and maturity check

Innovation opportunity 1: Flood Protection Measures (Pre-installed protective measures), Levee Defense and Levee Control

In line with the innovation opportunities identified by flood management specialists, there is a clear need for new technologies to support Pre-installed Flood Protective Measures, Levee Defense and Levee Control. The most frequently mentioned are remotely controlled robots and sensors that would transmit important information about the water level in a safe way for humans. An example of a robot that meets the requirements presented by specialists can be a group of unmanned aerial vehicles (UAVs) enabling control of propagation tracking of an expanding flood zone. In order to implement the control strategy, appropriate control algorithms for the UAV were proposed in research articles. The feasibility of the control strategy was verified by simulation (Bai, Asami, Svinin, & Magid, 2020). Flood prevention and control with the use of satellite observation and satellite data transmission is a topic undertaken by various institutions and companies for several years. In 2003, the European Space Agency proposed and financed projects to create software for retrieving information from satellites and designing events related to floods. The Copernicus EMS service, implemented by the European Commission DG Joint Research Center (JRC), has been fully operational since 1st April 2012. The Copernicus Emergency Management Service[1] is an increasingly popular, open service for downloading satellite data. It provides all actors involved in the management of natural disasters, man-made emergency situations and humanitarian crises with timely and accurate geo-spatial information derived from satellite remote sensing and completed by available, open data sources. Copernicus EMS contains a mapping component and an early warning component. The mapping component of the service has a worldwide coverage and provides the mainly Civil Protection Authorities and Humanitarian Aid Agencies with maps based on satellite imagery. An example is the FAME project[2] was to use satellite data as an additional means of mapping flood extent in zones close to rivers as well as creating more accurate flood risk maps and carrying out post-flood damage assessment. In the literature, there are proposals for a semi-automatic method for flood mapping, based only on free satellite images and open-source software (Notti, et al., 2018).

In summary, there are ready-made solutions such as special sensors and information trams. There are also prototypes of robots that could replace human work and reduce the risk of health and life. When it comes to maps and satellite information, the best solution is to use the Copernicus EMS system. It is possible that the system requires additional software components, but it is at the highest level of technological readiness.


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[1] https://emergency.copernicus.eu/

[2] https://www.esa.int/Applications/Observing_the_Earth/Satellites_assist_planners_preventing_floods

Innovation opportunity 2: Water rescue and Boat operations

For Water rescue and Boat, operations practitioners again mentioned the need to create new technologies using remotely controlled robots, drones and systems simulating subsequent stages of a flood. Existing search and rescue technologies rely mainly on old technologies and solutions such as search dogs or camera-mounted probes. Practitioners inform about the need for new, more advanced solutions, which has become the focus of scientists' interest. There are more and more ideas for intelligent robots equipped with advanced sensors in scientific publications. An example is a project aimed at developing a prototype of a mobile flood monitoring robot. This type of robot was to be equipped with a set of sensors to detect human body movement, a human body temperature sensor, and a heartbeat sensor, which would facilitate remote finding of people during a flood (Karthiyayini, 2017). As for the existing technological solutions in the field of flood modelling, there are ready-made solutions on the market. An example is OpenFlows FLOOD[3] - a flood modelling software for understanding and mitigating flood risks in urban, riverine, and coastal areas. OpenFlows FLOOD uses fully spatially-distributed numerical models to simulate all hydrological and hydraulic processes that occur in river basins, including rainfall, infiltration, surface runoff, channel flow, and groundwater flow. Another example would be FLOW-3D[4]. In case of flash floods FLOW-3D's advanced porosity models predict the drainage of water through porous, saturated or non-saturated soil. Its precipitation model captures the temporal and spatial accumulation of rain water over the surface layers etc.

