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The Emergency Plan for the use and management of the territory

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THE EMERGENCY PLAN FOR THE USE AND MANAGEMENT OF THE TERRITORY

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The cover image is a photo of the landslide that hit the municipality of Amalfi (Italy) in February 2021.

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Territorial aspects of emergency plans for dams. The case study of Lombardia Region

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Abstract
A directive of the Prime Minister in 2014 required regions where large dams are located to develop emergency plans to coordinate efforts and resources in case of sudden unexpected release or the worst case of partial or total collapse. The risk for downstream communities and assets is clearly a significant one, as many dams have been built some decades ago and there are evidences of changing trends in meteorological and climate relate extremes that are particularly dangerous for mountain relatively small catchments. In developing such new generation plans, the definition of risk scenarios describing territorial dynamics and features (in terms of hazard, exposure and vulnerability) provides a quali-quantitative representation of potential damages and losses that may occur in case downstream settlements and infrastructures are affected or, even worse, caught by surprise by an incident. On the basis of a recent experience carried out within a collaboration framework with the Lombardia Region, the paper provides indications on the current problems and opportunities related to risk management, emergency preparedness and planning in presence of dams considering technical, social and public policies decision-making issues as key. The paper provides initial reference to the national and international experience on the topic to discuss more in depth how territorial aspects have contributed substantially to shape emergency plans for dams and what are the consequent impacts on ordinary urban and regional plans at different scales.

Keywords
Urban and Emergency planning; Dams; Disaster risk impact assessment.

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1. Introduction

Currently, the presence of a watercourse artificial barrier as a dam must be considered in a social-economical perspective for the value it creates for the region and its inhabitants. On one hand, it represents a territorial resource as strategic infrastructure for the management and sustainable use of water resources in various sectors (i.e. civil, energy, agricultural, zootechnical, industrial) also in consideration of the European (and national) energy targets for the use of renewable and carbon free sources (Directive 2009/28/EC). On the other hand, it represents a potential threat to the safety and protection of downstream human lives, properties and the environment that could be affected by the flood wave as revealed during many past national and international disasters causing enormous damage and hundreds of deaths. In general, the risk due to the presence of a dam in a given territory ("dam risk") is defined as the occurrence probability of floods damaging the dam downstream valley and its elements in consequence of: 1) the collapse/failure of the main/ancillary structures of the artificial barriers for structural reasons or induced by external phenomena (i.e. earthquakes, landslides) ("dam break") or 2) sudden release of water required by large volumes of material (i.e. water, snow, rock) brought in by meteorological events or landslides or by very intense precipitation causing the reservoir to reach its safety limits.

Considering that "dam risk" may be determined by both controlled and uncontrolled phenomena, in order to minimize the associated territorial damage, in addition to safety control programs carried out by the dam's owner to monitor its structural behaviour, it's also fundamental to act on the capacity of social, economic and environmental systems in order to make them prepared in case of crisis in particular by prevention measures (both structural and non-structural) (Sendai Framework for Disaster Risk Reduction 2015-2030). In this sense and at different territorial levels, Civil Protection planning (or Emergency Planning) is recognized as a non-structural prevention activity, a set of strategies and actions implemented to mitigate negative impacts, helping communities to face and overcome emergency situations (Menoni, 2013). Overcoming past approaches that considered emergency plans as mainly aimed at organizing resources and operative procedures, the current approach attributes a more active role to a large variety of public authorities and subjects involved in the territorial risk prevention at different albeit integrated levels. This is a crucial point considering that territorial risk conditions may depend not only on the presence and structural behaviour of dams but also on the vulnerable land uses and/or on the geo-morphological features of the catchment downstream with several streams that can be also become dangerous under the same meteorological conditions that may cause dams' failure. In this regards, urban planning is also playing a fundamental role in the physical development of urban settlements ensuring public environment protection; then stakeholders must be involved on the basis of their competencies in the implementation of strategies and actions at different territorial scales to mitigate negative impacts in case of "dam risk" taking into consideration the characteristics of dam downstream valleys. Moreover considering the dynamic nature characterizing the current territorial processes, Emergency Planning must be considered as an operational process (Perry and Lindell, 2003) with a dynamic structure whose contents must be constantly updated both during the ordinary period (or peacetime) and in consideration of lessons learned over time (i.e. during emergencies and/or periodic exercises). On the basis of a recent experience carried out within a collaboration framework between Lombardia Region and Milano Politecnico aimed at supporting and developing methodologies and frameworks for civil protection planning in areas at "dam risk", the paper provides indications on the current problems and opportunities related to risk management, emergency preparedness and planning in presence of dams considering technical, social and public policies decision-making issues as key. In particular, starting from an initial reference to the national and international framework about normative and operative requirements for the Emergency Planning in presence of dams with focus

on the Lombardia Region experience, the paper discuss more in depth how territorial aspects have contributed substantially to shape emergency plans.

2. Normative and operative requirements for the Emergency Planning in presence of dams

In territories where dams are located, in addition to technical safety requirements for the design, construction, operation, monitoring and inspection of dams aimed at limiting the probability of their failure, civil protection provisions (i.e. Emergency Plans including warning, alert and recue systems) are adopted to protect properties and human lives and mitigate the negative consequences of potential events. In some countries in Europe (i.e. Finland, Norway, Portugal and Spain) both safety control requirements and civil protection measures are graded according to the evaluation of consequences due to dam failure (hazard classification); in other countries (i.e. France, Italy and Switzerland) the selection of normative and operational requirements depends on the classification of dams according to their size (i.e. dimensions of the dam body and/or reservoir capacity). So with a different approach on the topic, each country defines its own specific dam safety legislation regulating different issues as a) dams subjected to regulation, b) entities concerned, c) dams projects (construction, operations and decommissioning) and d) Emergency Planning for the protection of the population (ICOLD, 2018).

