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Emerging trends in disaster risk reduction and climate change adaptation higher education

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ABSTRACT

Increasing learning opportunities and teaching capacities in higher education (HE) institutions in the domain of disaster risk reduction (DRR) and climate change adaptation (CCA) is a key pre-requisite not only to enhance individual and collective knowledge, but also to forge resilient societies. However, several barriers exist that hinder the development and delivery of education curricula, including, e.g. fragmentation of DRR education offers across different departments and programs, limited availability of guidelines for standard requirements, and inadequate funding. Little research has been carried out to compare HE practices, to identify similarities, differences and emerging trends. In this paper, we present a review of the literature and of existing practices, including e.g. master's programs, postgraduate diploma/certificates, training courses, and transnational academic networks. The analytical framework includes content, pedagogical and structural features, practice orientation, and institutional anchoring. Emerging trends include an increasing relevance attributed to topics such as the use of big data for DRR/CCA, social aspects of DRR/CCA, multi-risk approaches, synergies between CCA and DRR, and links between disasters and development. Critical and creative thinking-led teaching, engagement of practitioners for teaching, multi-/inter- and trans-disciplinary approaches are presented as pedagogical innovations in several practices. Future research should focus on the development of databases, monitoring and evaluation approaches to provide an overview of HE practices for those involved in or willing to develop new initiatives.

1. Introduction

Disaster risk reduction (DRR) and climate change adaptation (CCA) education practice and research usually focus on the development of programs or activities to be conducted in schools or communities. Thus, the standard target groups are learners in primary, secondary and/or continued education. Little attention has so far been dedicated to higher education (HE) and to research about HE institutions. Some publications - primarily grey literature or working papers - address this topic (e.g., [1–7]) but little empirical research or systematic reviews have been carried out.

Yet, HE is crucial for professional development in DRR and CCA [7]. In recent years, the demand for DRR and CCA professionals has been steadily growing for several reasons. On the one hand, there is increased awareness of the urgency to tackle climate and other related risks and environmental changes, such as biodiversity loss. This is accompanied by greater recognition of the devastating effects of disasters. On the other hand, there is an acknowledged need to invest in, and implement effective solutions/improve safety standards to reduce climate and other risks. This requires specific skills and expertise.

The demand for CCA and DRR professionals has increased not only in the public sector but also among non-governmental organizations (NGOs) and in the private sector. In this case the reasons are different. For example, in the case of NGOs, since the results or efforts linked to development projects can be quickly destroyed by a disaster [8], it has become more and more essential to train staff in disaster preparedness and response. In the private sector, it has proven difficult to find private companies with the right expertise to

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qualify as contractors, for instance in the implementation of nature-based disaster risk reduction measures (Linnerooth-Bayer et al., 2023) [9].

In parallel with the increased relevance and demand for DRR and CCA HE, international frameworks and agreements, such as the Sendai Framework for Disaster Risk Reduction and the 2030 Agenda for Sustainable Development, underline the importance of guaranteeing access to relevant knowledge, information, research and data to adequately address regional and national needs, and to “strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries” ([10]; see also section 2). As a result, national governments have been invited to further develop and invest in DRR and CCA HE.

To keep up with the demands from the public, private and NGO sectors, there is an urgent need to develop skill sets and expertise that are “fit for purpose” for reducing disaster risk and advancing resilience to face the consequences of environmental change [4,11, 12]. To ensure the development of such skill sets, HE institutions must have human and economic resources to respond to the changing demands, needs, and expectations in society [13,14]. Adding to this, it is important to highlight the role that education plays in general for social, demographic and economic change.

To address the changing needs mentioned above, we conducted a literature and practices review of DRR and CCA HE. Practices includes master's programs, postgraduate diploma/certificates, stand-alone training courses, on-line course material, and transnational academic networks. We identified almost four hundred practices using a key word search on existing databases and online. After screening the practices, we carried out an in-depth analysis of eight practices using an analytical framework that includes content, pedagogical and structural features, practice orientation and institutional anchoring. By using this framework, we compared the analysed practices, identified key similarities and differences as well as emerging trends. In the conclusions, we pinpoint the highlights of this research, reflect on its limitations and outline ways to improve HE practices.