Scientific publications deal with the topics of solutions to the needs proposed by practitioners such as customised drones, robots etc. However, no ready-made high-TRL equipment dedicated to flood management was found. However, there are ready-made solutions on the market in the field of flood modelling.
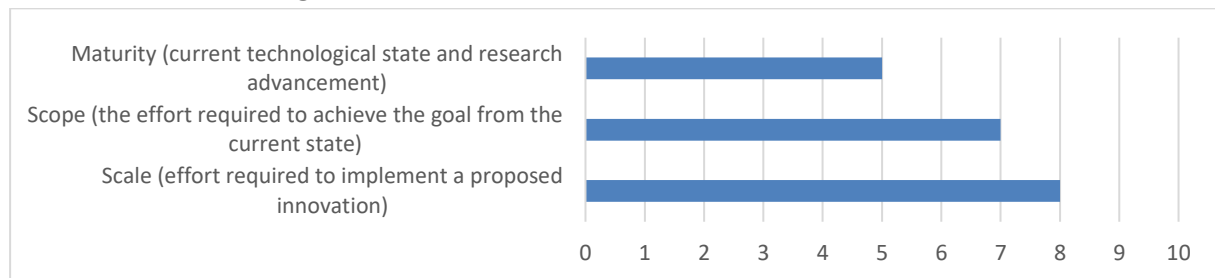

Innovation opportunity 3: Hygienic measures

Practitioners have expressed an interest and need for modern technologies in the field of mobile control devices serving as drinking water purifiers and treatment plants and mobile separators of hazardous substances, submersible walls, mobile water purification device. In the event of a flood, water may be contaminated with oils, petrol and diesel, household chemicals and other substances harmful to health. In this aspect, it is very important to make people aware of the existing threats and safety rules. Among the existing technological solutions is, for example, the Portable Water Purification System. It is system designed to address the difficulty of accessing clean and safe water, especially for flood disaster victims. The mobile, human-powered system allows the filtration of 0.5 liters of water per minute (Effendi, Azmi, sazli Saad, & Nasir Mat Saad, 2017). Scientists also developed portable flood water purifiers systems that are powered by the sun (Sonido, Balcueva, Pinpin III i Mosquera, 2019). Among the technological solutions and ready-made equipment, it is difficult to find one that meets the requirements set by practitioners. Despite many ideas for similar solutions and the relatively high TRL, no company producing ready-made, high-quality and meeting the requirements of the product was found on the market. It is also difficult to find available neutralizers or mobile devices for removing harmful substances from the water. The most popular are barriers to prevent the spread of harmful substances and skimmers, sorbets and dispersants.

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[3] https://www.bentley.com/en/products/product-line/hydraulics-and-hydrology-software/openflows-flood

[4] https://www.flow3d.com/products/flow-3d/

In conclusion, apart from water filters and barriers, there are not many modern, tailored solutions to neutralize or remove chemicals from floodwater.
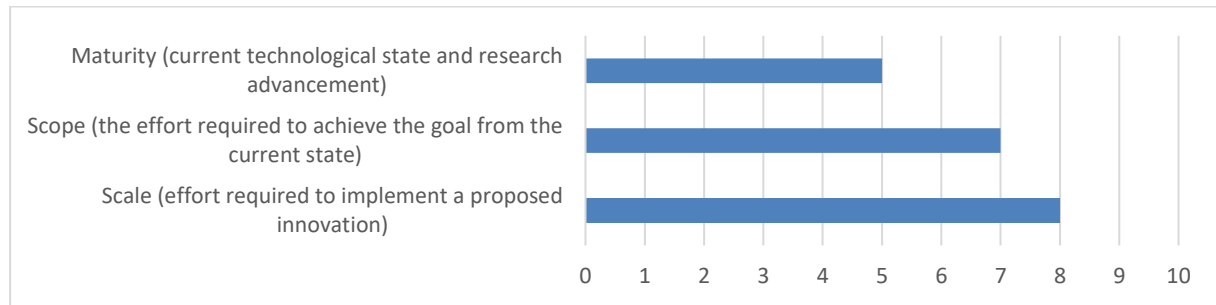
Innovation opportunity 4: Securing evacuated areas