The development and the implementation of Emergency Planning procedures are recognized worldwide as the key issue to minimise flood impacts. It is a common practice to divide the Emergency Plan into some fundamental components: 1) Identification and evaluation of potential risk conditions, 2) Risk emergency management (including rescue and evacuation of the population at risk), 3) Information, alert and warning system and 4) Training. A key element of the latter activities is the creation of inundation maps (carried out using numerical dam-break flood analysis) always required to represent the potential flood risk areas and organize accordingly operative procedures. In general, the legislation does not set technical requirements for this analysis but in some cases specific guidelines are available; for exmple in France, Portugal and Switzerland risk zones are identified depending on the time of flood wave arrival (ICOLD, 2018). Then in addition to downstream valley risk zoning, early warning system is another key element playing an important role in crisis management as non-structural measure intended - by the installation of warning signs along the stream and/or downstream the dam - to alert in case of sudden increase of the water flow related to the opening of the dam outlet works. Currently some European countries (i.e. France and Italy) have installed warning systems in the form of sirens at the dam site that are under the direct control of the dam owner responsible for the installation, to be activated before any voluntary opening of the outlets. In Italy, there is a mandatory procedure to issue an audible wail whenever spillway gates are operated (Ministry of Public Works Circular n. 1125 of 28 August 1986). Some other countries (i.e. Netherlands and Portugal) consider warning to the population at risk as a main responsibility for the civil defence authority and recommend for those most vulnerable areas a shared responsibility, between the dam owner and the civil defence authority. Public administrations at different scales hold the main responsibility (i.e. national, regional or local) in controlling the dam safety and protecting the populations and the assets downstream. However, an important role is played also by exposed communities, that must be appropriately informed about the plan and trained on life saving behaviours. Risk communication and training are key components of Emergency Preparedness. In fact, in many countries tabletop exercises are done annually. The latter can be "functional exercises" simulating different events and performing a role-play with participants seated in separated rooms to simulate their operation centre or "full scale" exercises where participants play their role "at site" in a most realistic environment. Starting from the definition of the main components and key elements of the Emergency Planning at European level, the next paragraph is aimed

to present and describe the Italian framework in terms of normative and operative requirements for the Emergency Planning activities in presence of large dams[1].

2.1 The Italian framework

With regard to dam safety and civil protection requirements, the Italian legislation is particularly complex. In addition to several general and detailed technical norms (both regulatory and administrative), there are a number of other provisions regulating the activity of the National Supervisory Authority and directives related to environmental and civil protection purposes.

At the national level, in addition to the Legislative Decree n. 1 of 2 January 2018 "Civil Protection Law" defining the civil protection functions aimed at protecting human life, urban assets and settlements also in case of "dam risk", the Directive of President of the Council of Ministers published on 8th July 2014 providing Guidelines for Civil Protection Activities in Areas Exposed to Large Dams (*Indirizzi operativi inerenti l'attività di protezione civile nell'ambito dei bacini in cui siano presenti grandi dighe*) (DPCM 2014) represents the current legal obligation for the management of emergency situations in territories where large dams are located. This Directive establishes updated conditions to activate alert phases for dam safety and management of downstream hydraulic risk and the shared responsibilities among institutional stakeholders involved in Emergency Planning activities. The Civil Protection Document (in Italian *Documento di Protezione Civile*, DPC) at the Prefecture level and and the Dam Emergency Plan (in Italian *Piano di Emergenza Diga*, PED) at the regional level are the two pillars of the entire process. The former is prepared by the Technical Office of Dams (in Italian *Ufficio Tecnico delle Dighe*, UTD) with the technical support of the Directorate General for Dams, the hydraulic authority, the Department of Civil Protection (at national and regional level) as well as the dam owner providing and is approved by the Prefecture. It does provide all technical information on the dam (and on its reservoir) and alert conditions depending on the type of event (the dam break or the full opening of the dam outlet works)[2] and the state of the dam (normal/limited/experimental operation; out of operation; under construction). The latter PED must be prepared by the Region in agreement with the Prefecture to manage the impacts of full opening of the dam outlet works or by its hypothetical collapse on downstream communities. In particular, the Dam Emergency Plan has to provide 1) the scenarios concerning areas potentially affected by the flood wave, 2) the strategies for dealing with the emergency situation by alert and alarm systems, including preventive safeguards measures, population assistance, 3) the intervention model defining the coordination system with the identification of stakeholders and the organisation of operational centres. Both documents must be continuously updated in relation to dam technical interventions and implemented in consideration of the three-year programme (approved on 30 October 2015) defining the annual level of priority for the updating of DPC of all the Italian large dams[3]. Lastly, the Directive requires that operative indications provided by the Dam Emergency Plan are integrated into the civil protection planning at local scale and tested through periodic exercises (D. Lgs. n. 1/2018, art. 18). In addition to the operative requirements of DPCM 2014, other technical documents are relevant for the Emergency Planning in case of "dam risk" as: 1) the Conditions for Operation and Maintenance Document (in Italian *Foglio di Condizioni per l'Esercizio e la*

1 In Italy, the "large dams" subjected to the national Dam Authority are defined by the following dimensional parameters: height H> 15 m, or reservoir volume V> 1.000.000 m3. The dam height is the difference between the elevation of the crest and the elevation of the lowest intersection point between the upstream/downstream face and the ground level. Before 1994, lower dimensional parameters were used (10 m, 100.000 m3).

2 In case of "dam break", 4 alert phases (pre-Alert, Alert, Danger, Collapse) are defined considering the progressively achievement of more severe structural stress states, or limit states (due to the increase in the level of the reservoir or in case of seismic events); in case of the full opening of the dam outlets, 2 alert phases (pre-Alert, Alert) are defined on the basis of the discharged downstream water flow.

3 The annual level of priority for the updating of DPC of the 534 large dams located in Italy is so defined: 122 large dams have priority I, 182 have priority II, 216 have priority III and 14 large dams are specific cases for which the updating priority of the DPC has not been indicated as they relate to dams for which construction has not yet been completed and dams out of operation.

Manutenzione, FCEM) defining the monitoring, inspections and surveillance activities to be carried out by the dam owner by the installation of monitoring signs, audible warning devices and hydrometric instruments; 2) the Project of reservoir Management (in Italian *Progetto di Gestione dell'invaso*) for the planning and implementation of the management operations of the sedimented material in the reservoir. About alert and warning systems, some installations have to be carried out by the dam owner at each dam site: a siren that can be heard 1000 m downstream, to be activated before voluntary opening of the gates; alert signs along the river, for ten kilometres downstream the dam, alerting about sudden floods due to water discharge from the dam water level recorder immediately downstream the dam (Ministry of Public Works Circular n. 1125 of 28 August 1986). About the level of dam reservoir silting due to sedimentation of soil and rock particles eroded in the catchment area upstream of the barrier and transported by the tributary waters, flaring, de-graveling and mud removal of the dams must be carried out on the basis of specific management project in order to ensure the maintenance of the reservoir capacity and the protection of the quality of the reservoir water and the receiving water body, as well as to ensure the functioning of the dams' components devoted to intake and discharge (Legislative Decree n. 152 of 3 April 2006; Ministry of the Environment and Land Protection Decree of 30 June 2004).