2. Background

The global DRR community officially considered education as a top priority in the 1994 Yokohama Strategy. Twenty years later, 72% of countries already claimed to have integrated disaster education into their national curricula [15]. In parallel, multilateral dialogs, scientific and policy negotiations have recognized the role of specialized disaster education and the need for its systematic integration into HE curricula [16]. The year 2015 provided a unique opportunity to align key global agreements through the convergence of the three main landmark UN agreements: the Sendai Framework for Disaster Risk Reduction 2015–2030, finalized in March 2015; the Sustainable Development Goals (SDGs), finalized in September 2015; and the Paris Agreement finalized at the 21st UNFCCC Conference of Parties (COP21) in December 2015.

A review of these agreements [17] reveals the important role of capacity development and training in each of the four priorities for action included in the Sendai framework, namely: i) understanding disaster risk; ii) strengthening disaster risk governance to manage disaster risk; iii) investing in DRR for resilience; and iv) enhancing disaster preparedness for effective response.

In addition, the Sendai framework promotes “the development of quality standards, such as certifications and awards for disaster risk management with the participation of the private sector, civil society, professional associations, scientific organizations and the United Nations” ([15]: 18). Already in 2009, the United Nations International Strategy for Disaster Reduction (UNISDR, now the United Nations Office for Disaster Risk Reduction, UNDRR) promoted capacity development as a concept that extends capacity building to encompass all aspects of creating and sustaining the improvement of knowledge, skills, and competences. In this way, capacity development does not only include conventional learning and training, but also the development of institutions, political awareness, financial resources, technology systems and the wider social and cultural enabling environment [18]. Finally, the SDGs similarly cover a broad range of topics linked to education and capacity building such as “improving education, awareness raising and human/institutional capacity on climate change mitigation, adaptation, impact reduction and early warning” (Target 13.3; [19]).

The recognition of the role of HE in building resilient societies in international policies and agreements is not always accompanied by the development of HE for the disaster and risk sector. In the past, it has been difficult to implement HE programs. One of the main reasons is that risk science has been slow to gain acceptance as a legitimate focus of contemporary scholarship [3,20]; sustainability science and other applied, cross-disciplinary fields, have been facing similar challenges [11]. Indeed, the complex and dynamic nature of these fields, as well as the extent of applications have long posed theoretical, disciplinary, and practical challenges to academic and research organizations working in the research (including training of young researchers) and/or education sector (including teaching and learning) [3,11,20] (*ibidem*). These organizations certainly play a critical role in consolidating the theoretical and methodological knowledge that is necessary to develop the disaster risk domain. This process of consolidation can also be characterized by a number of dedicated actions, such as the development and maintenance of specialist data bases (e.g., EM-DAT: the OFDA/CRED International Disaster Database, located at the Université de Louvain, Brussels, Belgium); the creation of natural hazards research centres (e.g., Natural Hazards Centre at the University of Colorado at Boulder, USA; University College London Institute for Risk and Disaster Reduction, UK); the training of a generation of researchers and practitioners that can advance the domain conceptually, methodologically, and empirically; the availability of human and economic resources for research and training.

More than twenty-five years ago, Alexander [20] already criticized the academic community commitment to disaster research. He maintained that disciplinary trainings impose a point of view and are an obstacle to holistic forms of understanding that are needed for disaster risk. This has led to a dominance of technocratic disciplines – such as engineering, geophysics, hydraulics, meteorology – in the field [20]. He went on to explain that this outcome was partly due to the fact that no coherent academic field (namely disaster risk science) had emerged from the multiplicity of disciplines involved in disaster research (*ibid*).

To better understand the reasons for slow progress in the development of this academic field, it is first important to define disaster risk science in the context of HE. We are aware that there are multiple ways to define and classify disaster risk science for HE purposes

(see also [6]). Here we define it as the systematic study of disaster risks, their determinants, and consequences in order to inform disaster risk management, promote sustainable development and strengthen resilience (based on [21]). This definition is based on three key areas of knowledge: natural hazard knowledge (e.g., physical geography, climate science, hazard assessment, earth sciences); human, social, environmental, vulnerability and resilience knowledge (e.g., human geography, social sciences, psychology and environmental management); and knowledge of relevant spatial tools, methods (e.g., geographic information systems) and disaster risk reduction measures (e.g., engineering) [3].

