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## Envisioning the future by learning from the past: Arts and humanities in interdisciplinary tools for promoting a culture of risk

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### ABSTRACT

Disaster risk is the result of complex interactions between the drivers of vulnerability such as poverty and lack of access to resources and the impacts from multiple hazards (with differing intensities and recurrence intervals). These risks are difficult to understand, quantify or convey. Historical hazard events have important potential in generating understanding of multiple potential risks. They provide historical and near-historical records of the real-life experience of relevant hazardous events and their physical, political and social consequences in physically familiar terrain. In this paper, we explore the use of historical research, memory, and emotion in developing conversations around the complexities of multi-hazard risk in urban settings through co-produced interdisciplinary museum exhibits and an educational transmedia platform in Quito, Ecuador. We argue that the opportunity for impact in Disaster Risk Reduction (DRR) arrives by targeting DRR education from an interdisciplinary perspective, with a narrative that draws on history and memory, and that uses art to address emotions and to communicate and visualise two sometimes overlooked but essential dimensions in DRR education: 1) understanding the risk drivers that turn hazardous events into disasters, and 2) building the capacity of communities to imagine future scenarios that reduce risk and create open and participatory processes of risk-sensitive urban planning as proposed by the Tomorrow's Cities Decision Support Environment (TCDSSE).

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## 1. Introduction

Disasters occur when society or individuals are seriously disrupted by the impacts of hazardous events, either in the moment or in the aftermath. The risk of this happening is a complex function of the nature of the event itself, the degree of exposure to that event, and, most crucially, the vulnerabilities the communities or individuals at risk and their assets have [1,2]. In turn, disasters act as a considerable brake on the progress of sustainable development [3]. Thus, despite their association with hazardous events, at their root disasters are constructed from the social, cultural and political processes that ultimately result in vulnerability and exposure to risk (e.g. Refs. [4,5]). In the context of cities or urban conurbations, vulnerabilities are propagated by uneven approaches to urban planning, development, and social and economic constraints (e.g. Ref. [6]). To reduce disaster risk, disaster risk management (DRM) incorporates a systematic approach to the identification, assessment, and reduction of risk [2]. Incorporating disaster risk management into urban planning and development should then significantly reduce disaster risk in future cities. This is the mission of the UKRI GCRF Tomorrow's Cities Hub, an interdisciplinary impact-oriented research hub deployed in several cities exposed to multiple hazards in low- and middle-income countries around the world [60]. The work presented here is part of this hub, and addresses the question of how interdisciplinary science, arts and humanities methodologies can be introduced in DRR education to transform the culture of risk, shifting towards a logic of prevention by foregrounding the multi-dimensional root causes of disasters. Can these tools help engage different stakeholders and audiences on understanding inclusive and science-based urban planning as an important opportunity for reducing disaster risk in the future?

A comprehensive assessment of disaster risk is extremely difficult [7], let alone the subsequent identification of tangible measures to reduce risk in the context of urban planning and improving decision-making. The complex interactions between the drivers of vulnerability, such as poverty and the lack of access to resources, combine with the outcomes from multiple hazards with differing impact potentials and recurrence intervals [4]. These are difficult to understand, quantify or convey [8,9]. Nonetheless, a considerable body of research points to the capacity of individuals and communities to accommodate and adapt to risks when they present themselves within the likely eventualities of a lifetime [10,11]. This new literature also shows the efficacy in prevention when mitigation against likely risks is embedded into legislative frameworks [12] or cultural understanding of risks is accounted for [13]. An important dimension here, however, is cultivating preparedness and awareness of the risks associated with intensive hazard events, and the often-non-linear interactions between multiple or cascading events. These events (such as large magnitude earthquakes or the direct passage of high magnitude hurricanes) often have a recurrence interval that is much greater than a political cycle and even human lifetimes, so preparedness or even awareness is predicated on understanding processes or outcomes that may not have been witnessed directly.

Here, historical hazard events have important potential in generating understanding of multiple potential risks, their intersection with one another, and the real-life experience of surviving them. Historical and near-historical records provide real insights into the consequences of relevant hazardous events in physically familiar terrain. While capacities to understand and cope with hazardous events may have changed such that historical events may not be reconstructed as a direct analogue for future risk [63], the cultural connections with past events and their impacts on previous generations can have a powerful role in community resilience by memorialisation through rites, traditions, and social learning processes [14]. Furthermore, the exploration and recreation of concretised events, interactions and examples can also help multiple stakeholders imagine the interactions between different elements of risk in the future.

In this paper, we explore the use of historical research, memory, and emotion in developing conversations around the complexities of multi-hazard risk in urban settings. There are many examples of the use of historical records or compilations of past hazardous events being used to inform future planning. These have been used in various ways, from extracting damage data to performing informed analyses of hazard impacts (e.g. Ref. [15]) to widening social memory of high impact, low frequency events (e.g. Ref. [16]). More recently, the interrogation of historical or near-historical records from a variety of disciplinary perspectives has informed forensic analyses of the key drivers of risk [30]; [61], [17]. We focus here on the value of arts-based and historical approaches to understanding the complexities of disaster risk in urban settings, and to promote the participation of different stakeholders in inclusive evidence-based planning.

In disaster risk contexts, learning and education are proposed as the cornerstone of preparedness strategies, from the Hyogo Framework<sup>1</sup> (2005) down to the Sendai Framework<sup>2</sup> (2015), implemented by the UNESCO through the Global Action Plan (GAP) for Education in Sustainable Development (ESD) [19,20]. In a review of 30 countries, two of the less targeted essential dimensions in DRR education were the understanding of risk drivers and how hazards can become disasters (dimension 3), and building community risk reduction capacity (dimension 4) [21]. In this paper, we contextualise learning as the starting point from which mutual understandings of risk are achieved, and measures to prevent future risk are identified by discussing risk drivers and the importance of community vulnerabilities and capacities in urban planning and development – an essential contribution to Tomorrow's Cities Decision Support Environment (TCDSE) (Fig. 1.). The vehicles we used for this learning process were a series of interdisciplinary museum exhibits and a multimedia digital education platform for use in schools.