3. The piloting experience of emergency planning for dams in the Lombardia Region

In the Lombardia Region, Northern Italy, several territories are at-risk considering the presence of 77 large dams located mostly in mountain areas in the provinces of Sondrio, Bergamo and Brescia (Fig. 1) and 5 large dams located in surrounding regions in Italy (Isola Serafini dam in Emilia-Romagna and Brugneto dam in Liguria) or in Switzerland (Poschiavo, Albigna and Lugano dams). Moreover, worst risk conditions and negative territorial impacts may be also determined considering both dams location in the seismic areas (D.G.R. 11 July 2014, n. 2129) and the current dam silting phenomenon. With regard to the first aspect, 3 large dams are located in medium-high seismic probability (Seismic zone 2), 64 are in seismic zone 3 (medium seismic probability) and 10 in seismic zone 4 (low seismic probability). About dam silting phenomenon, a management plan of the reservoir is currently expected for 68 large dams considering that 12% of large dams are subject to a level of silting that is not negligible level and 21% to a significant silting level[4].

Currently a total of 2,000 million m^3 reservoir volume is mainly intended for hydroelectric use (90%) (Lombardia Region, Structure for the management of hydroelectric reservoirs, water utilities and energy networks). With regard to normative and operational requirements for Dam Emergency Planning, currently the Civil Protection Document has been provided for all large dams located in Lombardia Region and for almost all of them, technical studies characterizing the downstream valley risk zoning have been prepared.

About it, the Directorate General for Dams and Water and Electricity Infrastructures (in Italian *Direzione Generale per le Dighe e le infrastrutture idriche ed elettriche*) has provided a specific Webgis application to share - with the National Civil Protection System subjects - the technical information and digitalisation of artificial flood waves studies both in cases of the full opening of the outlet works and of the hypothetical collapse of Lombardia dams[5].

In relation to the three-year programme defining the annual level of priority for the DPC updating also for Lombardia Region large dams[6], first activities aimed to prepare the Emergency Plans of the regional large

[4] The level of dam reservoir silting can be "not negligible" (5-20% and/or with annual silting rate: 0,5-1% and/or trend in dam outlet works silting) or "relevant" (>20% and/or with annual silting rate: > 1% and/or trend in dam outlet works silting). In all the other cases, silting phenomenon is "negligible".

[5] Directorate General for Dams and Water and Electricity Infrastructures - Webgis application on technical information and digitalisation of artificial flood waves studies flood waves. Available at website: http://onde.mit.gov.it:8080/mit

[6] The annual level of priority for the updating of DPC of the 77 large dams located in Lombardia Region is so defined: 8 large dams have priority I, 30 have priority II and 39 have priority III.

dams started in 2019 in the context of the collaboration experience carried out between Lombardia Region and Milano Politecnico. An Working Group named "DAMS EMERGENCY PLAN - DPCM 8 JULY 2014" was established by the regional Directorate General for Territory and Civil Protection of (Decree of the Director General n. 215 of 11 January 2019, extended by Decree of the Director General n. 4675 of 17 April 2020) in order to define all the subjects involved in the Emergency Planning activities for each large dam located in Lombardia. Currently the PED has been approved for two large dams: 1) Ponte Cola dam in Brescia Province (BS) (Lombardia Region, DGR n. 3405 of 20 July 2020) and 2) Pagnona dam in Lecco Province (LC) (Lombardia Region, DGR n. 3731 of 26 October 2020) (Fig.1).

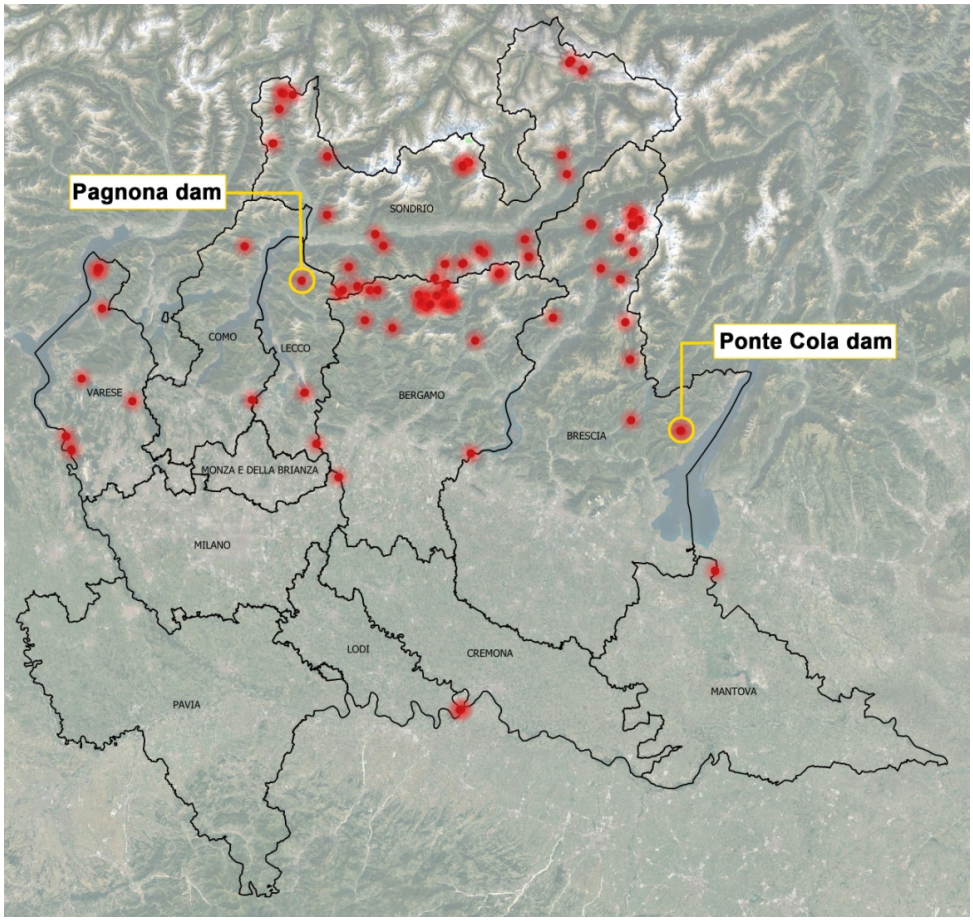
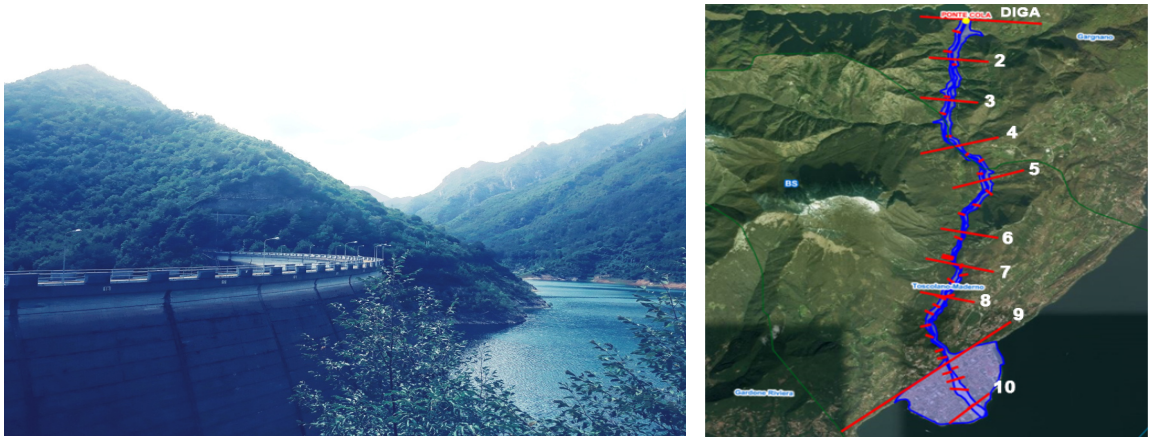


