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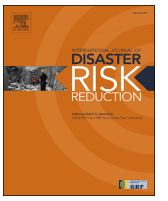

Governance strategies and tools towards the improvement of emergency management of natural disasters in transboundary areas

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ABSTRACT

Cross-border emergency management is a pressing issue, especially in contexts where economic, social, infrastructural and natural interdependencies ignore political borders. Different legislative, administrative and organisational barriers can hinder the homogeneity, coordination and effectiveness of any emergency response to a common natural hazard. The GESTI.S.CO. project (Italian acronym for "Management of emergencies and disasters without borders"), co-funded under Grant Agreement No. 475062 of the Italy-Switzerland Interreg Cooperation Programme, has been designed to study and address this issue in the highly interconnected and densely populated border area between the Cantons of Ticino (Switzerland) and Lombardy (Italy). The main objective is to strengthen cross-border cooperation in the management of natural disasters through common solutions for the preparedness of local administrations on both sides of the border, in order to increase cooperation, coordination, integration and mutual assistance in case of need. The GESTI.S.CO. governance approach has produced many results: some of them have been included in the official procedures and tools of the institutions in charge of emergency planning and management in both countries; others, more informal, have helped to share knowledge and know-how and to improve the cooperation and response of stakeholders and local communities in the event of natural disasters. Some of these products have already been positively validated during some hydrogeological and wildfire events that occurred in the study area in 2021 and 2022. Such an approach may be useful for other transboundary areas where some results may be replicable under selected conditions.

1. Introduction

The impact of transboundary emergencies and civil crises on management demands has been under-researched and understudied for several years, including before the emergence of the COVID-19 emergency [1–7]. Transboundary emergency management continues to affect conventional socio-administrative and policy responses to disasters, causing collective and individual stress, which may

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be more significant than previously acknowledged [8–12]. A range of natural and man-made disasters, including floods, epidemics, hurricanes, wildfires, earthquakes, tsunamis, droughts, volcanic ash clouds, animal or agricultural diseases, power cuts, nuclear or chemical incidents, oil spills, and more, can necessitate the deployment of a joint response due to the existence of reciprocal interdependencies among countries.

The issue of cross-border dimensions in disaster risk reduction (DRR) is a topic that has been given significant attention by the United Nations Office for Disaster Risk Reduction (UNISDR) in recent years. In 2017, the UNISDR dedicated a chapter to this matter in a series of special topics for consideration, as part of the "Words into Action Guidelines on National Disaster Risk Assessment" [13]. The chapter underlines to United Nations members that the "systemic and cascading consequences of natural disasters call for careful attention to cross-border concerns in national disaster risk assessment and management". It provides examples of the transboundary nature of natural hazards, citing the fact that 270 rivers cross national boundaries worldwide and that ten per cent of floods between 1985 and 2005 were transboundary [14]. Furthermore, with regard to the subject of transboundary floods, the Transboundary Waters Assessment Programme (TWAP), initiated by the Global Environment Facility (GEF), has updated its assessment of transboundary river basins, which now stands at 286. These river basins span[1]151 countries, include more than 2.8 billion people (approximately 42 % of the world's population), cover 62 million km^2 (42 % of the total land area of the Earth), and produce around 22,000 km^3 of river discharge each year (approximately 54 % of the global river discharge) [15].

Furthermore, the European Committee of the Regions (ECR) also provided a detailed opinion, in a comprehensive document of Policy Recommendations [16]. In the aforementioned document, the ECR emphasises that disasters have no borders and that developing prevention, resilience and effective emergency responses therefore requires cross-border cooperation. It is further stated that cross-border cooperation would provide advantages for the 37.5 % of the EU population living in border areas. In 2021, the European Commission published a Staff Working Document entitled "Overview of natural and man-made disaster risks the European Union may face." This document highlighted that the assessment of cross-border impacts in the context of flood risk in Europe remains inadequate [17]. The catastrophic flooding of July 2021 in Germany, Belgium, and the Netherlands (and also in France, Luxembourg, Switzerland, and other European countries) is one of a number of recent calamitous events that demonstrate the potential consequences of cross-border disasters in terms of human lives lost, infrastructure disruption, and production interruption, particularly in one of the most industrialised international areas of Europe (and indeed the world) [18].

Of course, nations have different approaches to emergency management structures and methods at national or sub-national levels [19]. Cross-border specialisation in emergency management can therefore grow on such a basis and benefit from joint cross-border cooperation strategies in a framework where, again, the ECR highlights the need for a more robust multi-level governance stance to achieve the goals of the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR). Indeed, in previous policy recommendations on the EU Action Plan on the SFDRR, entitled "A disaster risk-informed approach for all EU policies" [20], the ECR, emphasizing that local and regional authorities are key partners in DRR, while emphasizing that local and regional authorities are key partners in DRR, suggested that "sufficient resources should be allocated to programmes supporting cross-border cooperation in the field of disaster risk reduction and crisis management". Outside Europe, the issue was also highlighted in 2019 by the Centre for Emergency Situations and Disaster Risk Reduction of the Secretariat of the Regional Forum of Central Asian Countries, through a concept note on "the regional mechanism for responding to large-scale and transboundary emergencies", which underlines that "some 80 million people are exposed to almost all types of natural and man-made disasters, including earthquakes, floods, landslides, mudflows/mudslides, avalanches, droughts, extreme temperatures, epidemics, dam failures and hazardous substance emissions".

Given this frame, this paper contributes to the topics related to transboundary emergency management starting from evidence coming from the activities of GESTI.S.CO. project (acronym of the Italian *GESTIone delle emergenze e delle catastrofi Senza Confini* which means management of emergencies and disasters without borders"), co-funded by the European Union's Interreg V-A "Italia-Svizzera – Italie-Suisse – Italien-Schweiz" cooperation program and by Italian and Switzerland funds (https://interreg-italiasvizzera.eu/), under Grant Agreement No. 475260 for the Axis 5 "Strengthening cross-border governance" of the program, the investment priority "Promoting legal and administrative cooperation and cooperation between citizens and institutions" and the objective "Increasing cooperation, coordination and integration between administrations and stakeholders in order to strengthen cross-border governance in the area and improve the participation processes of stakeholders and civil society". The project is concerned with the original ways in which local institutions in neighbouring nations can enhance the governance of transboundary emergency management, in this case when triggered by natural disasters. It demonstrates that this approach could be quickly rewarding. Furthermore, the project offers an opportunity to deepen and systematise theoretical aspects that could facilitate the replication of project outcomes, as is typically required by the EU "Interreg" project family. It is obvious that the proposed approach is valid under certain conditions as far as similar contexts (or parts of them) are concerned. What follows is a demonstration of the relevance and applicability of a cross-border dimension to disaster risk reduction (DRR) policy and its specific characteristics, not only in terms of how disasters affect cross-border territories, but also in terms of how they necessitate interdependence between foreign institutions, how they evolve in the context of DRR activities, and how they require a unique analytical framework to identify appropriate solutions for cooperation.

[1] The Convention on the Transboundary Effects of Industrial Accidents already encourages member countries to share their risk assessment methodologies (UNECE - United Nations Economic Commission for Europe, 2001, https://unece.org/fileadmin/DAM/env/documents/2006/teia/Convention%20E%20no%20annex%20I.pdf.

[2] Note that the official Italian name of this Swiss federal Office is Ufficio Federale della Protezione della Popolazione (UFPP), a naming choice underlying a larger role if compared with the National Italian Civil Protection Service.

2. The distinctive framework of analysis of emergency management in transboundary areas

2.1. Functional schemes for classification of international cooperation in response to disasters in transboundary areas

In the event of a cross-border emergency, it may be necessary to request assistance from higher levels of government, with the first level of assistance being national or federal, and the second being regional or international. For instance, in response to a request for assistance from certain states, the European Union, through the EU Civil Protection Mechanism, dispatched additional flood rescue teams, helicopters, and boats from France, Italy, and Austria, which were affected by the July 2021 transboundary catastrophic flooding in Germany, Belgium, and the Netherlands. Similarly, in response to a single state request for assistance in combating the ongoing wildfires on the island of Sardinia, the EU Civil Protection Mechanism deployed two aerial forest firefighting planes from France and Greece to assist Italy. Similarly, the International Search and Rescue Advisory Group (INSARAG) of the Office for the Coordination of Humanitarian Affairs (OCHA) of the United Nations intervenes to facilitate the coordination between the various international Urban Search and Rescue teams available for deployment in countries experiencing earthquakes or analogous events [21]. Other regional initiatives operate in a similar manner, as exemplified by the Caribbean Disaster Emergency Response Agency of the Caribbean Community and the Agreement on Rapid Response to Natural Disasters of the South Asian Association for Regional Cooperation [22–25]. Furthermore, the effects of cross-border interactions can be observed at various levels, including regional and global scales [26].