Past research identified several barriers to the development of disaster risk science and associated HE curricula, including: the fragmentation of the DRR education offer in different departments and programs (e.g., multiple disconnected programs in different departments or single programs split between multiple, disconnected departments); partial and often short-term national and international funding for establishing new academic initiatives; limited availability of guidelines for standard requirements; language barriers (most of the disaster-related literature is in English); limited theoretical and methodological coherence across disciplines, as in the case of the concept of vulnerability, which is defined and operationalized in completely different ways in the social and natural sciences [3,4,6,7,22,16,17,23–28,15].

Despite these barriers having been identified, we could find only few studies that pinpoint ways to address them or, more generally, that provide an overview of existing academic programs in disaster risk HE [1,5,29–31]. This gap was an important starting point of our research. We describe the methodology to address it in the following section.

3. Methodology

We conducted a scoping review of literature and HE practices in the DRR and CCA domains by triangulating different data collection methods [32,33,34]. We defined “practice” as a HE initiative focused on DRR and/or CCA, thus including master’s programs, postgraduate diploma and certificates, stand-alone training courses, and transnational academic programs. The goals of the review were to analyse the literature and selected practices, to compare them, and to identify key similarities, differences, and emerging trends.

After the scoping review, we identified practices in three phases. In the first phase, we consulted the UNDRR knowledge database, where we found 375 practices by using the following key words: “master”, “master programme”, “certificate”, and “training course” (data refer to June 2020). In parallel, we searched for other practices available online. This, together with our knowledge of existing practices, allowed us to identify an additional 21 practices.

This total number of screened practices (396) is far from being a global mapping because of the selection bias related to the availability of online information in English. Another limitation of the analysis is that online databases are not always updated. Importantly, practices that are no longer offered may still be included, while information about new or recent practices may not yet be published.

In the second phase, we filtered practices by using the following criteria to conduct an initial selection: practice type (based on a DRR typology developed by [26]); geographical distribution; hazard type (geological vs. hydrological); and online data availability. This screening allowed us to identify 44 practices (data will be made available on request).

In the third phase, we selected 8 practices for in-depth analysis on the basis of three criteria: geographical distribution, hazard distribution, and, especially, data availability. The latter was partly evaluated in relation to the framework we developed for the analysis, which is synthesized in **Table 1** and includes key contents, structural and pedagogical characteristics, uniqueness, and transfer potential.

The practices selected for in-depth analysis are: i) Master’s Programme in Disaster Risk Management and Climate Change Adaptation (Lund University, Sweden); ii) CERG-C Specialization certificate for the assessment and management of geological and climate related risk (University of Geneva, Switzerland); iii) Master of Science (MSc) in Disaster Management and Sustainable Development (University of Northumbria, United Kingdom); iv) Master of Philosophy in Disaster Risk Science and Development (Stellenbosch University, South Africa); v) Master Programmes at the Institute for Risk and Disaster Reduction (University College London, United Kingdom); vi) Master of Art Programme in Climate and Society (Columbia University, United States); vii) Master of Civil Engineering for Risk Mitigation (Polytechnic of Milano, Italy); viii) Erasmus + Master in earthquake engineering and/or engineering seismology (held in Greece, Turkey, Italy and Netherlands).

The data were primarily collected from the websites of the practices. When available, we used grey literature and other publications focused on the selected practices. We collected material about the objectives, contents and syllabi of the main courses and topics addressed in the practices under study, including an overview of DRR course syllabi conducted online by using Open Syllabus, a repository developed by The American Assembly, an independent non-profit organization affiliated with Columbia University. The

Table 1

Analytical framework for the in-depth analysis.

General characteristics	Title, aims, year of inception, country and organizing institution, target group(s)
Content features	Topics and modules/courses, schedule, teaching team, number of credits, hours, other key aspects
Practice orientation	Fieldwork, training, internships
Structural features	Institutional anchoring, partnerships, funding, fees, career prospects
Pedagogical features	Candidate eligibility, number of students, number of graduates, learning outcomes, inter- and transdisciplinary orientation, evaluation
Uniqueness	Highlights and distinguishing characteristics of the course
Transfer	Transfer and adaptation potential to other contexts

data used for the analysis are available on request and include: the list of courses analysed to identify emerging trends, information extracted from the Open Syllabus database, the list of consulted websites and databases, and the in-depth practices analysis.