Practitioners expressed the need and interest in IoT systems that would communicate with each other and send alerts to appropriate services when necessary. They also drew attention to the possible mobility of sensors and devices that would perform such a function. Systems for water level monitoring are quite popular and well-known. Appropriate sensors provide information on the water level and pass it on to appropriate services. It is not a new idea to combine sensors with appropriate transmitters so that they provide an alert to safety and rescue services. For example, in 2018, a simple system was proposed that combines several elements: sensors for measuring the water level from the reservoir, Rasberry Pi, GSM module and SMS alert generating system (Shah, Arif, Shahrin, & Hassan, 2018). The idea was that when the water reaches a high level, it triggers the water sensor and data is transmitted to Raspberry Pi and pass to GSM module for generating SMS alert to the residents, as a warning to be cautious and prepared. The experiment with these elements was carried out in laboratory conditions. The test results are positive, the proposed solution has a good chance to prove itself in real conditions (Shah, Arif, Shahrin, & Hassan, 2018). Despite the existing ideas for solutions and a clear need for practitioners, no ready-made technological solutions fulfilling the described functions have been identified.

The ideas of using the Internet of Things in flood operations appeared in several publications. A prototype of communication systems has been proposed, but there are no ready-made, dedicated solutions on the market. It is possible that there are IoT systems that are designed for other needs that, with a little adaptation, would meet the requirements of practitioners.
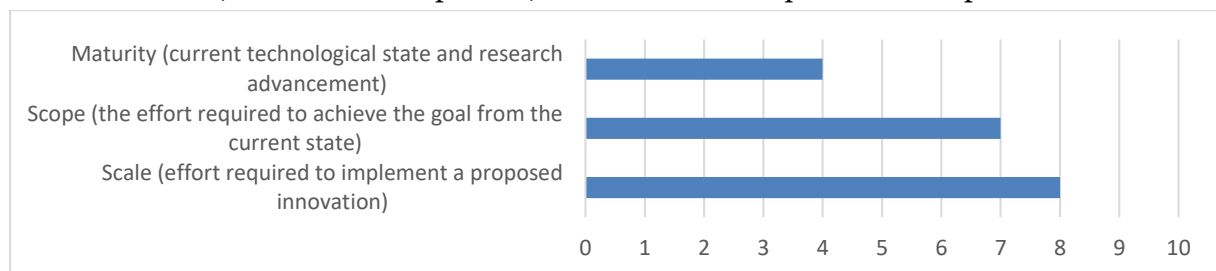

Innovation opportunity 5: Social Media handling

For Social Media handling the employees mentioned the need to control and prevent misinformation and unified current information system. The problem of misinformation, especially on the internet, is difficult to solve, and despite attempts, there is no good system for recognizing, reporting or removing fake news and the like yet. There are algorithms that detect specific image elements, keywords that automatically report content as suspicious, but they do not work perfectly and require a lot of moderators' work. Currently, the best way is to control the content by internet users who can report false content. It is likely that awareness-raising campaigns about the harmfulness of fake news and the possibility of reporting on the Internet could induce people to check the accuracy of the information and report abuse. When it comes to informing the public about natural and terrorist threats, etc., there are unified current

information systems. For example, in Poland, Alert RCB (Government Security Center[5]) was established. It is a system of SMS notifying people about threats. It is used only in emergency situations when there is a really high probability of an immediate threat to life or health in a significant area. The RCB alert is created on the basis of information about potential threats received from ministries, services such as the police, fire brigades, border guards, offices and central institutions, such as the Institute of Meteorology and Water Management and voivodeship offices. The Government Security Center monitors the situation for various types of threats 24 hours a day, 7 days a week and, if necessary, triggers an alert. The system is used to inform people about strong, dangerous winds, storms and other weather anomalies as well as about other important issues, e.g. changes in the restrictions related to the Coronavirus pandemic.