However, cross-border events can have a direct or indirect impact on local communities, affecting multiple nations simultaneously or in a non-synchronous manner. These events can have a significant impact on a limited number of cities or specific transboundary contexts. Consequently, it is essential to consider the involvement of local administrations in each affected country at an equivalent institutional level. In such cases, it is necessary to consider the possibility of implementing additional measures of "localised" cooperation in order to enhance the effectiveness of disaster management. This would involve utilising the time gained by taking action in real-time, rather than merely awaiting the arrival of delayed "humanitarian" assistance from higher levels of government or international agencies after an event has already occurred. Such collaborative efforts are duly acknowledged in the literature, as exemplified by the two principal classes of interdependencies between units of a complex system (in this case, countries). The two main classes of interdependencies between units of a complex system (countries, in our case) are referred to as "*sequential*" and "*reciprocal*" [27]. Such cases are different from that of the cited request of assistance of INSARAG, which type is a third case, called "*pooled*". A graphical representation of these types of interdependencies is shown in Fig. 1.

In the case of a sequential (or serial/unidirectional) approach, the consequences of a disaster on one side of the border may be the inputs for the occurrence of unwanted effects on the other side (unidirectional exchange). Consequently, the latter may be interested in cooperating to support or assist the first affected zone (to mitigate the impacts received) and/or to prepare appropriate countermeasures (while the disaster is occurring on the other side of the border and before it strikes its frontier zones). In contrast, the reciprocal (or bidirectional/multidirectional) model entails numerous real-time interdependencies and unrequested exchanges across boundaries, which are induced by disasters. This necessitates stronger cooperation or coordination across borders. The borders must be based on quick and transparent bidirectional (or multidirectional) communication and on high levels of mutual trust, which can only be deployed if a specific preparatory work has previously been done to assist affected areas on both sides of the border. Finally, in the case of a pooled or separated approach, there is a situation of lack of cooperation workflow among the sides of the border coping with the same disaster, often local contexts poorly achieving in facing disaster consequences. Such situations are those in which substantially little is done before the request or arrival of assistance from outside the stricken area (thanks to the actions of dedicated international agencies), because of the heaviness of occurred events (sometimes unavoidable), or, not rarely, because the unpreparedness of entities and bodies in charge in involved nations.

It is logical to conclude that the first two classes, sequential and reciprocal, are the most important and fruitful to be framed in enhancing cooperation between two or more neighbouring regions of two or more countries, and for preparing or upgrading their transboundary specific local emergency plans. In practice, as evidenced by the available literature on the subject, such plans are more effective when there is a greater possibility of shared or common hazard and risk maps, systems to monitor and forecast natural phenomena, and tested organisational schemes of reaction. Above all, the identification of risk scenarios on a broad cross-regional scale can facilitate the purposes of surveillance of expected events. This, in turn, can contribute to a more effective and joint understanding

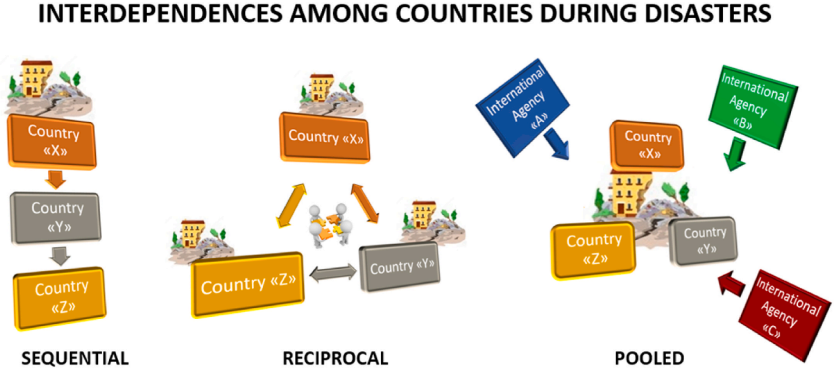

Fig. 1. Type of interdependences among countries when they are facing disasters: sequential, reciprocal and pooled.

and assessment of risk dynamics, both from the geographical (nature) and the functional (human-built assets) points of view [28,29]. Consequently, as a preliminary measure, information on hazard, vulnerability, and risk exposure coming from mapping, at the cross-border level, according to the opinion of ECR, "should be publicly available and adequately publicized on both sides of the border to prevent, mitigate and prepare a response to disasters" [30]. To the same conclusion, analysing the different transboundary contexts of Eurasian space, another study came, underlining that, "taking into account the *trans*-border character of natural disasters" a joint coordinated work of technicians and policymakers is required to "identify and map the areas with the largest risk level, as well as to develop an effective system of measures for risk management and preparedness for possible natural disasters" [31].

2.2. The growth path of disaster risk reduction transboundary cooperation

As stated by the intergovernmental expert working group on indicators and terminology relating to disaster risk reduction established by the United Nations General Assembly, the pursuit of disaster risk reduction goals is achieved through the implementation of policies and strategies designed to prevent the emergence of new disaster risks, to reduce existing disaster risks, and to manage residual risk. The implementation of such policies and strategies constitutes the set of activities that comprise disaster risk management. It is essential that these activities contribute to the strengthening of resilience and the reduction of disaster losses. This is feasible within the context of a specific system of disaster risk governance, which encompasses a range of institutions, mechanisms, policy and legal frameworks, and other arrangements designed to guide, coordinate, and oversee disaster risk reduction and related areas of policy [32].

In light of the aforementioned framework, it is recommended that cross-border cooperation should also pursue the implementation of necessary disaster risk reduction (DRR) measures in a coordinated manner, under a governance system that is able to oversee joint strategies. In the real world, such forms of cooperation are developing at a gradual pace, often as a result of the efforts of policymakers when confronted with specific challenges or emerging priorities. For instance, tsunami information centres have been established with the objective of alerting emergency officials and, when necessary, the public [33], The Caribbean Tsunami Information Center (organ of the Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions), the Indian Ocean Tsunami Information Centre, or the North-Eastern Atlantic and Mediterranean Tsunami Information Center may be consulted for further information. Similarly, international coordination among countries is necessary for the management and protection of transboundary river basins. One such example is the Danube River, which is overseen by the International Commission for the Protection of the Danube River [34], the case of the Rhine river, with the International Commission for the Protection of the Rhine [35], and other cases in Europe [36]; or it is the case, in Asia, of the Mekong River Commission [37]. In each of these cases only a portion of DRR policies is shared, or in common, among countries (in the EU also thanks to legislative advancements, such as the Water Framework Directive 2000/60/EC and the Directive on the Assessment and Management of Flood Risks 2007/60/EC). A review of the cases reveals that non-structural and non-mandatory measures of emergency management are frequently selected as the initial step of collaboration and cooperation in transboundary contexts. These measures are designed to go beyond the basic humanitarian aid provided in the aftermath of disasters, which is typically limited to search and rescue operations and the supply of material assistance. Instead, they aim to prevent or mitigate the impact of disasters through the implementation of organizational solutions and the establishment of bodies responsible for early warning systems, hazard mapping, capacity building activities, and joint training.

The preceding analysis allows us to propose a classification of the levels of collaboration for transboundary cooperation in the event of a disaster (Fig. 2). The first category of emergency management collaboration activities can be placed under the "residual risk" category of disaster risk reduction (DRR), which refers to situations where effective DRR measures have not been implemented and the focus is on post-disaster humanitarian aid. The second category comprises non-structural and non-mandatory actions, which are focused on the initial growth of emergency management cooperation. The third category of emergency management collaboration is characterised by the implementation of a comprehensive disaster risk reduction (DRR) strategy, which may include joint efforts to address structural issues or shared resources for the prevention and treatment of disaster risks.

Logically, the levels of such classification could be connected to the previous one, namely the types of interdependencies among countries affected by the same catastrophic event. When the interdependence is pooled, it is more frequently the case that the level of cooperation is limited to post-disaster humanitarian aid only, or at least some kind of warning. Conversely, when a sequential or reci-

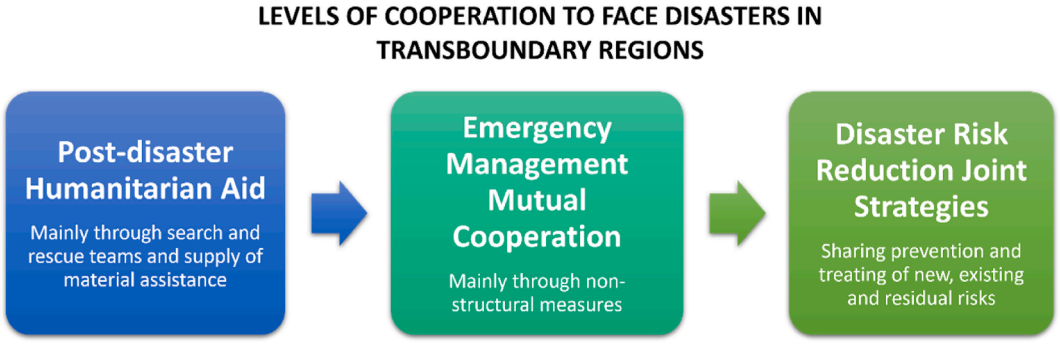

Fig. 2. The collaboration levels of the growth path for the cooperation among countries to face disasters affecting transboundary regions.

procal interdependence in collaboration is triggered, two following levels of cooperation can be identified, allowing for a growing response capacity or event action, for instance, hazard mitigation. In this paper, we demonstrate the path traced by the GESTI.S.CO. project, which was developed with a clear understanding of the underlying framework. We begin with a realistic starting point for analysis and trajectory. It is hoped that, following the initial steps taken during the GESTI.S.CO. project, further steps can be implemented, not only to manage disaster risk but also to jointly prevent and treat it. It is evident that the decision of the legal authorities in charge must be respected.