The methodological approach we adopted has several limitations linked to data access and quality, language, and generalization. First, the database of practices we used was not created for academic purposes, unlike databases traditionally used for systematic literature reviews such as Scopus or Web of Science. Also, we collected information exclusively online, where available data are not homogeneous. Moreover, the sample is biased towards formal educational programs. Some of these may be linked to, or generate non-formal or informal learning opportunities, but identifying these systematically was beyond the scope of our review (see also [35]).

Second, since our internet searches used English language terms, we missed programs taught in other languages. While we are aware of some such programs, e.g., in South America or Russian Federation, an estimate of their number was impossible.

Third, the analysis is based on a small sample, thus any patterns identified cannot be generalised. Our analysis is qualitative and exploratory, designed to identify emerging trends and key issues for future in-depth research. We further elaborate on the limitations of our approach in the Discussion section.

4. Emerging trends

The results of our analysis reveal a number of emerging trends in DRR and CCA HE presented in this section (for an overview see Scolobig & Balsiger, 2020). We distinguish between the literature and practice review results.

4.1. Literature review

In conducting this research (in 2020), we identified five main studies specifically aimed at reviewing academic HE programs in the areas of DRR or CCA. Most are available as grey literature or working papers and were published after the year 2014 e.g. [1,5,29–31]. These studies and their key findings form the basis for the review of practices (see Section 4.2).

More specifically, in 2014, Holloway conducted an “indicative desk review of academic courses in higher education on disaster risk reduction” ([31], 6). She found around 100 master’s-level programs offered in 48 countries. The analysis came to two main conclusions. Firstly, the author found that the focus of the courses taught in the analysed programs had shifted over time from ‘emergency management’ (in the 1990s) to ‘risk’ and ‘resilience’. Secondly, in countries that are repeatedly affected by natural disasters and other threats, she observed an increasing trend towards post-graduate training in disaster management.

Further, Holloway reported that even in resource-constrained but recurrently exposed countries, post-graduate disaster risk-related degrees are increasingly available (e.g., the University of Tribhuvan in Nepal, Bahir Dar University in Ethiopia, or the University of Gadjah Mada in Indonesia) [31]. Such developments underscore a growing, locally owned institutional capacity [36] to sustainably develop strategic human resources for addressing recurrent risks.

A year later, in 2015, a review of 59 DRR Master of Arts (MA) and Master of Science (MSc) programs in Western Europe and Scandinavian countries conducted under the auspices of the European Union’s Erasmus project Knowledge for Resilient Society (K-FORCE) found that most courses had been introduced within the last five years [30]. In addition, 30 and 18 of the Masters examined were either professionally oriented disaster/emergency management or geo-technically oriented, respectively (*ibidem*).

Similarly, an analysis of the capacity of European HE institutions to address threats from natural hazards [5] took into account 58 academic programs across Europe, with an emphasis on engineering courses. The authors claimed that there had been an increase in such programs in Europe since the early 2000s, especially at postgraduate level. Other studies such as [29] provide an overview and in-depth qualitative analysis of three Master’s programs. Their findings show that there is an increasing need for more training, for more skills in organizational management, in legal aspects of disaster risk management, for economic elements related to the costs of prevention, lack of prevention and intervention (*ibidem*).

They also provide some guiding principles for HE in DRR and CCA. For example, HE should be open, i.e., teachers should come from academia and research on the one hand and from governmental agencies, NGOs, or the private sector on the other. Lifelong and distance e-learning should be encouraged. Furthermore, collaborative learning seems to be a crucial aspect in the programs analysed in-depth by the authors. Co-learning between stakeholders from the public and private sectors is considered particularly valuable to guarantee an exchange between theory and practice. More “self-reflexive” professionals can recognise the need for science to “frame” problems and co-produce solutions [37,38–41]. In this regard, significant cross-fertilization can be achieved between programs offered at universities and courses organized within emergency management agencies at different governmental levels.