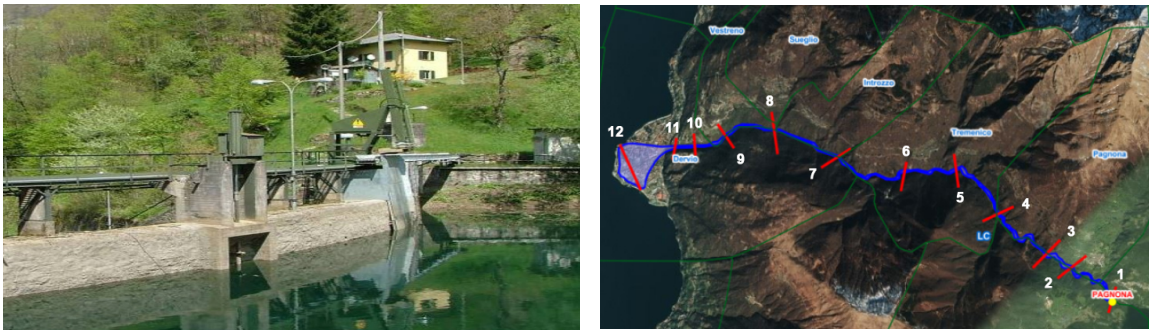
Fig.1 Territorial location of large dams in Lombardia Region.



(a) (b)

Fig.2 Ponte Cola dam: (a) view of upstream face and reservoir and (b) flood area in case of "dam break".

They are artificial barriers with different technical characteristics (with particular regard to the size, volume and state of the reservoir and silting level), located in different seismic hazard zones (Ponte Cola is in zone 2 at medium-high seismic probability; Pagnona is in zone 3 at medium-low seismic probability).
Therefore, the geo-morphological conditions of their engraved valleys and streams are quite similar ending in debris conoids of Garda and Lecco lakes where urban settlements of Toscolano Maderno (BR) and Dervio (LC) are located respectively.
In both municipalities, there are many tourist settlements determining - especially in summer - an increase in number of potentially exposed people, so in the level of territorial exposure and risk consequently to be considered in the Emergency Planning activities. Similarities and differences of the two dams and their own territorial context at risk in which they are located are evident looking at Fig. 2a, b and Fig. 3a, b.



(a) (b)

Fig.3 Pagnona dam: (a) view of upstream face, reservoir and guardhouse and (b) flood area in case of "dam break".

4. The Dam Emergency Planning elements in a territorial perspective

Information and knowledge regarding the territorial features and dynamics of the valleys downstream large dams is key to both plan for emergencies and properly address land use zoning and regulation to ensure sustainable territorial development.
Starting from the review of national and international requirements for the Dam Emergency Planning and on the basis of past working and research experiences on the topic, the developed methodological approach considers emergency planning as a dynamic process producing as an output a document consisting of two main parts:

- Part 1 "Framework of the Plan" aimed at structuring data and information on dams technical details and on their geographical context, also in terms of hazard level, the description of significant past events that affected the community and the assets downstream;
- Part 2 "Operational Plan" aimed at characterizing risk scenarios, delineating operative procedures and actions for the alert, emergency, post-emergency and surveillance phases. In addition to the risk scenarios, this part includes the intervention model, the identification of staging areas for rescuers and resources in case of crisis, the emergency phone book, maps and technical documents related to the dam (i.e. Civil Protection Document).