2.3. Institutional models of response to disasters

The disciplines of emergency management and, even more, disaster risk reduction, are relatively young [38,39]. Consequently, their cooperative development along the borders of two or more countries is still at an early stage and a research topic of today. The additional challenge is linked to the design of interactions with the institutional models and praxis already existing in each country. National institutional models change from country to country, and many critical issues and barriers hinder and complicate their cooperation. The implementation of disaster risk reduction (DRR) strategies and policies in a single country is already a challenging endeavour, given the multitude of institutions involved (governments, public bodies, and local administrations). This is further compounded by the need to address cross-border areas, where specific initiatives are essential to facilitate the additional effort required to achieve effective management cooperation. In order to enhance emergency management cooperation along borders, which is a fundamental prerequisite for the development of integrated and collaborative disaster risk reduction strategies, it is necessary to initiate localised efforts to foster deeper relationships between public bodies, stakeholders, residents and their socio-economic structures, as well as their disaster management practices.

The organisational choices made to set the public services in charge of managing responses to disasters vary considerably around the world. This is due to the fact that countries often have completely different institutional models and operating methods. This is also true in cross-border areas, despite the territories often being substantially homogeneous and having common risk scenarios. Conversely, the necessity for strong adaptation, collaboration, and cooperation among administrations, public bodies, and private entities is already evident in the case of internal disasters. This need is further compounded when interdependencies, information, knowledge, competencies, and authorities are dispersed across two or more nations, and when cultural, socio-economic, institutional, and organisational approaches are differentiated and fragmented [40]. Schematically, multiple dimensions can be combined to help recognize institutional models of public services to manage responses to disasters (updated if compared with [41]), as synthesized in Fig. 3.

Based on such updated synthesis, we have four dimensions helping us to recognize most of the different situations of each country:

- Dimension 1 - Governmental leadership (sector/ministry or institutional body) in charge of disaster management function: prime minister/president, ministry of interior, ministry of defence, ministry of civil protection (or similarly named);
- Dimension 2 - Body in charge of emergency planning activities: elaboration competence assigned to a national body, such as firefighters or army; competence assigned to elected national institutions (approval included); competence assigned to a special technical agency.
- Dimension 3 - Competences hierarchical subdivision (on a geographic basis): distributed (or partially distributed) among institutional levels, such as municipalities, groups of municipalities, local districts/counties/departments/cantons/provinces, regions/states/land or exclusive responsibility of the national/country level government;
- Dimension 4 - Public/private engagement (or even societal involvement): exclusive public jurisdiction; shared or joint responsibility of actions between public and private sectors (insurance companies, volunteers' associations, private means, and resources).

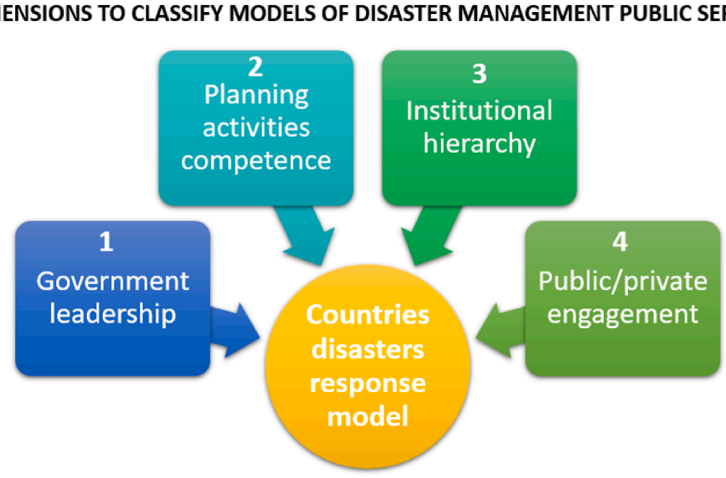

Fig. 3. Multiple dimensions to be combined to recognize institutional models of public services to manage responses to disasters.

Taking into account these dimensions, it becomes clear that there are a number of different combinations of roles and responsibilities that have been developed in different countries. For instance, in France, firefighters play a particularly important role, while in Italy, volunteers' associations have a long tradition. Switzerland has a system in which the army is the most important pillar of the system, while in Germany and the USA, regions, states and land display a fundamental combined action. In addition to the aforementioned dimensions, it is crucial to acknowledge the international nature of the field of action, as transboundary crisis response may be influenced by political issues and needs affecting international relations between involved countries. Consequently, the establishment of favourable international relations is a prerequisite for the implementation of genuine collaboration, rather than merely facilitating communication between senior decision-makers and representatives of the two countries on either side of the border. Conversely, the establishment of fruitful cross-border cooperation is contingent upon the implementation of a joint cross-border risk assessment and transboundary coordination, which must be underpinned by mutual respect for national sovereignty and the endorsement of both national decision-makers and domestic and local stakeholders and institutions [42].

2.4. Transboundary emergency management critical issues from local communities' point of view

As previously indicated, the pursuit of success in transboundary emergency management necessitates the formulation of specific responses at both the institutional and technical levels. It is hoped that emergency management plans will be considered as part of a DRR strategy, which will already have been developed in a coordinated manner. Such plans will frequently have to take account of a number of different interests and interactions, which will need to be analysed and included in the options for action. However, when the transboundary scale is taken into account, an additional layer of complexity is introduced [43].

In the field of literature, it is already established that the majority of responsibility in the context of disasters typically falls on local jurisdictions [44] Consequently, the local level of a disaster response management system is regarded as the "bedrock" of emergency preparedness and is expected to play a pivotal role in making cities resilient [45]. In such a context, local levels are often perceived as being more precisely and effectively reactive in the implementation of actions and countermeasures to address transboundary catastrophic events. However, several obstacles can impede a prompt response based on cross-border cooperation [46]. The administrative local levels of different countries are logically organised in different manners and are linked with their national powers and authorities in multiple ways. In addition to the aforementioned considerations, there are a number of other critical issues that must be addressed in order to ensure the efficient management of emergency situations in transboundary contexts. These can be grouped into four categories, as illustrated in Fig. 4.

In detail, we have four groups of critical issues in organizing transboundary emergency management based on the collaboration of local levels of government:

- Group 1 - Barriers against transboundary horizontal integration such as divergent political priorities of countries or local authorities involved; different chains of command legitimation; different funding mechanisms; competition for resources to be shared with other local authorities in different territories (imbalances in available resources); language difficulties; religious differences;
- Group 2 - Obstacles in transboundary vertical integration: local deployability of national-owned needed resources, or in their reciprocal sharing, as, for instance, required logistics and personnel or scientifically relevant data and expertise (causing decision difficulties when officials are dependent on the information held by other authorities or countries to manage their uncertainty situations); different time of mobilization and positioning of resources (and related organization of supply management); less “art of improvisation” of first responders when operations field is not a well-known and an already experienced area by foreign rescue teams;

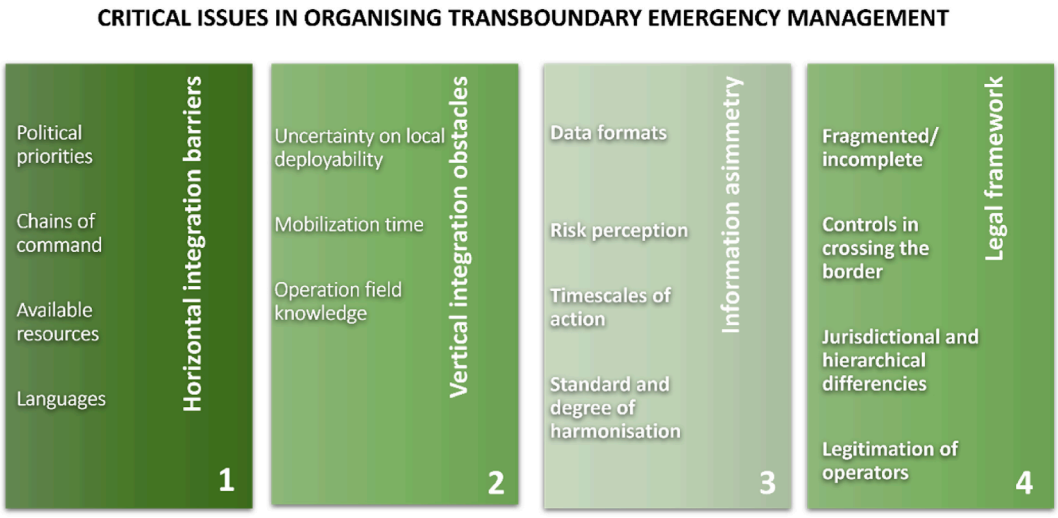

Fig. 4. Groups and examples of critical issues to be considered in organizing and planning transboundary emergency management.