Overall, these studies reveal some common trends. The models for DRR/CCA HE practices generally have a clear disciplinary focus (core knowledge, e.g. in engineering or physical geography) combined with a broad interdisciplinary perspective. This means for example that a student who pursues a track focused on natural sciences needs to know the basics of social sciences applied to disaster research; the opposite is also true. Cross-cutting teaching and co-learning – at the interface between science and practice – are also two important new features, along with the promotion of lifelong and distance e-learning.

Importantly, only one of the studies we reviewed provides an in-depth comparative analysis [29]. We found the results particularly revealing and for this reason we also conducted an in-depth analysis of eight selected practices, which we present in the next section.

4.2. Practice review

This section is structured around the key features identified in the analytical framework presented in section 3. Thus, it focuses especially on the in-depth analysis of the eight selected practices. However, it also includes selected findings and insights about the other research phases described in section 3 (e.g. practice mapping and screening).

4.2.1. Content features

The UNDRR knowledge database provides an overview of academic programs in the field of disaster risk reduction and climate adaptation. In 2020 (when we conducted this research), the database included 375 academic programmes and practices, including Master's programmes, certificates and diploma, stand-alone training courses and PhD programmes. Most of the programs are organized by public or private institutions in Europe (117), followed by Asia (56), the Americas (52), Africa (27) and Australia/Oceania (16). The remaining programs are organized by international organizations.

The key topics covered in these practices are (UNDRR database information): disaster risk management, risk identification and assessment, environment and ecosystems, health and health facilities/disaster medicine, climate change, governance, recovery, complex emergencies, GIS and mapping, societal impacts and social resilience, urban risk and planning, structural safety, community based DRR, economics of DRR, information management, education and school safety, capacity development, critical infrastructures, water, food security and agriculture, vulnerable populations, advocacy and media, space and aerial technology, humanitarian action and role of civil society/NGOs, early warnings, gender issues, insurance and risk transfer, science and technology, cultural heritage, and small islands developing states. In terms of hazards, most of the practices focus on earthquakes, followed by floods, wildfires, epidemic and pandemic, landslides, cyclone, tsunami, volcano, technical disasters, droughts, tornado, nuclear risks, storm surges and avalanches. Several practices deal with multiple hazards, even if not all of them provide courses on multi hazard-risk assessment.

In our in-depth analysis of the eight selected practices, we identified topics and/or courses (e.g., as Master highlights on the websites) that are considered to be innovative and/or necessary for students and practitioners to address the new challenges in contemporary DRR and CCA. These topics include big data and role of social media for DRR; cascade and conjoint effects and multi-risk/systemic approaches; risk perception, communication, and science-society interface; synergies between CCA and DRR; and links between disasters and development.

Firstly, social media and digital technologies open up new opportunities for DRR by improving agency communication and interaction with the public (e.g., by providing real-time safety checks and recommendations), supporting mutual public support in times of crisis, facilitating the collection of real-time data on public behaviours and promoting crowdsourcing, citizen science and other collaborations. At the same time, they also pose some challenges such as making available an enormous amount of data and information that are difficult to process unless artificial intelligence (AI)-assisted tools are used. Other challenges include an increase in inconsistent information, misinformation, disinformation and various ethical dilemmas including potential breaches of privacy. The results of our analysis show that master's programs increasingly provide students with knowledge on these topics, including big data knowledge management, semantic modelling, international disaster surveillance IT systems, AI-assisted early warning and response to disease outbreaks and emergencies, social media analysis, and behavioral analysis using big data (e.g., Columbia University, University College London, Stellenbosch University). These courses usually present the key technological systems underpinning, e.g., weather/climate data collection, early warning, and response, and provide an overview of the challenges and opportunities created by new technologies. Importantly, these new courses respond to an increasing need for new roles and responsibilities at the interface of science and digital technology, e.g., data managers that need competences in both computer and climate/disaster risk science (see also [42]).

Secondly, natural, and anthropogenic hazards and associated risks are often treated separately. This means that they apply single or multiple single-hazard and single-risk methods, neglecting the temporal and spatial interdependencies that frequently arise between them. These interdependencies are crucial to better understanding cascading disasters, compound, and interconnected risks such as the case of Fukushima, Japan, where an earthquake triggered a tsunami and multiple landslides which in turn caused a nuclear power plant core meltdown. New theoretical and methodological frameworks have been developed to better understand interactions amongst hazards. Several practices increasingly address the issues of multi-risk assessment or systemic risk, etc. (e.g., University College London). In the systemic risk domain, increasing attention is also being paid to the health-related consequences of disasters and climate change.