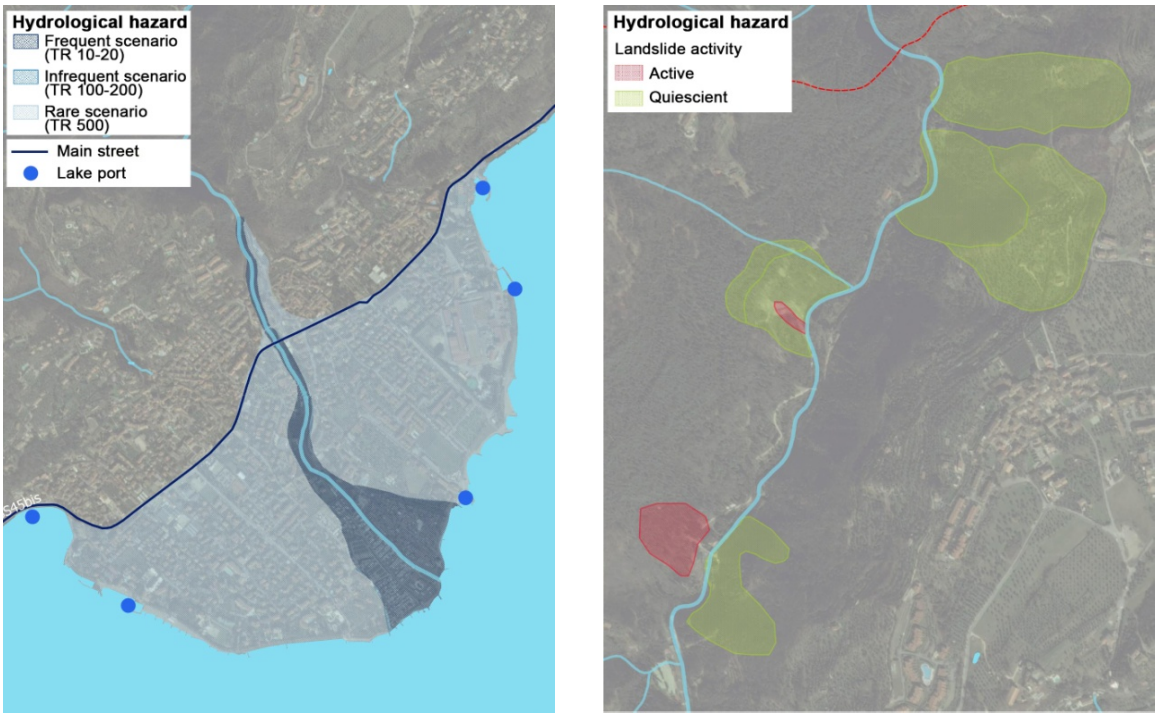
Considering this sequence and studies and research activities carried out to draw up the Emergency Plans of Ponte Cola and Pagnona dams, relevant territorial contents and elements are presented and characterized in the following paragraphs.

4.1 Characterization of the territorial context components

Considering the very basic definition of risk as a probability of damage, where damage is a function of several parameters, including hazard, exposure and vulnerability, all of the latter three must be properly assessed for the purpose of the emergency plan.

Technical information concerning the characteristics of the dam and its reservoir (i.e. outlet works, catchment basin, downstream valley, dam accessibility, silting level) as provided by the main reference documents (i.e. the Civil Protection Document, the Document of Conditions for Operation and Maintenance or the Project of reservoir Management) must be complemented by the analysis of the geographical context considering the exposed social, economic and environmental systems. In order to assess the exposure and vulnerability of downstream communities the following information has been carefully collected and analysed, regarding: administrative and demographic context; orographic, hydrographic and weather-climatic conditions; mobility system and accessibility (by roads, railways, lake, etc.); technological networks; presence of businesses activities and cultural heritage assets, in line also with the requirements of the Flood Directive.

In the specific case of the Emergency Plan in presence of large dams, the analysis of territorial hazards should include the possibility of the simultaneous occurrence of different types of hazard in a territory, such as for example the possibility that consequences of flood wave produced by "dam risk" be combined with the effects determined by earthquakes, landslides or floods. In this regard, the Ponte Cola dam is emblematic as it is located in an area classified in seismic zone 2 (Medium-high seismic probability) and the main urban settlements located in the Toscolano Maderno conoids are potentially affected also by floods caused by Toscolano river flooding (Fig. 4a). Lastly, a partial reactivation of quiescent phenomena as well as numerous new detachments and slope collapses along the valley (known as *Valle delle cartiere*) occurred in recent years (Fig. 4b). The valley is a highly vulnerable territorial area where - in case of extreme weather conditions - buildings, infrastructures and people (especially tourists during the summer) may be affected. Existing hazards may damage strategic or relevant infrastructures for emergency management, limiting the accessibility and making rescue or evacuation extremely challenging.



(a) (b)

Fig.4 Hydrological hazards in Toscolano Maderno (BS): (a) floods and (b) landslides.

Finally, a specific section of the plan has been devoted to envisage the territorial impacts that past events may have today considering the already felt effects of climate change in combination with recent urban and building transformations increasing exposure and vulnerability to floods. In order to feed the estimation of future likely scenarios, information on damages recorded during past natural disasters to different sectors and assets as

obtained from the regional RASDA system7and from specific documentation available at local level (municipal or provincial) has been used. Recent events should be integrated in the scenario to be prepared for as they highlight the possibility of phenomena and impacts that may not have been considered insofar. For example, in the case of the Pagnona dam, on June 12 2019 an unusually intense precipitation caused severe flash floods involving significant debris and sediment transport down to the Dervio municipality where they provoked a temporary "dam effect" filling the railway bridge with consequent overflow, an incident that is still under investigation.

4.2 Definition of risk scenarios including Exposure and Vulnerability analysis

Intended as a semi-quantitative representation of damage and losses that may occur in a specific context as a result of hazardous events (Simmons et al., 2017), a risk scenario is not limited to provide meteoric and hydrological descriptions but must also comprise and assessment of how given events can impact the downstream territory. Moreover, considering the indications provided by the main regulatory documents on the topic and in particular by the Civil Protection Document, risk scenarios must be based on the existing official documentation described in the first section of this paper. At present, these studies are rather outdated and therefore do not permit to account for the already tangible effects of climate change (manifesting in particular in the occurrence of very frequent and intense meteorological events) nor the territorial dynamics that have transformed the downstream areas over time. In fact, the "dam risk" depends not only on the delimitation of the potential flood wave downstream main variables (according to the arrival time, duration, maximum height and velocity) but also on the evaluation of the level of territorial exposure and vulnerability.