- Group 3 - Asymmetric information systems, potentially causing troubles during actions jointly managed: from discrepancies in risk perception to lack of reaction promptness or possible mismatched timescales of action when needed; standard and degree of harmonization of procedures, equipment, and forms of organization; incompatible data formats or mismatches in activating interfaces on connection and coordination (radio frequencies, mobile phones networks, …);
- Group 4 - Inadequate international legal frameworks: fragmented or incomplete, and often not binding rules to put in place and sustain (abroad) assistance actions; rapidity of controls in crossing the border of men and (special) vehicles; dissimilar territorial jurisdictions, often showing significant differences in their logics and priorities (including insurance and health coverages); lack of unified decision-making authority; legitimation of foreign operators with citizens to be supported.

Thanks to such a distinctive "four-pillars" framework of analysis of transboundary emergency management, we can give a conscious position to the chosen approach to the transboundary cooperation of GESTI.S.CO. project activities, able to allow a rational comprehension of choices and solutions put in place and facilitate proper decisions for different conditions as far as changing contexts of Levels of cooperation, Models of disaster management public services and Critical issues in organizing transboundary emergency management could be concerned and could have to be faced.

3. GESTI.S.CO. Project: a tailored and balanced transboundary local-level strategy

3.1. Project objectives, features, and structure

GESTI.S.CO. is an Italy – Swiss Interreg-funded project, conceived between 2016 and 2017, also as a follow-up of the "Odescalchi 2016" cross-border exercise, simulating a railway accident in a tunnel between Italy and Switzerland. The partners involved in the project are the Environment, Construction and Design Department of the University of Applied Sciences and Arts of Southern Switzerland (SUPSI), Regione Lombardia, ARPA Piemonte (the environmental protection agency of Regione Piemonte), the Civil and Environmental Engineering Department of Politecnico di Milano, Comune di Como, Repubblica e Canton Ticino and Fondazione Politecnico di Milano. For operational reasons, Arpa Lombardia and MeteoSvizzera, in charge of weather forecasting and warning respectively for Regione Lombardia and Repubblica e Canton Ticino, have been involved in the project by local authorities.

GESTI.S.CO. started at the end of 2018, therefore before many of the papers and documents cited here on the subject of transboundary emergency management. For this reason, it seems to be a reliable independent set of studies and field tests on the topic of transboundary emergency management, and it is ideal to give additional inputs or confirmations to regulate progress for its future improvement. As briefly anticipated, the GESTI.S.CO. project pursues the attempt to improve the emergency management of transboundary disasters, mainly in the highly interconnected and populated border area between the Canton of Ticino (Switzerland) and Lombardy (Italy). The physical borders of this area, an Alpine sub-region largely defined by the Ticino River basin, do not coincide with the political borders. Moreover, the two countries have strong economic, political, human and cultural ties and frequent institutional relations at various levels [47], although only Italy is a member of the EU. The aim of the project is to strengthen cross-border cooperation with governance actions in the field of natural disaster management, through common solutions for the preparedness of public administrations to increase cooperation, coordination, integration and mutual assistance. Similar needs have already emerged, for example, without the knowledge of the GESTI.S.CO. project partners, in the trinational metropolitan area of Basel between Switzerland (Canton Basel City), Germany and France, where local authorities regularly conduct disaster exercises [48].

GESTI.S.CO. carried out three main groups of "disaster risk reduction oriented" activities:

i) *Strengthening a common information framework in the field of emergency management between Italy and Switzerland.* Strengthening a common information framework in the field of emergency management between Italy and Switzerland. A work package (WP) consisting of the following studies: 1) analysis and comparison of the respective regulatory systems and civil protection systems, practices and working methods at both national and regional level; 2) creation of a specific glossary comparing technical terms; 3) study of natural hazards and related event scenarios affecting the cross-border area through the production of vulnerability maps for four natural hazard scenarios: floods, forest fires, rockfall and shallow landslides; 4) analysis of the respective meteorological monitoring systems with exchange of best practices for the generation and dissemination of improved early warnings.

ii) *Setting the governance of a selection of new joint processes and the availability of innovative tailored intervention tools.* This has been performed through: the establishment and supply of operational equipment (including vehicles) of *Nucleo Unitario di Valutazione e Risposta Emergenze Transfrontaliere* (NUVRE), a cross-border emergency assessment and response joint unit; the updating of tools for supporting municipal local emergency planning in case of cross-border events (local communities guidelines); the integration of the transboundary agreements for the operational exchange of meteorological observations in real-time.

iii) *Developing the related capacity-building track for people and public bodies involved in transboundary emergency management.* The final work package is composed of three actions: training for the staff of the Civil Protection of Regione Lombardia and of the Population Protection of the Repubblica e Canton Ticino in charge of coordinating cross-border emergencies and early warning procedures, training activities for municipal technicians on cross-border emergency planning and information campaigns for cross-border citizens, with a particular aim of dissemination in school, have been organized.

The project closure, originally planned for the end of 2021, was postponed to May 2022 in order to complete all planned activities that were suspended due to the COVID-19 pandemic. In this context, GESTI.S.CO. received further funding in 2021 to work on an additional WP module MAC (Additional Covid Module) to strengthen cross-border governance in the context of health emergencies

[49]. Moreover, given the strategic relevance of the results obtained, in 2022 the Interreg Italy-Switzerland Authority financed capitalisation activities related to some GESTI.S.CO. products, including the extension of the flood vulnerability mapping to the whole territory of Lombardy and the additional training and learning visits between operational units, both of which ended in September 2023.

3.2. Cross-border area of GESTI.SC.O. Project

GESTI.S.CO. concerns the cross-border area between the eastern side of Lake Maggiore and the western one of Lake Como, as shown in Fig. 5. This area includes 150 Italian and 90 Swiss municipalities, with a total population of 881,856 inhabitants (based on 2022 demographic statistics). From a climatic, morphological, hydrological, socio-economic, cultural and linguistic point of view, the area is rather homogeneous and highly integrated, as it also belongs to the same Ticino river basin and has centuries of partly common historical roots and multiple interconnections. Natural hazards, namely rockfall, shallow landslides, floods and forest fires (the risks addressed by the project), are spatially evenly distributed. They threaten densely populated areas, but also transboundary roads, railways and technological networks, which, if involved in an event even at a very local level, are potentially capable of causing direct and indirect effects, spreading damage, losses and service interruptions simultaneously in Switzerland and Italy. We recall, for example, the blackout that hit Italy in September 2003: a tree fell on a power line during a storm in Switzerland, triggering a chain of events that left almost 57 million Italians without electricity for many hours and for the whole day in several zones [50].

As the largest and most interconnected border area between Switzerland and Italy, this area is an ideal place to test solutions for cross-border cooperation in emergency management between the countries. Most of the rest of the border between Italy and Switzerland coincides with the Alpine water divide, often in high mountain areas with peaks above two, three or four thousand metres. The results of the project can therefore easily be extended to other border areas between Italy and Switzerland, areas that are certainly less interconnected, although they could also be separated by greater linguistic differences (German spoken in the canton of Grisons or French spoken in the canton of Valais).

3.3. GESTI.S.CO. Approach to the transboundary cooperation in emergency management

During the design phase of the activities to be implemented, we had the opportunity to correctly position the approach of the GESTI.S.CO. project and ensure its replicability, as requested by the bilateral authority (EU-Swiss Federation), the main financier of the aforementioned Interreg programme. Taking into account the analytical framework of transboundary emergency management presented in the previous paragraph, we can now identify the characteristics of the study area. Although the two countries share the same river basin, with the Swiss part upstream of the Italian part, the situation is not one of sequential interdependence, but of mutual interdependence (Section 2.1) due to the social, economic, infrastructural and technological characteristics of the area mentioned above. With regard to the levels of cooperation for cross-border cooperation between countries (Section 2.2), the Swiss and Italian project leaders have chosen the second level, i.e. "emergency management cooperation". From an institutional point of view (Section 2.3), these cooperation activities are characterised by the fact that they are "bottom-up" in that they are carried out by local institutional subjects in whose territory the border area can be identified, within the existing legal frameworks, without the need to modify them and without changing national emergency practices.