Thirdly, several practices address the science-society interface in disaster risk management and governance to train students to be effective communicators, understand stakeholder concerns and needs, and investigate risk perception. These courses provide students with skills and tools to analyse, for example, how communities live with risk, why people do not adequately prepare for a disaster, and to develop communication strategies for increasing preparedness levels. More specifically, these courses introduce students to i) cognitive, social, anthropological, and integrated risk perception models/frameworks; and ii) risk communication theories and practices. In an increasingly interconnected and digitalized world, knowledge about basic communication mechanisms and the acquisition of elementary communication skills (e.g., Lund University, University College London, Columbia University) is increasingly considered necessary.

Fourthly, as concerns the synergies between CCA and DRR, we found that while CCA and DRR are understood to be linked in some way, they are rarely taught as a complementary set of actions requiring better coordination amongst all concerned stakeholders. The reasons behind this gap can be attributed to multiple factors such as institutional barriers, diverging political priorities, limited coordination and communication across different sectors, and unequal funding sources [43]. There is an increasing awareness that reducing these divergences and streamlining synergies can assist in delivering better DRR and CCA solutions. As a result, several of the international practices we examined increasingly deal with this topic (e.g., Lund University).

Finally, DRR is an interdisciplinary subject with links to other sectors such as sustainability, development, and human security. The interconnections between DRR and these other sectors are included as courses or key topics in most of the practices under study.

4.2.2. Practice orientation

Conducting fieldwork on disaster-related issues and promoting engagement between students and practitioners is a core feature of several practices we analysed. Indeed fieldwork makes DRR more applicable and authentic. Moreover, long-term internships and the opportunity to collaborate with public and private organizations working in the field of DRR are often offered to students.

However, balancing theory and practice is a delicate task in the development of DRR HE practices. One of the key features included in the analytical framework (see section 3) is the role of fieldwork, internships, and other forms of training in the eight selected practices.

The analysis reveals that there is a clear divide between practices with a strong focus on fieldwork (e.g. University College London) and programs that favor internships (e.g. Lund University/Northumbria). The time dedicated to internships and fieldwork can vary greatly (from 184 h to several months) especially considering that fieldwork can be the backbone of the Master's thesis or final dissertation.

The analysis also shows some tensions between academic qualifications and the practical skills that are essential for DRR. Finding the most effective way to provide appropriate professional and practical training support is a difficult task, particularly for some areas of DRR, such as strategic planning or policy making (see also [44]). The less formal area of "on-the-job" training and knowledge sharing based on practitioner experience is relatively under-addressed. Finally, some of the practices (e.g., Columbia University, Lund University, Northumbria University) also focus on the social and political aspects of DRR -e.g. training on questionnaire surveys, practices for stakeholder engagement -, but the mainstream and well-supported tradition deals with the natural aspects of geo-physical and hydrological phenomena.

4.2.3. Pedagogical features

The following main themes emerged from the analysis of pedagogical features: new skills sets; research-led teaching and strong engagement of practitioners; and multi-, inter-, and *trans*-disciplinary approaches in teaching and research. We provide a detailed description of each theme below.

Firstly, the confluence of a world characterized by increasing risk complexity with rapidly changing work demands has direct implications for the skills needed to strengthen resilience and risk reduction [45]. This is evident in many practices, where two types of new or emerging skills sets are recurrent: i) big data analysis, machine learning and ITC competences for disaster risk management purposes; and ii) strengthened capabilities in critical and creative thinking. For example, problem-solving oriented group work is included in several course syllabi and/or the course evaluation is conducted via individual assignments designed to foster critical thinking and self-directed learning (e.g., University of Geneva, Lund University).

Secondly, research-led teaching is emphasized as a strong point in many of the practices we looked at (e.g., University College London, Columbia University). The connection between the practices and existing research centres at the respective universities is also a signal that teaching, and research are often considered as necessary and integrated parts of academic life, acknowledging that teaching without research becomes outdated and that research without teaching can neglect the application of theoretical advances. Another emerging trend is the engagement of practitioners, especially — but not exclusively — in the humanitarian sector and public administration, as instructors or educators (e.g., University of Northumbria, Lund University).