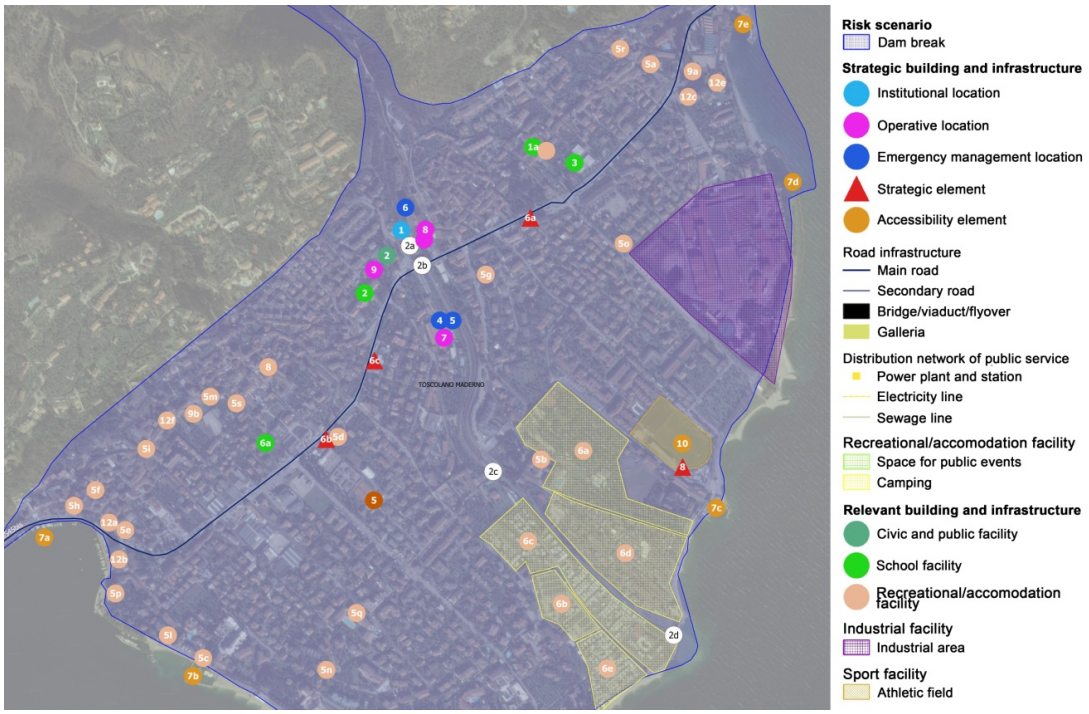


Fig.5 Mapping of strategic and relevant elements located in potentially flood area of Toscolano Maderno (BS) in case of Ponte Cola "dam break".

Human occupation (i.e. urban/rural settlements), public health (related with water supply, electricity, etc.), property (i.e. homes as well as industrial, commercial, touristy, agricultural and recreational facilities),

[7] RASDA system - Database on Lombardia Region damage collection. Available at website: www.rasda.regione.lombardia.it/rasda/

transport infrastructures (i.e. roads, airports, railroads) and environmental resources are some of the elements that must be appraised. In this regard, the list of buildings and infrastructures approved by Lombardia Region (D.d.u.o. n. 7237 of 22 May 2019) lists all the assets to be considered - for civil protection purposes - strategic for their command, supervision and control function or relevant as public buildings susceptible to crowding or structures whose collapse may have serious consequences in terms of environmental, historical, artistic or cultural heritage. Moreover, in the evaluation of the human presence, specific conditions and the period and season of the year must be taken into account, since many areas downstream of dams have a tourist vocation and therefore it is possible to foresee a different presence of different population groups depending on when the hazardous event occurs.

For each exposed element, it is important to provide information not only on its geographical location (Fig.5) but also on the presence of any "features of Vulnerability" which may influence the propensity to physical damage of the element itself and/or of people who may be exposed at the time of the extreme event occurrence. In particular, the physical characteristics of the buildings/infrastructures (i.e. number of floors including underground floor, presence of temporary structures or barriers, etc.) and of particular categories of people in the urban function (i.e. disabled, elderly, etc.), the land use (i.e. commercial, productive, receptive), the possibility to have redundant functions and infrastructures must be taken into account to understand if and how the given urban system and its elements are able to cope with emergency conditions.

4.3 Operational response

On the basis of the defined risk scenarios, the operational response must be defined taking into due account the territorial perspective in emergency plans and coordinated with ordinary urban and land use planning.

In addition to the information provided by the Civil Protection Document for the definition of the intervention model (in particular about alert phases and communications flow), some actions can be better specified in the Emergency Plan and tailored to the territorial context, providing detailed indications regarding the different organisations and stakeholders involved, the establishment of new monitoring critical points (hydraulic and hydro-geological). Some indications have a direct impact on urban and land use planning, such as the need of an alternative road access to damaged areas; the need of an alternative location for emergency management facilities (both temporary and permanent) within the potentially floodable area; the implementation of an adequate population alert and warning system in "dam risk" areas. An important point that was raised in the discussion for the development of the Ponte Cola emergency plan related to the temporary use of the river for fishing and other recreational purposes during holidays, weekends and in the summer, requiring specific actions and alerting systems to be implemented.

Moreover, detailed indications should be given with regard to the identification of suitable areas for the deployment of rescuers equipment and vehicles needed to ensure an efficient intervention in the affected areas. Following field surveys such areas are selected on the basis of a set of criteria including: dimension (average size of about 25,000 m^2), location (in central position at provincial level but closed to the emergency planning area), type of pavement (paved or not), accessibility (closed to main roads system), availability of basic services. In such selection, coordination with local authorities that know the area and also the land ownership situation, is essential. Moreover, such areas cannot coincide with areas already identified in the Municipal Civil Protection Plan for safe staging of the evacuated population.

Last but not least, thematic maps are fundamental to describe the distribution of hazard levels, identify the perimeter of the areas affected by the flood wave in case of dam collapse and/or opening of the dam outlet works, the location of the strategic/relevant buildings and infrastructures, the location of the selected rescuers' and resources' staging areas. Maps also provide support for decision making at an individual, family or community level, for the adoption of the most effective self-protection actions that can be consciously undertaken. It is not a matter of experiencing the presence of the dam as a potential and imminent risk, but

of being aware of how it is managed in case of emergency conditions. As defined by Italian Civil Protection Code, citizens must be actively involved in risk prevention and civil protection exercises as opportunity to better know the specific procedures and actions.