Social media management, detection and removal of fake news is a big problem that concerns many areas. Systems for informing citizens about forecast or occurring extremal situations are used in Europe. The example of the Polish solution is interesting and relatively easy to impel, but due to possible differences in legal regulations, reaching and using telephone numbers may be a problem.
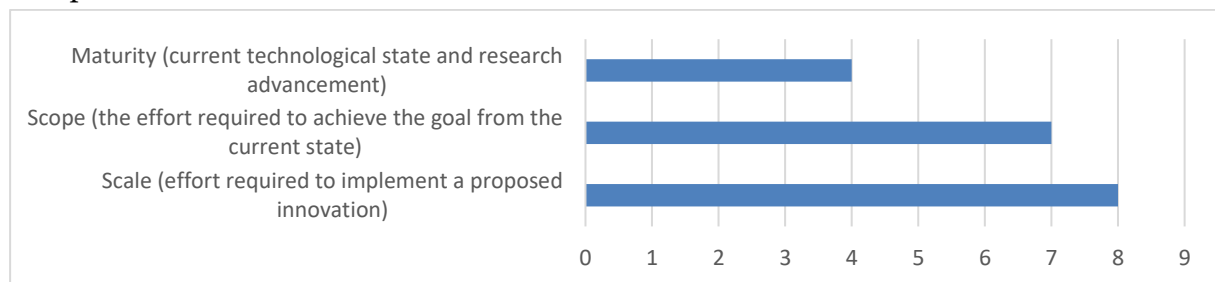
Innovation opportunity 6: Removal of flotsam/log jams

In this category, practitioners listed the need for modern solutions for clearing culverts, footbridges and bridges, removing alluvium. Also, the entire water management process, both clean and fluid maintenance, needs improvement. In addition to response and recovery phases, actions should be taken at the prevention stage - monitoring and taking measures even before floods. Watercourse drainage is one of the most important steps to prevent flooding. It includes sand removal, silt, ballast, clay, gravel and other materials from the bed and banks of main river. For these activities, an excavator of an appropriate size with a bucket and a long arm is necessary. In the case of larger water reservoirs and large rivers, natural drainage and protection of banks is essential.

In this category, there is a large innovative potential for prototyping and creating specialized, dedicated equipment.
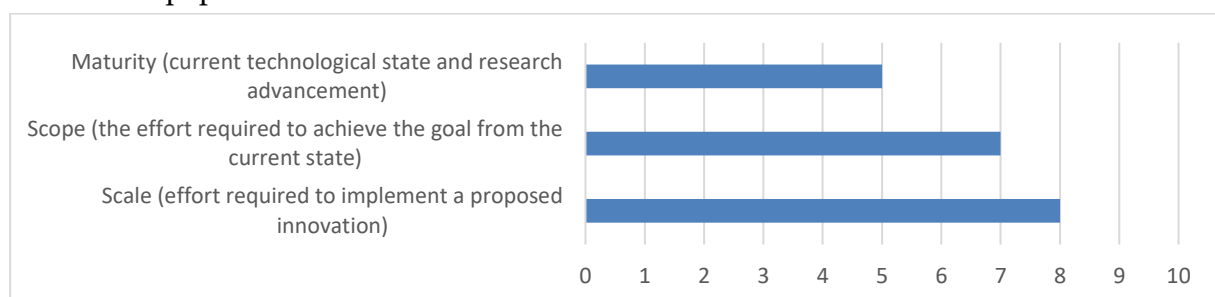

Innovation opportunity 7: Early Warning

With regard to Early Warning, practitioners pointed to the inability to reach all citizens and two-way communication with people in need, especially elderly and disabled people. Communication systems should enable simple and quick sending of information about the need

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[5] https://rcb.gov.pl/alertrcb/

for help, being in a state of emergency, along with information about the location. As described above, there are systems for informing citizens about the threat (e.g. Polish solution - Alert RCB), however, communication in this case is one-way. In a crisis situation, it is very important to be able to send quick information about the threat to the emergency services. An example of a technological solution that could fulfil such a function is, for example, JIXEL[6]. It is a suite of web-based software applications allowing emergency services (Fire Brigades, Ambulances, Police, Civil Protection, Volunteers) to manage rescue incidents and exchange information during operations.