Thirdly, multi-, inter- and transdisciplinarity is emerging as a new requirement, integrating concepts, theories and methods from different scientific disciplines (in this case geography, environmental sciences, geology, economics, sociology, civil engineering, urban and regional planning, forestry, hydrology, atmospheric sciences, etc.) to generate new knowledge about a certain topic such as the design of early warning systems or risk mitigation plans. The ambition behind many of these is to teach skills that cross boundaries not only between disciplines, but also between theory and practice. This suggests a transition towards transdisciplinary approaches that mirrors education developments in other sectors such as sustainability or mountain studies [35,46]. Indeed, several programs increasingly adopt transdisciplinary approaches, with strong involvement of practitioners as teachers or as supporters of internships. At the same time, the analysis also revealed a tension between interdisciplinary teaching and the rhetoric of integrated, skilled capacity building to solve 'real world problems,' and the reality of a continued bias in favor of siloed, disciplinary learning (see also [4]).

Finally, it has been challenging to find formal evaluations of how these approaches have been applied and whether they contributed to enhancing students' skills. Lessons from other sectors, such as sustainable development, can offer inspiration for formal evaluations in DRR HE ([47], in press, [48]).

4.2.4. Structural features

The fourth element of our analytical framework for analyzing DRR HE practices refers to structural features, which we define as the combination of institutional anchoring, partnerships, funding, fees, and career prospects for students (see Section 3).

Faculty networks, the cooperation and coordination between different departments or institutes are critical for the success of a Master's program and DRR/CCA practices [49]. Yet, the characteristics and mission of the research institutes and faculty networks that enabled the analysed practices spin-off can be quite different. For example, the International Research Institute for Climate and Society — which is a key resource for the MA "Climate and Society" at Columbia University — was established in 1996 as a cooperative agreement between a public authority (namely the U.S. National Oceanic and Atmospheric Administration Office of Global Programs) and Columbia University. In the case of the MPhil in Disaster Risk Science and Development at the University of Stellenbosch, the Disaster Mitigation for Sustainable Livelihoods Programme, which is a research/advocacy unit, played a critical role when the Master's was established (1996) and between 1998 and 2008. In its own turn, it is acknowledged that South Africa's experience of dis-

aster management policy and law reform processes provided an important contextual driver to the Programme [3]. Also, in the case of this Master's Programme, a differentiated educational offer (master's courses, short courses, training, etc.) is considered as a factor.

It is important to mention that there is a difference between intra- and inter-institutional networks, such as in the case of cross-country transnational initiatives. Examples include: AUEDM, i.e. an Asian network of universities undertaking education and research in the field of environment and disaster management; PERIPERI U, i.e. an African transboundary initiative involving 12 universities and 185 staff, speaking eight different languages; ANDROID, i.e. a partnership representing a collaboration of 64 Higher Education Institutions (HEIs) from 28 European and 3 non-European countries, that aims to generate a clearer understanding of the factors that enable physical, socio-cultural, politic-economic, and natural systems to adapt and sustain.

Our analysis reveals that there are three main governance models for programs shared between countries.

The first model is what we define as a “weak network model.” It consists in the establishment of loose networks between universities working in a specific area in order to facilitate disaster education at tertiary level through the development of regionally suitable and flexible curriculum structures across countries. AUDEM is an example of this type.

Second, the “cross-country/polycentric model” consists in conducting the first half of a semester (Autumn Semester, September–January) in one country, for all students. In the following half, students can choose between two tracks, each one in a different country. In Semester 2 (Spring Semester, February–June) students continue their respective advanced modules according to the chosen study track focus plus a hands-on, practical internship at any of the universities or associated centres included in the program. This model has been adopted for example by an Erasmus Mundus Master Programme in Public Health and Disasters which involves three countries.

The third type is the “one country centered/monocentric model,” where students from all countries conduct the semesters in one institution but must follow at least one course or do dissertation research in two other partner institutions. This model has been adopted by Erasmus + Master Programme in earthquake engineering, which includes universities in four countries.