4.4 Relationship with ordinary urban planning

There are several levels of needed integration between emergency and urban planning that nevertheless are still considered and administered as totally separated and independent documents. A first regulatory attempt to overcome such inconvenient separation is provided by article 18, point c of the National Legislative Decree 1/2018 setting the reform of civil protection in Italy. The decree leaves some room to interpretation, but what it clearly does is to require a stronger coordination between emergency and land use plans. In the following we attempt to provide some elements that should be considered as necessary steps for such stronger integration. The first and perhaps more obvious relates to the type of data, maps, and risk assessments on which both are grounded. In fact, emergency plans are broadly using scenarios, that is a number of deterministic hazard inputs occurring in a given area at different times of the year and day to account for differences mainly in exposure. Land use plan use have been broadly speaking mainly using probabilistic risk assessment as a reference, as the longer time horizon and the type of investment that is required makes it reasonable to account for probabilities of differential levels of severity of expected impacts. However, such clear cut distinction is not always satisfactory. If we look at what is the rule in the case of industrial risks and in particular regarding land use planning in the vicinity of hazardous installations according to article 13 of the Seveso Directive (2012/18/EU), different options have been taken by European countries, comprising a combination of approaches that privilege a scenario approach accounting for the differential likelihood of each potential occurrence whilst balancing the latter with the severity of damages.

Transferring this approach to emergency plans for natural hazards or combined man made (dams) and natural hazards (intense precipitation, landslides, slope instability), one needs to consider that if emergency plans are depicting a scenario as particularly devastating, the latter cannot be neglected in urban and land use plans, even when such scenario is evaluated as extremely rare. In fact, whilst envisaging the possibility of some kind of uses, for example temporary uses, particularly sensitive ones, such as critical infrastructures, schools, nursery schools or elderly facilities should be avoided. Therefore what can be suggested is that instead of a yes/no alternative, meaning any use or no use, urban and land use plans should discern among different types of uses, based on the understanding of the concentration and vulnerability of the population that is likely to use the space or the building in the area indicated as highly exposed in case of an incident to the dam. By the way such considerations may be well extended to any type of incident, combined or not, as was the case for the methodology to support a decision support system for planning developed in the EU funded Armonia project (Menoni, 2012). Certainly, what has to be harmonized in the future is the data foundation of both types of scenarios and probabilistic risk assessment especially when complete event scenarios that are including impacts on exposed territorial systems must be considered.

In the latter case, the geospatial data, maps, enumerated critical facilities should be common to emergency and land use plans to inform their design and updating. This is often not the case so that there is a misalignment between the two in terms of considered vulnerable and exposed elements and systems. More advanced information systems and more precisely interoperable and communicating databases should allow for overcoming such condition, permitting a mutual update and cross check of the continuous changes in the environment, both built and natural. Such systems are just starting to become operational in the administrations in charge of policies implying or impacting on territorial and spatial assets and systems, but in the near future they are likely to change the way the informational and knowledge base of public policies in different domains will be formed and maintained. In this regard, the Lombardia Region piloting experience must be mentioned in providing the Online Civil Protection Plans service as a dedicated information system to

support urban planners, local professionals and technical office personnel in drafting and updating a civil protection plan. By coordinatiing activities among the involved Prefectures, Provinces and Municipalities, the Online service permits to share geospatial data and information not only about the level of hazard, exposure and vulnerability of a territory but also on the presence of strategic and relevant buildings and infrastructures or the identification of the gathering areas for rescuers and resources to be considered in case of crisis conditions.

Whilst the technological advances may depict a rather bright future, still there are crucial aspects to be discerned and further investigated. The first relate to spatial scale. In fact, datasets and maps that are available nowadays derive from data collection campaigns requiring different granularity and levels of detail, making it possible from a technical point of view to merge the information, but determining results of differing quality and requiring a rigorous description of the metadata behind. Spatial scale is also relevant when considering the level at which plans are developed and to guarantee their coordination. Both in emergency and urban planning there are plans developed at different scales.

Large scale emergency plans should in principle define regional scenarios, the deployment of regional or inter-agencies resources, whilst municipal plans identify specific locations for staging areas for the population, describe critical facilities that require attention. Nevertheless, local places may host strategic assets and infrastructures for the entire region, therefore the latter must be addressed also in regional plans. This type of interconnection has been constantly experienced in the regional emergency plan for dams discussed in this paper.

The latter are in fact key when several municipalities are involved in the same incident and therefore "cross-border" issues and necessities for mutual aid and support arise. In a rather similar vein, also land use and spatial plans are organised across different scales, apparently aiming at different purposes: at the larger scale more strategic considerations are pursued, whilst at the local level zoning and urban patterns are figured out. However, strategic infrastructures such as networks or even point shaped elements such as hospitals may well cross or lay within a neighbourhood, but clearly require a much broader understanding of their connection with other places and their role regionally or even nationally or internationally. Here again, information system can be of much help in providing the supporting layers needed for checking such interconnections, however the issue of the mutual regulatory regime and the level at which decisions are made must be still solved.

This rather annoying state of affairs requires that a different standpoint is taken, less concentrated on the multiplicity of different sectoral plans on the one hand and avoiding to require a total fully comprehensive documentation for each area, whilst focusing on the crucial risks (in our case) and opportunities (considering the entirety of interests and uses implied by a spatial or urban plan) that are specific to a given context, a given place, and researching the most relevant criticalities and solutions to problems that are in the meantime intersecting different "topics" and domains and specific to the area at stake.

Going back to the concept of scenario as a base of both land use and emergency plans, albeit considering in part distinctive features and differently prioritizing elements and assets, the temporal scale becomes very relevant as well. A time scale pertains to the phenomenon itself. As suggested by one of the speaker at the final seminar where the results of the joint effort between the Politecnico and the Lombardia Region teams were shared and discussed, the same return period considered for the design of safe dams is subject to changes. First, because of new legislation requiring for example a more cautious approach and that has shifted the requirement for safe dams shifting the return period probability for critical incidents from 500 to 1.000 years; second, because the way such probabilities and scenarios are estimated may be updated whenever better models or new knowledge becomes available; third because the phenomenon has changed for example as a result of climate change.

Such considerations are valid also when extending the evaluation to the full impact scenario, as exposure and vulnerabilities are subject to changes overtime and in some cases also rapidly and may vary depending on the

time of the year or the hour when the event occurs. Very similar considerations can be held true also for scenarios that are used for spatial and land use planning purposes in accordance for example with article 6 of the Floods Directive (2007/60/CE). One in fact should not only focus on the changes in the physical phenomenon but also on how the use of the territory, permanent and temporary, the use of buildings and their parts by different populations (for example with an increase in allowing basements' occupancy by dwellers) has changed vulnerability and exposure to natural extremes. Finally, there is the issue of how to update scenarios whenever new circumstances or a recent disaster has occurred. In this respect there is the need to complement planning with data that is generated after the event and sheds new light on unforeseen exposure, vulnerability or hazards features that had been underestimated or not properly addressed in previous risk assessments.