As regards the so-called level one ("Post-disaster humanitarian aid through the provision of search and rescue teams and the supply of material assistance") of "pillar two", Italy and Switzerland have already signed two cooperation agreements in the past. The

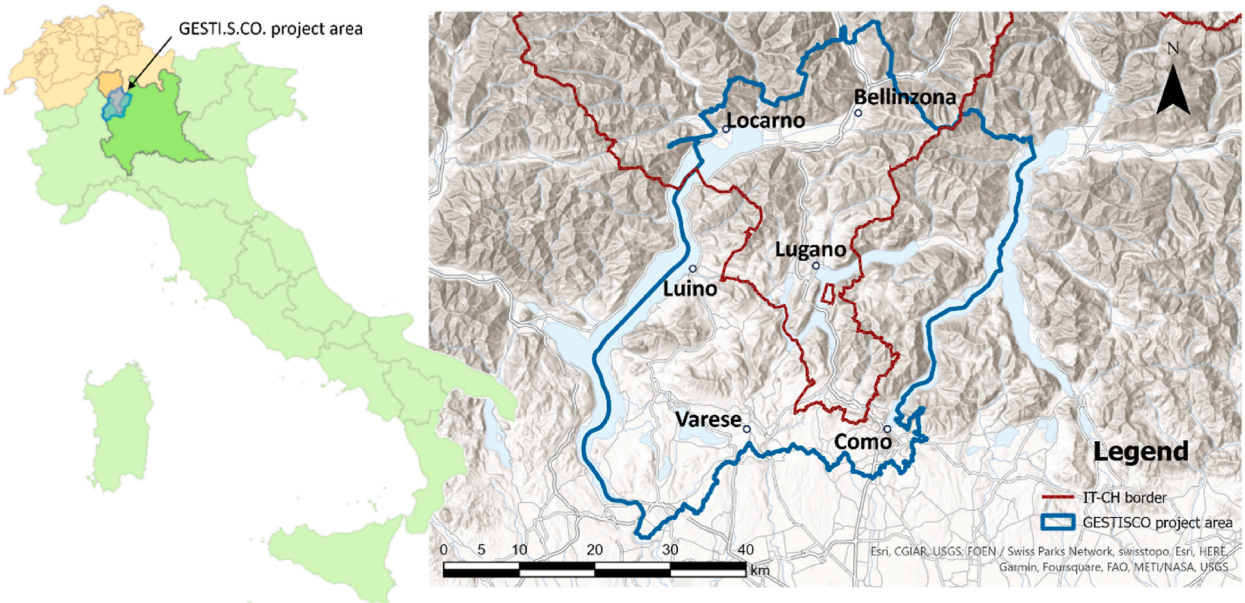

Fig. 5. Cross-border area of GESTI.S.CO. project.

first, dating back to 1995, was a bilateral agreement that allowed for the rapid and efficient movement of personnel, vehicles and equipment, the exchange of scientific data and knowledge, and the organisation of seminars, visits and exercises. The second act, updated in 2013, concerned some operational procedures for formal contacts, requests for assistance and the recognition, identification and authorisation of rescue teams at the border. If we consider the third pillar of our suggested framework of analysis of transboundary emergency management, there is only a partial overlap of the respective institutional model of response to disasters.

Looking at the third pillar of our proposed framework for analysing cross-border emergency management, there is only partial overlap in the respective institutional models for responding to disasters. While emergencies and crises on both sides of the border are managed by the head of government - the Federal Chancellery in Switzerland and the Presidency of the Council of Ministers in Italy - operational activities in Switzerland are led by the army (through the Federal Office for Civil Protection - FOCP[2]), while in Italy they are led by the elected national and local institutions, involving local forces of a distributed system called the National Civil Protection Service. In this context, it should be noted that the FOCP is also responsible for dealing with risks related to war. The FOCP has five partner organisations for natural and man-made disasters: the police, the fire brigade, the health services, the technical services and the civil protection service. The latter has a specific support role to reinforce other organisations (such as the army and the fire brigade) in the event of serious and prolonged incidents, and provides specialised services such as management support to cantonal and municipal crisis management teams, spreading the alarm among the population, assisting the homeless, protecting cultural assets, carrying out rescues from damaged buildings, etc. On the other side of the border, in Italy, the Civil Protection oversees decisions on all emergency needs; consequently, military bodies and assets must act under its control, which is expressed in operational centres managed by civil authorities (such as mayors at the municipal level). Moreover, in Italy, emergency planning is mandatory in every municipality. In Switzerland, this obligation is regulated by the cantons, according to the law on areas exposed to natural hazards (LTPNat) adopted in 2017.

On the other hand, private involvement is more developed in Italy as far as volunteer associations are concerned, probably because the forces needed in the event of disasters are automatically provided by the existence of compulsory military service in the Swiss army or in the civil protection units (for those who are ineligible for regular military service, but not for those who are exempt); on the other hand, private involvement in the insurance market is stronger in Switzerland and underdeveloped in Italy due to the central role of the state in compensating private and public losses.

With regard to the fourth pillar, namely critical issues to be considered in organizing an effort to improve transboundary emergency management (Section 2.4), it is evident that there are notable differences between Switzerland and Italy in the chain of commands (civil in Italy, military in Switzerland), in strategic priorities (planning in Italy, operational readiness in Switzerland), in emergency management technical praxis and vocabulary, despite both populations being Italian-speaking, and in the legitimation of foreign field operators, in a legal framework that is not unfavorable, but characterised by the fact that Italy is part of the European Union, while Switzerland is not. Fortunately, political issues or needs do not affect the international relationship between Switzerland and Italy, who jointly manage cooperation programmes in several fields of action and study. This is done with mutual respect for national sovereignty, and they have excellent relationships. This has constituted a pivotal and favourable starting point, allowing local institutional subjects (the Republic of Switzerland and the Canton of Ticino and the Lombardy Region), in collaboration with other actors, to work towards the enhancement of emergency management cooperation along borders. This has involved the stimulation of deeper relationships and reciprocal knowledge, beginning with an analysis of the characteristics of public bodies, stakeholders, the socio-economic structure and disaster management praxis.

In consideration of the framework analysis as a whole, it can be stated that the approach to transboundary cooperation employed by GESTI.S.CO. encountered obstacles that were overcome by a mutual willingness to address the issue. A strategy was devised based on a set of calibrated activities, which were tailored to the specific circumstances of the involved areas and the interactions between the relevant institutions. This strategy comprised a combination of formal and informal actions, and its effectiveness was evaluated in order to identify any lessons learned and to confirm the suitability of the proposed framework for analysing emergency management in transboundary areas.

4. Discussion on main formal and informal outcomes and tools of GESTI.S.CO

GESTI.S.CO. “disaster risk reduction oriented” activities have produced many results: some of them, formally adopted, entered into force into the procedures or the available tools of institutions in charge of emergency planning and emergency management, both in Italy and in Switzerland; others, informally, are substantially able to allow a more efficient cooperation and reaction in case of need, mainly based on a better knowledge of the contexts where operate and of the people with whom to work. Both, formal and informal, provide elements for recognising the specific nature of DRR in cross-border areas and suggest dedicated and rational efforts to be made by potentially affected local entities of the countries involved.

4.1. Strengthening a common information framework in the field of emergency management in the border area across Italy and Switzerland

The strengthening of the common information framework on the DRR context on both sides of the border has been carried out with different types of activities, both from an administrative-operational and phenomenological point of view.

As a first step, a group of experts in regulatory systems for civil protection issues in Italy and population protection in Switzerland, coming from local institutions and academic centres of the cross-border area, produced an agile and updated guide of comparative law (the propaedeutic Italian part of which has been peer-reviewed in Ref. [50]). The document has been employed during the training activities conducted in the latter stages of the project, as it is well-suited to the specific preparation of personnel engaged in transboundary emergency management.

A second focus has been placed on the analysis and comparison of the respective civil/population protection systems, practices, and operating methods, following the definition of the regulatory systems, even at the regional/cantonal scale. This activity has been performed, first of all, by organizing several workshops and visits to operational centres both in Switzerland and Italy. These meetings have been attended by professional figures coming from border territories of both countries, which has facilitated the growth of a "joint team spirit". The principal outcome of this activity is the production of nine summary worksheets that compare, for different geographical scales of intervention, the emergency management systems of the two countries and the directional and operational figures involved. These sheets can be used as practical resumes under operational conditions in case of emergency. Furthermore, these visits highlighted the necessity for a specific glossary comparing technical terms in the field of emergency management on both sides of the border. This resulted in the creation of a digital glossary comprising 214 words, with 110 from Italy and 104 from Swiss. Fig. 6 illustrates the tool developed, which collates, defines and, where possible, compares the principal terms employed in the cross-border area.

Sub-glossaries have also been created to assist the end-user in conducting a more accurate semantic analysis of the terms, which are drawn from the Italian language but are used in different ways, largely due to the influence of different administrative practices. This tool has been designed to facilitate comprehension during emergencies among teams on the ground and operational centres [51].

In addition to these administrative and operational activities, the analysis of respective meteorological monitoring systems and the exchange of best practices for the generation and dissemination of upgraded early warnings have also been achieved. This work, conducted by Arpa Piemonte, encompassed the territories of Lombardy, Piedmont, and the Canton of Ticino. The final reports present a comparative analysis of three key topics: the technical specifications and geographical distribution of the sensors comprising the hydro-meteorological network, the characteristics of the radar meteorological network, and the warning procedures. Additionally, schematic tables of comparison are included in the documents as a tool for learning how forecast and warning messages are obtained in the area, thus facilitating the rapid identification of all pertinent information required for the coordination of intervention.