5. Discussion

Our literature review shows that little research has been conducted so far to analyse, compare, and contrast HE practices in the DRR and CCA sectors. One of the reasons is linked to the difficulties of building a coherent academic field from the variety of disciplines that contribute to the study of disaster and climate risk, including e.g., geography, engineering, geophysics, hydraulics, atmospheric sciences, geology, social sciences, and anthropology. The HE enterprise has only recently embraced all these disciplines as a credible scholarship domain, in parallel with an increasing demand for DRR and CCA professionals. Another reason is that DRR and CCA research focus usually is on hazards, risks, or on how people or risk management authorities live with and reduce risks. Less attention has been dedicated so far to the community of educators, including teachers, lecturers, professors, etc. as research subjects.

For these and many other reasons (see Sections 2 and 4.1), it is not surprising that – to our knowledge – the first systematic review of disaster/climate risk HE practices only appeared in 2009 [3]. Since then, a few additional studies have been published (see section 4.1 for a review) that show a rising trend of post-graduate disaster risk related education, especially in countries exposed to recurrent natural or other threats.

The practice review conducted for this study identified close to 400 practices. The results show that existing models for DRR/CCA HE practices tend to have a clear disciplinary track (core knowledge in, e.g., physical geography) coupled with a broad interdisciplinary perspective. Research-led teaching, engagement of practitioners, and multi-, inter- and transdisciplinary approaches in teaching and research emerge as core pedagogical features of the practices we examined.

Three emerging trends in DRR/CCA HE stand out. First, we identified topics that are considered to be innovative for students and/or practitioners to address the new challenges in contemporary DRR and CCA. These include the use of big data for DRR/CCA, social aspects of DRR/CCA, multi-risk approaches, synergies between CCA and DRR, and links between disasters, sustainability, and development.

Second, a divide emerges between practices/programs with a strong fieldwork orientation and programs that privilege internships, even if the two are not always mutually exclusive. Time for internships and fieldwork can vary considerably but usually involves several months.

Third, faculty networks, department/institute coordination, and cooperation are critical for the success of a Master's program and DRR educational practices. Academic institutions with disaster-focused research centres usually provide a wide array of learning and training options for students, and beyond. Evidence from several countries proves that these centres are often key drivers of national policies and law reform processes, thus extending their influence far beyond teaching and research.

These findings are partially tempered by the methodological features of our study. Most notably, it builds primarily on qualitative evidence, collected through extensive desktop research (see Section 3 for an overview of the methodology and limitations). Quantitative evidence, including, for example, indicators for analysing and monitoring changes in practices over time, would strengthen the robustness of the framework and the findings. For this evidence to be created it is also essential to improve existing databases and to update them regularly. Clearly, this effort requires the availability of human, economic and institutional resources.

6. Conclusion

There is a growing recognition that disaster risk related HE is critical to promoting a culture of prevention and is directly applicable to a wide range of disciplines and sectors, including environmental management, engineering, public health, urban planning, public administration, and governance. In particular, HEIs play a crucial role in advancing DRR knowledge and practice, in creating a well-educated, prepared and risk-aware population and in supporting disaster risk research and policy at all levels. In this paper, we

present the results of a scoping review of the literature and of HE practices in the DRR and CCA sectors, including master's programs, postgraduate diploma/certificates, stand-alone training courses, on-line course material, and transnational academic networks. The results show that existing DRR/CCA HE practices tend to have a clear disciplinary focus (core knowledge in e.g., engineering, or physical geography) combined with a broad interdisciplinary perspective. Cross-cutting teaching and co-learning – at the interface between science and practice – are also key features. Critical and creative thinking-led teaching, engagement of practitioners in teaching, multi-/inter- and *trans*-disciplinary approaches are presented as pedagogical innovations in the practices examined. Topics such as the use of big data for DRR, social aspects of DRR, and multi-risk approaches are increasingly important. We could not find formal evaluations of pedagogical innovation, that focus on, for example, how inter- and transdisciplinary approaches contribute to improving students' skills and capabilities in the DRR/CCA sector. Future research should focus on this aspect, and more generally, on the development of monitoring and evaluation tools that can provide an overview of DRR and CCA HE practices for those involved in or wishing to develop new initiatives.

CRediT authorship contribution statement

Anna Scolobig: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Jörg Balsiger:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

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Data availability

Data will be made available on request.

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