Early information and communication to citizens is not a big problem, but the citizen-rescue team communication becomes a challenge. The system for alerting, reporting an emergency that would automatically inform about the location of the citizen (with high accuracy) is needed and could significantly improve search and rescue operations.
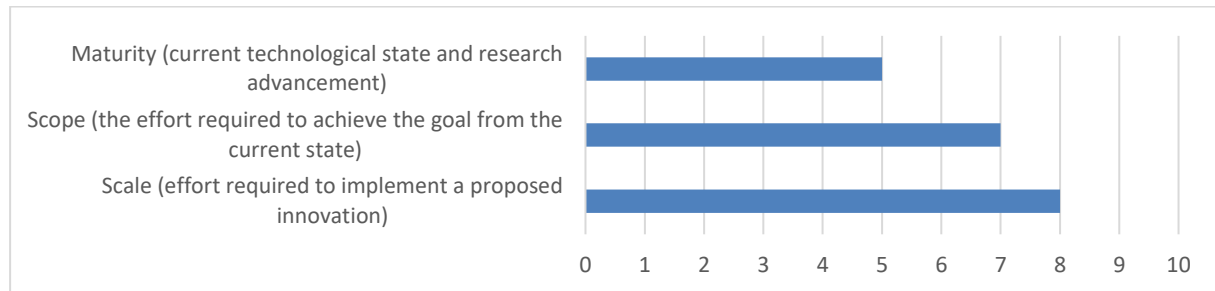
As a summary from the second level of the RDI assessment process – scoping and maturity check – it is possible to state that all identified Innovative opportunities reached the level:

- from 4 to 5 points from 10 as a result of maturity check of current technological state and research advancement,

- of 7 from 10 points with regard to the effort required to achieve the goal from the current state,

- of 8 from 10 points with regard to the effort required to implement a proposed innovation.

3.3. Assessment against Terms of Reference

Given the system of work related to the whole roadmapping cycle and within all steps of the project, this type of assessment is present from the specification of challenges, through the identification of RDI topics to the setting of priorities for innovation opportunities. Based on this approach, compliance with the ToR is confirmed for each specific innovation opportunity.

3.4. Assessment against external factors

This part represents the fourth level of the RDI assessment process. The aim was to assess the relevance and feasibility of innovation opportunities against external factors, such as synergies with flood prevention, compliance with existing national innovation strategies, economic constraints and national cultures in the practice of flood management.

The successful introduction of innovation based on identified Innovation opportunities depends on a series of highly critical external factors such as political, economic, Synergies with EUCPM and with EUSDR. By evaluating the compatibility of the innovative solutions, a score listed in the table below was determined:

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[6] https://jixel.eu/

Category	Questions for assessment	IO 1	IO 2	IO 3	IO 4	IO 5	IO 6	IO 7
		Likert scale evaluation (1-10)						
Political	Is this innovation opportunity compatible with national innovation strategies?	7	8	7	7	7	8	9
	Is this innovation opportunity compatible with flood management plans?	8	7	7	7	7	8	8
	Is this innovation opportunity compatible with flood risk management plan?	8	8	8	8	8	8	9
	Is this innovation opportunity compatible with national legal framework?	7	8	8	7	8	7	8
Economic	Is this innovation opportunity expensive for implementation?	9	8	9	8	7	7	9
	Is this innovation opportunity ensuring fair and equal access to innovation?	9	8	9	7	8	9	9
Synergies with EUCPM	Which is level of enabling or enhancing benefits of this innovation opportunity through the support from the EUCPM facilities and services?	8	8	9	7	8	9	9
Synergies with EUSDR	Which is level of redundancies and synergies with the Action Plan, and with the general goals and priorities of the EUSDR?	8	8	9	7	8	9	8
Total		8,00	7,88	8,25	7,25	7,63	8,13	8,63

Table: Assessment against external factors

The analysis of the impact of the mentioned external factors on innovative solutions involved the design and use of a methodology consisting of several interrelated phases that aimed at the most objective process of evaluation of external factors on the Likert scale (1 - completely irrelevant/incompatible, 10 - completely relevant/compatible). In the first step, it was identified all papers in the Knowledge and other bases which were important for the analysis of the impact of external factors such as political, economic, Synergies with EUCPM and with EUSDR. After that, analyses were performed in which a group of researchers from the University of Belgrade, Faculty of Security assessed the level of compatibility for each of the mentioned innovations and the dimensions of external factors. The assessment involved quantification of the evaluation based on expert assessments concerning the level of existing political, economic, and synergies with the EUCPM and EUSDR. To improve the evaluation of use, the following research questions were used by the team members: a) whether the innovative solution is provided in the national innovation strategies, flood management plans, national legal framework, etc. b) to what extent it is compatible - whether it is applied and at what level by practitioners; the extent to which it has been developed and implemented with legal and planning regulations; what problems are present during their implementation; c) whether its implementation is relevant and feasible concerning its cost and support by EUCPM facilities and services. Depending on the positive answers (positive 1/negative 0) to the mentioned questions, approximations of the aggregate values on the Likert scale were determined.