Another strategic tool developed is a pixel-based susceptibility analysis of the study area to natural hazards, including rock falls, shallow landslides, floods, and forest fires. All susceptibility maps produced are available online at URL *https://mappegestisco.dica.polimi.it*. They can be used not only to prepare emergency plans in cross-border areas or to manage transboundary emergencies in real-time, but also to disseminate awareness among citizens, as this is becoming increasingly common in recent years [52–54]. Fig. 7 depicts a screenshot of the website, which allows users to visualize the maps and download them in a scale of 1:150,000, accompanied by the relevant reporting in PDF format.

This has been achieved through a joint bilateral territorial analysis, utilising data from a range of information layers that were originally cross-border in nature, including the Digital Terrain Model (DTM), geological surveys, satellite images and land use classification. A substantial database of past events, available for both Switzerland and Italy, has also been considered. The maps were designed to be in accordance with the cartographic praxis of both countries, with the aim of facilitating the best and quickest comprehension of events on both sides of the border, as well as within each country. This should also facilitate joint discussions during emergencies Indeed, the issue of comparability among risk analysis is often further complicated in cross-border areas, where additional challenges in risk analysis arise due to the diversity of databases, analysis and models [55].

In more detail, rockfall susceptibility is comprised of two distinct analyses: the first examines the propensity for detachment, while the second addresses rockfall propagation. The latter analysis was conducted using the distributed empirical model Flow-R [56]. In contrast, the susceptibility of shallow landslides has been mapped a priori. The input data comprise only DTM, soil cover, and the mechanical features of the superficial deposits. Consequently, the hydrological component has not been taken into account. The output is a classification of the pixel as either unconditionally stable or not, according to slope stability mechanics. In the context of forest wildfires and floods, the event dataset has been employed to train a prediction model that is capable of associating the propensity of a given territory to be involved in a specific event with a set of features pertaining to the territory itself. These features include, but are

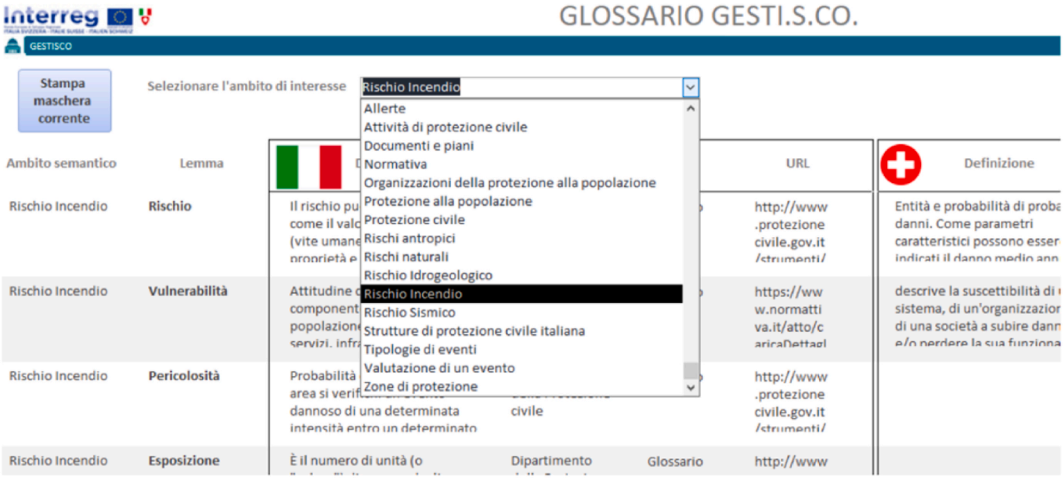

Fig. 6. A screenshot of the developed digital glossary of GESTI.S.CO. project.

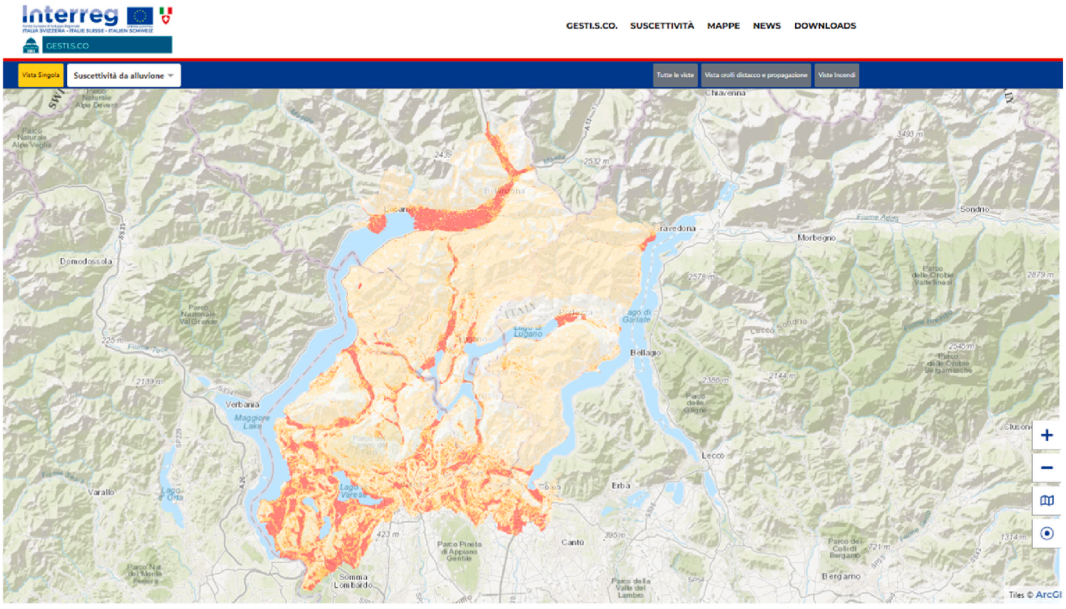

Fig. 7. A page view of the web platform of the susceptibility maps of GESTI.S.CO. project.

not limited to, elevation, land use, distance from a drainage network or streets. The mappings were initially conducted using a statistical procedure based on the Bayes theorem, referred to as the Weight of Evidence (WOE) [57], which has been widely employed in the literature to assess slope and, more recently, to predict floods and other natural hazards. With regard to wildfires, two maps were produced, one for the winter fire regime and one for the summer fire regime. The flood susceptibility map was subsequently enhanced through the incorporation of an analysis of the entire Lombardy region during the latter stages of the project. This involved the utilisation of artificial intelligence techniques, which had already been employed in other case studies [58].

4.2. Setting the governance of new joint processes and the availability of innovative tailored intervention tools

The first result of this group of activities is the establishment of the NUVRE, composed of operators coming from both Regione Lombardia and Repubblica e Canton Ticino, specifically dedicated to the role of "liaison officer" in the event of a cross-border emergency. The NUVRE is made up of 2 crews, one for each country, equipped with the appropriate instruments and in charge of jointly assessing (crash scouting) the extent and intensity of a given cross-border event and reporting the results of the assessment to the respective control rooms. The two units, which are available 24 h a day, 365 days a year, are made up of members wearing a specific uniform and are equipped with two special vehicles bearing the official logo of the Interreg Italia - Svizzera programme; these vehicles were used during the Odescalchi cross-border exercise in 2022. In addition to the creation of such joint units, thanks to the capitalisation funds obtained in 2022, Italian firefighters purchased some fire hoses compatible with both Italian and Swiss standards and additional radio equipment to be provided to Swiss rescuers coming to Italy (their standard radio equipment does not work in Italy).

Another important milestone was the updating of the tools to support local emergency planning in cross-border territories. This allows local administrations to be aware of the additional challenge posed by cross-border territory and provides them with practical tools to deal with it. Thanks to the vulnerability maps produced and the knowledge of the warning and emergency practices of the territories on the other side of the borders, the municipalities will be able to include in their plans a wider range of event scenarios, appropriate sources of information about them to be used in real time, people to be in contact with to collaborate for updates or even additional support. The main "testing ground" for this activity were the flood hazard scenarios faced by the Civil Protection Service of the Comune di Como. Thanks to the funds of the project, the Municipality has purchased mobile barriers to protect built-up areas from water, both in the border area with Chiasso in Switzerland and along the shores of Lake Como, following a block-level approach in the application of flood protection techniques [59].

Finally, two specific agreements were signed between MeteoSvizzera, ARPA Lombardia and ARPA Piemonte to ensure technical cooperation between weather forecasters in order to provide more accurate information and details on meteorological events that may affect border areas and their local authorities. The documents provide guidelines for cross-border meteorological briefings and the exchange of digital data from sensors (precipitation, wind, temperatures …). In detail, the data exchange of the first agreement covers 74 stations located in Lombardy and 88 in Switzerland, while the second agreement covers 109 stations in Piedmont and 96 in Switzerland.