The need to use post disaster damage data has been increasingly called for in recent activities at the European Commission level (see Marin Ferrer et al., 2018; Menoni et al., 2017; Walia and Menoni, 2020). However, in order to inform risk assessments and scenarios such activity must become part of an ordinary procedure and carried out according to a certain level of standardization. Elsewhere (Menoni, 2018) we have suggested that adaptive planning seems a recommendable solution in order to uptake new evidence and new information that becomes available at certain turning points (such as a disaster that has occurred in the area). In an article dated 2005, Couclelis argued that adaptive planning must be considered a defeat of strategic planning and thinking, giving up providing a vision for the future of an area whilst trying to accommodate for incremental changes. The Author was referring though to scenarios of future land and territorial configurations as derived from models articulating a number of alternative economic, social and geographic pathways. However, here we wish to respond to the reasonable critique with the following two arguments. First the type of future scenarios that Couclelis (2005) had in mind do not or only marginally include significant changes in the environment, that instead seem to be relevant especially in the light of current large environmental changes we are facing at different spatial scales; second we would like to suggest that adaptation by means of including new information and knowledge whenever it becomes available my well re-direct a more strategic vision, providing actually the possibility to monitor to what extent the territorial system is going towards the "wished" type of development. In this regard, whilst continuing to consider large disasters as turning exceptional points, emergency plans can still be the basis on which the knowledge, experience and understanding of the environment and the territorial setting of a large number of stakeholders, albeit not ordinarily considered as being part of the "urban and land use planning community", can be taken on board, highlighting criticalities and changes that are generally neither perceived nor tackled by ordinary spatial and urban plans.

Instead, in a more integrated process, envisaged changes in land uses and in urban functions and configurations can inform and direct the attention of emergency planners and risk managers towards emerging threats and vulnerabilities, whilst on the other side, emergency preparedness may inform variants or recent additional documents to cities and regional plans, such as climate adaptation strategies or resilience plans.

5. Conclusion

The experience reported in this paper is the result of a joint collaboration between researchers in engineering and land use planning and the Department of Civil Protection of the Lombardia Region. It describes the challenges and the solutions to a rather complex work necessary to develop an emergency plan for dams that provide sufficient consideration for the complexities in terms of vulnerability and exposure of communities and assets downstream. The legislative framework that governs the development and the expected outputs of such plans at the regional level are described and compared to other countries. The proposed methodological approach and the model plan are described in detail and some examples are provided on how territorial aspects have been appraised and integrated in the envisaged response mechanism.

Both achievements and challenges have been associated to this effort. As for the former, certainly a significant added value is embedded in the systemic approach that has been taken linking the hazard factors to the exposure and vulnerability of infrastructures, the built environment and communities living downstream. The territorial context has entered in all considerations regarding the potential impact in the form of full damage scenario and the logistics of the foreseen response. Different data layers have been used taking advantage of the rather rich and well developed GIS open system of the Lombardia Region. Integrated data and contributions have been achieved thanks to a cooperative approach between different levels of governments and with interested parties and stakeholders not without some frictions due to competing land uses and to the need to balance energy production with safety. In this regard, the construction of a digital platform can be useful for knowledge management and territorial organization of the emergency in a resilient perspective (Di Lodovico and Di Ludovico, 2018) with the integration of plans identifying - at different levels – information and actions to be considered by all the stakeholders involved in the territorial management (before, during and after) of flooding events caused by water releases, planned or unplanned.

Challenges and criticalities have been encountered too, mainly related to the difficulty in convincing administrations of the need to take a dynamic multirisk approach, considering in the meantime the potentiality for simultaneous hazards occurring and triggering one another and the dynamic evolution of urban settlements both requiring a frequent update and reconsideration of scenarios. As the latter are approved in official settings it is then difficult to change, update or reassess them even in the face of evident need to do so as many years have passed since the undertaking of the studies on the basis of which scenarios have been produced. Also, multirisk approaches are difficult and require a deep understanding of multiple phenomena and the limitations of models available to tackle them, though they lead to a condition in which it is not always easy to determine what has been the exact trigger of damage in a given event. Furthermore, multiple hazards as well as multirisk situations require by definition cross-scale analyses that develop from local to regional and from regional to local to account for different types of phenomena entailing different spatial levels and to systemic vulnerabilities due to complex interconnections between infrastructural, economic and social systems. This challenge the current structure of public administrations and government in general as correctly suggested by Handmer (1999): segments of decisions and resources are managed in silos with few interaction and cooperation activities that are most of the time carried out by individuals but not rewarded adequately at the institutional level. A different approach is clearly needed to manage complex hazards (composite, such as those related to the presence of a large dam) in complex settings, morphologically, environmentally as well as for the existing infrastructures, social and economic drivers. Such an approach should stem from the acknowledgment that complex risk situations and multi-level plans of different types call for shared responsibilities including more participatory approaches involving local communities and an extended risk governance (May and Williams, 1986).

Finally, some considerations have been developed on the necessary relations between urban, spatial and land use plans on the one hand and emergency plans on the other. Partly different stakeholders are involved, and also different timescale: the horizon of the latter is much shorter than that of the former type of plans. Still significant advantages can be obtained using common datasets, maps and risk assessments. Considering the time scale, urban planners should become more familiar with the idea that landscapes, especially in mountain areas where many large dams are located, may be very dynamic and sometimes change even dramatically in a matter of few hours. In our visit to the Pagnona dam the dramatic transformations produced by each intense precipitation episode was under our eyes and clearly defeated the many attempts and projects already in place to manage properly the infrastructure. In the light of such dynamics implying different temporalities, emergency and land use planners can get significant advantage working more closely together and constructing jointly full event scenarios the consistency of which can be measured and monitored overtime

and which can provide a basis for different types of projects aimed at the safety and the well being of communities living downstream large dams.

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Image sources

Fig.1; Fig.4 and Fig.5: elaboration by the authors.

Fig.2 and Fig.3: Directorate General for Dams and Water and Electricity Infrastructures webgis application

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