The order based on this evaluation is as follows:

Innovation opportunity abbrev.	Innovation opportunity full name	Points
IO 7	Early Warning	8,63
IO 3	Hygienic measures	8,25
IO 6	Removal of flotsam/log jams	8,13
IO 1	Flood Protection Measures, Levee Defense and Levee Control	8,00
IO 2	Water rescue and Boat operations	7,88
IO 5	Social Media handling	7,63
IO 4	Securing evacuated areas	7,25

Table: Results from assessment against external factors

4. Prioritisation and edition of RDI roadmap

In view of the above information, it is possible to set priorities for the seven identified and analysed areas of innovation opportunities in mathematical way and to formulate a final ranking, as shown in the table below.

A further prioritization is rather difficult, since the innovation opportunities are not addressing a homogenous group and are not universal. Therefore, stated order have to be considered with reserve and dedicated chapters have to be taken into the account.

At the same time, it is important to mention that all the opportunities meet the needs and requirements of practitioners and obtain high score in all types of provided assessment. They meet the criteria and are strongly recommended for further development within Practitioners-driven Initiatives.

Innovation opportunity abbrev.	Innovation opportunity full name
IO 7	Early Warning
IO 3	Hygienic measures
IO 1	Flood Protection Measures, Levee Defence and Levee Control
IO 2	Water rescue and Boat operations
IO 6	Removal of flotsam/log jams
IO 5	Social Media handling
IO 4	Securing evacuated areas

Table: Prioritized innovation opportunities

5. Conclusions

As one major outcome of the DAREnet project, this RDI roadmap indicates innovation opportunities or innovation topics to strengthen the capabilities in dealing with floods and ultimately enhance the resilience towards floods in the Danube River region.

Within DAREnet a number of RDI topics were identified, and within this the third roadmap 7 innovation opportunities areas were analysed around the core theme of "Technology and Equipment". As a part of the roadmapping cycle they were checked for relevance, compliance with the DAREnet terms of reference.

Based on the above-mentioned assessment, concrete innovation strands to address the related gaps and requirements were defined and discussed in the according subchapters. At the same time, these strands shall also serve to project timelines for the uptake, describing the varying levels of maturity, further R&D and the time required for industrialisation, standardisation and market-entry.

The main goal of this document is to draw and highlight the critical pathways for effective innovation in the region. For this reason, links to concrete, existing solutions have been very limited to ensure ease of access for the reader. Further details can be found in the related project deliverables (Report of Topic Working Groups: Knowledge Base for assessment and roadmapping cycle 3).

The innovation opportunities compiled in the present document are recommendations for concrete innovation initiatives in the future, which will be further promoted by the "Danube Flood Resilience Innovation Competition". By this call, practitioners are invited to share their ideas or evolving project concepts with the community to foster exchange or to leverage support for their realisation.

A general remark in the context of a RDI roadmap for the Danube Region is, that it would be a huge support for the civil protection and disaster relief community, if the future programs push practitioner driven initiatives even more than the current ones.

This means technological as well as methodological initiatives, which should be either new ones or rooted in current or recently finished projects. Further, there might be a new form of projects needed between basic R&D projects and PCP projects to bridge the gap between research and operations, especially for non-technical results.

Given the fact that DAREnet will call for new initiatives, a stronger linkage to our project (or other CSA network projects) would be extremely beneficial. Also calls for capacity building programs should be stronger based on the results of closed or running FP7 or H2020 projects. This would also support the transition of R&D results into operation. Last but not least money and financial sources, especially in perspective of technology and equipment, were selected as key aspect in practitioners´ capacity building. This is the topic behind the scope of DAREnet project, but this element is pointed out with importance for the future steps of related authorities also.

6.   References

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