4.3. Developing the related capacity-building track for people and public bodies involved in transboundary emergency management

The training of the staff of the Civil Protection of Lombardy and the Population Protection of the Canton of Ticino, in charge of coordinating cross-border emergencies and early warning procedures, started with the visits to operational centres in Italy and Switzer-

land, which took place between July 2019 and February 2020 and involved 75 participants. Moreover, at the end of the most intensive phase of COVID-19, the project promoted additional training courses in 2021 for operators of the Centro Operativo Comunale (the Italian municipal emergency management centre), municipal technicians involved in cross-border emergency planning and Italian firefighters (in the framework of capitalisation activities, during 2023).

Citizens living in the GESTI.S.CO. project area have been informed thanks to the creation of dissemination material on the project's communication media (newsletter, Facebook and LinkedIn pages) and thanks to the participation of project staff in some events specifically dedicated to Civil Protection topics. The project's conferences and seminars have also trained professionals and students to compare laws and practices and to use the tools, guidelines and maps produced by the project. A special publication has been written and produced for schoolchildren, with the help of communication and illustration specialists. The result is a summary of the main contents of GESTI.S.CO., presented in an entertaining way, with a style and language suitable for the youngest (Fig. 8). The book has been presented in some selected schools in the cross-border area during a lesson on the project themes (Fig. 9), which can be reproduced by teachers to prepare children to think "cross-border" in the future.

4.4. Validation of GESTI.S.CO. products in real context and impact on institutions and field activities during emergencies

On 27 and 28 July, an exceptional wave of bad weather hit the border area between Como (Italy) and Chiasso (Switzerland). The situation was assessed as requiring a joint intervention by Italian and Swiss teams, which was carried out effectively and quickly. This demonstrated the utility of the methodologies introduced by GESTI.S.CO. in emergency situations. One of the interventions took place at the underpass of Via S. Franscini (Como), which had previously been identified as a critical point during the definition of the cross-border scenarios. Furthermore, the strengthening of contacts between Swiss and Italian local authorities has led to a fruitful

Fig. 8. A page from the "La Protezione non ha confini - GESTI.S.CO." text for school children.

Fig. 9. One of the lessons held by the project team to children at S. Fermo della Battaglia Elementary School (Como, IT).

joint real-time monitoring of water levels in the Breggia river, which flows from Switzerland into Italy. In the same area, the Italian municipality of Maslianico was severely affected by the flooding of the tributaries of the Breggia. Fig. 10 presents an estimate of the extent of the flooded area based on photographs and videos from online news sources, along with the output of the flood susceptibility mapping produced during the project. As illustrated in the map, the highlighted area exhibits a susceptibility level of high to medium, thereby confirming the efficacy of this tool for a comprehensive classification of the susceptibility of the area to being flooding, even on small rivers, streams and ditches, which are typically not covered by the traditional and well-established flood hazard maps. This is a valuable resource for local emergency management planning, particularly in hydrologically connected transboundary areas, as evidenced by the present case.

Furthermore, a positive was observed in the wildfire event that occurred in the canton of Ticino on Mount Gambarogno, situated in close proximity to the border, at the end of January 2022. This event was managed by the Swiss Army with the support of the Italian Canadair and the civil protection of the Lombardy region. Once again, the sharing of knowledge and expertise between the emergency managers proved to be a crucial factor in the rapid resolution of this incident. The wildfire susceptibility maps facilitated the prompt implementation of necessary actions, underscored the significance of collaborative and concerted efforts, and enabled the successful field testing of this tool. Susceptibility maps also demonstrated their effectiveness a few months later in Angera (in the Italian province of Varese, on Lake Maggiore). The wildfire, which occurred on the night of 15–16 April 2022, affected approximately 8 ha of woodland on the San Quirico hill and caused the evacuation of some families. A post-event recognition demonstrated that the burnt area, mapped by the Carabinieri Forestali (the Italian environmental police), was correctly marked with a level of susceptivity from low to medium (Fig. 11).

The findings of the GESTI.S.CO. project were employed to prepare the 2022 edition of the Odescalchi cross-border exercise (following the 2016 exercise), which simulated an intervention to rescue some people in a multi-hazard scenario (a landslide blocking the way to them and a forest fire nearby). The exercise involved a helicopter of the Italian Fire Brigade, the Army and health personnel, as well as the corresponding Swiss units, in various missions to monitor the fire front of the forest fire and to locate missing persons. Emergency evacuations of injured personnel and civilians were carried out using "floating bridge" boats. The event provided an opportunity to test the glossary and normative schemes developed by the project in the field. In addition, NUVRE was activated to better simulate the joint management of such activities.

In addition to the aforementioned opportunities to evaluate the work carried out during the project on the ground, there is the daily new cooperation between the meteorological services of the Republic and Canton of Ticino, the Lombardy and Piedmont regions, and several bilateral initiatives for professional exchanges between the emergency services on either side of the border. Positive feedback on the results of GESTI.S.CO. has also been expressed by senior managers of the Italian National Department of Civil Protection and by senior officers of the Swiss Population Protection during public seminars held with stakeholders to share the results

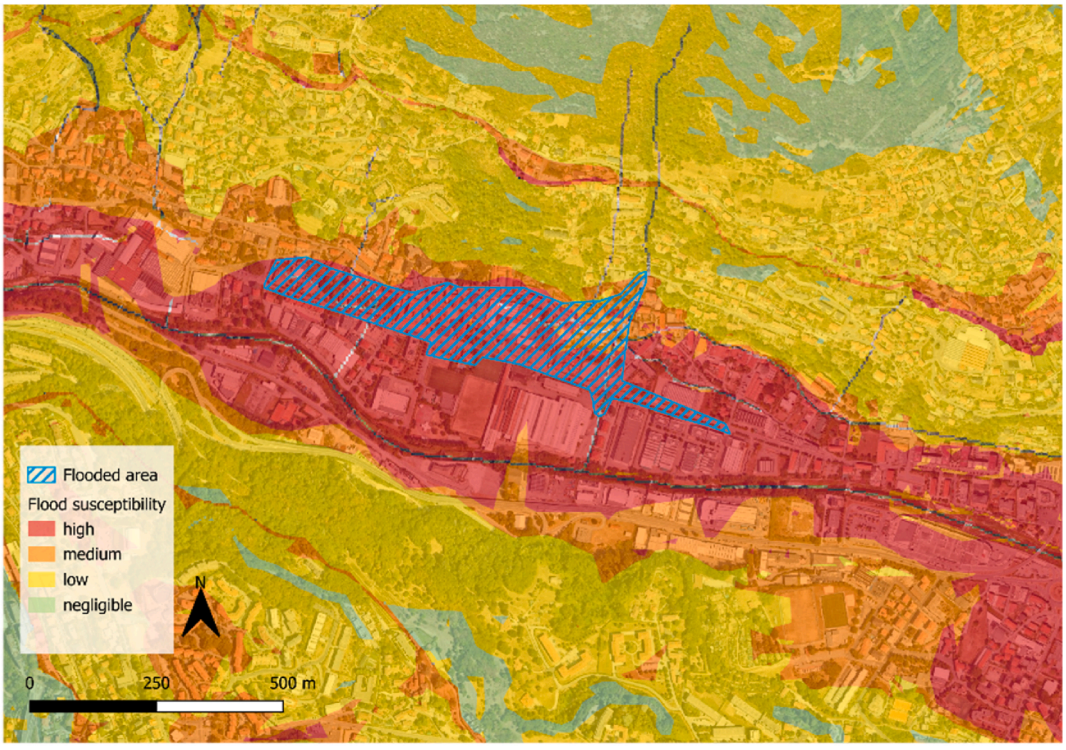

Fig. 10. Flood susceptibility map for the territory of Maslianico (Como, Italy). In hashed light blue the flooded area during the event of the 27–28 July 2021.

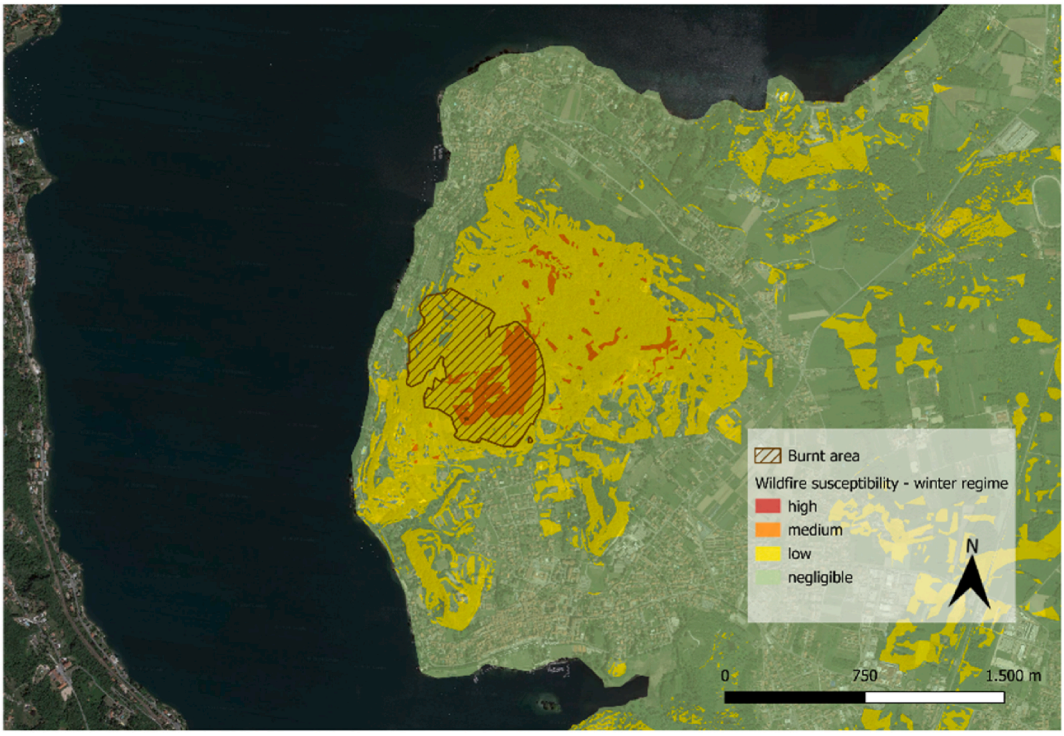

Fig. 11. Wildfire susceptibility map for the territory of Angera (Varese, Italy) considering the winter regime. In hashed brown, the burnt area during the wildfire event of 15–16 April 2022.

of the activities carried out. This demonstrates that activities conceived, designed and implemented at local level, even if regularly shared with higher levels, can make a positive contribution and be appreciated by the system as a whole.

In conclusions, it can be stated that the activities carried out by the GESTI.S.CO. project represent a multifaceted and quite comprehensive approach to promoting governance and preparedness in the context of emergency management in transboundary areas, particularly in the context of natural disasters. GESTI.S.CO. has provided a number of solutions to deal with critical issues that need to be taken into account when organizing efforts to improve transboundary emergency management (see Section 2.4). GESTI.S.CO. addressed issues related to differences in the chain of command and in risk governance terminology (horizontal integration barriers) and it managed, consolidated and shared the exchange of human and material resources (vertical integration barriers). As concerns information asymmetry, GESTI.S.CO. has developed specific digital tools and maps (available in shared different types of GIS and repositories). From the perspective of the legal framework, each activity is carried out in accordance with the prevailing regulations, thereby expanding the available options and the framework for action (formal adoption, at both local levels, of the tools prepared). Finally, cross-border cooperation for joint preparedness for emergency management has proven to be an effective means of comparing practices and methods applied in similar operational fields and of providing a framework for future action, not only for joint emergency management, but also for the rethinking or revision of part of the Disaster Risk Reduction (DRR) and resilience strategies for the local communities involved and for the public bodies in charge of related tasks in their countries. The feedback from numerous individuals engaged in the activities of GESTI.S.CO. indicates that a profound understanding of the methodologies, procedures, and instruments employed by another country has enhanced the general utility of cross-border emergency management and cross-border collaboration. This understanding serves as a foundation for future endeavors.

It is evident that not all border relations are as harmonious as those between Switzerland and Italy. Switzerland, for instance, is not a member of the European Union (EU), and as a consequence, it does not adopt the EU Civil Protection Mechanism of Council Decision 2001/792/EC, nor does it implement the Floods Directive and the Water Framework Directive. As previously stated in Section 2.3, the nature of the relations between the countries involved may influence cross-border crisis responses. The establishment of good international relations is a prerequisite for the establishment of a level of cooperation in the field of natural hazard emergency management that extends beyond the provision of post-disaster humanitarian assistance. Furthermore, it is important to note that not all regions of the world are as wealthy as Switzerland and northern Italy. Nevertheless, even in relatively poorer and hostile border regions, such as between India and Pakistan in the Kashmir region, or between Armenia and Azerbaijan in seismically active areas, or even between Turkey and Syria, as in the region affected by the 2023 earthquake, a basic level of support is possible, even in the absence of pre-existing agreements. Indeed, it is conceivable that collaboration in the context of shared disaster scenarios could serve as a means of enhancing cross-border relations. It is possible that nations could recognize a common interest in minimising human suffering and economic damage in order to avoid increasing tensions [60–62]. But beyond such extreme cases, there are many other

"grey" situations where more or less barriers exist. In such cases, we can suggest that some of the activities carried out by the GESTI.S.CO. project could be useful in different contexts:

1. First of all, the project teaches that bottom-up initiatives are possible in the field of cross-border cooperation; local authorities can carry out successful (perhaps limited) actions that are only subsequently appreciated by governments, thanks to the generally more "administrative" and "less political" role they play in society;
2. Cooperation between experts, for example from academic centres (but not only), could be an agile first step of a larger cooperation, favoured by the attitude of technicians to share and study different methods and approaches, for example to produce guides, manuals or other kinds of tools to try to face disasters together; experts often have the trust of their border sides and understand each other; if language problems were significant between Italy and Canton Ticino, both speaking Italian (even if in a different administrative context), such a barrier could be heavier for other border regions. In any case, tools such as the glossary developed could be a first step towards building an additional capacity of interaction for emergency management purposes, for example also using "bridging" or "third" languages. Talking about languages and the cooperation of experts, the production of shared maps and the implementation of protocols for the exchange of monitoring data, as has been done in GESTI.S.CO., means speaking an ‘‘international language’’, made up of numbers, classifications, and procedures, more easily understood by people familiar with technical codes, often recognised at international level; moreover, such "codes" are less influenced by cultural, religious and legal differences or practices;
3. Encouraging mutual meetings and exchanges of knowledge between people and personnel in charge of emergency management (and of course to set up a joint response team) could further reduce the response times in cross-border cooperation, with even greater results when starting from a context where languages and cultures are more different than in the context of the GESTI.S.CO. project, thanks to targeted actions that are less costly in terms of time and resources. Direct knowledge between individuals creates personal relationships that can prove invaluable in emergencies;
4. In order to be prepared for face events triggered by cross-border scenarios, updated emergency plans and specific training and information actions, carried out autonomously in each country, could also be based on national initiatives (subsequent interactions between experts), adapted to the cultural and social context of each border country;
5. Logically, any border region in which a competent authority (public, private or third sector/NGO) wishes to set up some kind of cooperation in the field of natural hazard emergency management, could choose from this list of activities to start a longer journey or to plan a tailor-made way of implementing cross-border cooperation on the ground.

5. Conclusion

Among the different types of cross-border emergencies, those that affect cross-border local areas have peculiar characteristics that require specific types of responses when compared to emergencies at the regional or global level. GESTI.S.CO. addressed this issue by providing local communities with a set of tools to develop a strategy that includes responses to their scenarios and organisational needs. Thanks to the proposed distinctive framework for analysing emergency management in cross-border areas, it is a tested work that seems to be easily comparable with other cross-border contexts and potentially applicable, even partially, in different types of border regions.

As a first lesson learned, it can be highlighted and confirmed that many objectives can be achieved in terms of natural disaster management without significantly triggering regulatory processes and rule-making [63]. But we can also add that cross-border cooperation to improve cross-border emergency management can be based, first and foremost, on the preparation, sharing and assimilation of knowledge about the different types of contexts required, enabling actors to know and manage the differences in territories and procedures. This multidisciplinary knowledge makes it possible to involve those responsible for the management of emergencies in local border areas, thus triggering cooperative governance that goes beyond the cooperation required by law [64]. People knowing exactly who to contact in times of emergency can be easily found in local communities, exploiting in this manner a local knowledge that allows gaps to be filled and obstacles easier removed when staff or other changes inevitably happen, obtaining organizational connections that remain strong, being based on human factors and links [65,66]. The creation of a strong network is very important when there is a need for joint and coordinated action in emergencies: one of the results of the project activities is certainly the creation of repeatable opportunities for building interpersonal relationships and exchanging experiences. After the project, in addition to the formal knowledge gained through the various products we've shown in this article, there is a crucial level of knowledge, even if it has grown informally: Italian operators clearly remember the names, roles and faces of their Swiss counterparts, and vice versa.

The GESTI.S.CO. project has led to the creation of a kind of cross-border emergency plan. But now, as with any plan, there is a risk that it will become obsolete. The challenge for the future is therefore to counteract this obsolescence, to "maintain the initiative" [67]. Tools and methods, with people at their core, need to be constantly in place well in advance and regularly tested to be ready when called upon. Future steps to consolidate the level of preparedness achieved could be not only to organize regular exercises, but also to build something new, to be systematic and to continue with exchanges and meetings, with the elaboration of scenarios, maps and guides, and to include them in the common program of activities and training, managed by a common cross-border initiative.

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CRediT authorship contribution statement

Daniele Fabrizio Bignami: Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Christian Ambrosi:** Validation, Supervision, Funding acquisition, Conceptualization. **Manuel Bertulessi:** Writing – review & editing, Visualization, Investigation, Formal analysis, Data curation. **Giovanni Menduni:** Validation, Supervision, Project administration, Methodology, Conceptualization. **Maurizio Pozzoni:** Writing – review & editing, Investigation, Formal analysis, Conceptualization. **Federica Zambrini:** Writing – review & editing, Investigation, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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