Furthermore, there is evidence that the most important factor in effective risk-sensitive urban planning is a strong institutional

<sup>1</sup> Education is key in 3 of its 5 principles: (3) use knowledge, innovation and education to build a culture of safety and resilience at all levels; (4) reduce the underlying risk factors by reducing vulnerability; and (5) strengthen disaster preparedness for effective response at all levels. See Ref. [18].

<sup>2</sup> Education is especially important in priority 1: understanding risk. The Sendai Framework identifies children and youth as relevant stakeholders, as "agents of change, and should be given the space and modalities to contribute to disaster risk reduction, in accordance with legislation, national practice and educational curricula".

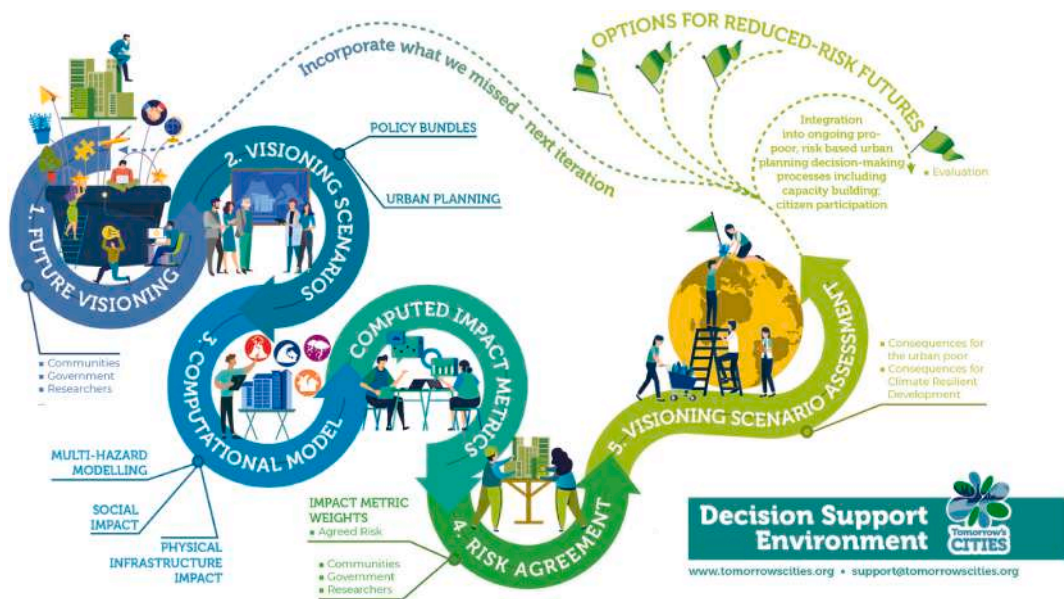


Fig. 1. Graph of Tomorrow's Cities Decision Support Environment designed to better communicate its different modules in simple language and images. (Credits: Karina Barragan, Elisa Sevilla, Daniel Andrade, John McCloskey, Mark Pelling).

setting. However, most low- and middle-income countries rank low in the strength of their institutions. It has been suggested that “public participation in risk reduction – possibly involving NGOs in partnerships with local government for improved planning, risk awareness and public accountability – is a solution that has a much higher potential for reducing risk” ([59], p. 2). Recently, it has been shown that co-governance -i.e. the articulation of state and non-state actors-is a key feature for optimal post-disaster policies in Latin America [22]. We argue that the arts and humanities cannot only convey the interdisciplinary complexities of DRR to wide audiences, but that the data and interactions resulting from this process create new knowledge and understanding that adds to our knowledge of risk drivers, too. This accessible and less politically-charged spotlight on past disasters can act as a catalyst for public participation in effective risk-sensitive urban planning, thus avoiding “planning for exclusion” by not accounting for inequality in the process and driving the most socio-economic vulnerable groups to build informal settlements in hazardous areas [28].

One of the TCDSE's most innovative aspects is that the whole process of risk-informed planning is facilitated by the participation of diverse stakeholders all along the process, especially in the future visioning and risk assessment modules, which include a “particular consideration for the priorities of marginalised urban populations who bear the brunt of disaster impacts” ([60], p. 4), [7,23,24]. In this paper, we also argue that the humanities, especially history, can help in framing the desired future city as part of a change in the trajectory of urban development and risk building, and at the same time can provide temporal distancing for taking action towards planning as a tool for reducing future disasters. We propose the use of history and arts in the “decision fora modules”, including “future visioning” and “risk scenario assessment” modules of the TCDSE (Fig. 1.). We will demonstrate how these methods create a space for reflection and emotional engagement to promote working with others towards a common goal – in this case, risk-sensitive and inclusive planning through the TCDSE. Psychological distancing -i.e., being able to think in the distant past or future (temporal distancing), or to think in a faraway place or as someone else-has been shown to be part of the human abstract thought process that “seems to enable people to see the “big picture better” [25]. This technique can help pursue more valued long-term goals; and plays a role in reducing self-control failures, i.e., when choosing immediate temptations over what rationally is regarded as the best decision for the future [26,27]. Thus, the use of historical methods can facilitate these psychological tools for future visioning in risk-sensitive urban planning.

An important feature of this work is the acknowledgement of the use of emotion and memory. The memorialisation or remembering of disasters is inherently political, and the choices about what to represent and how to represent it are designed to shift perception, whether explicitly or implicitly [57], and are politically contested, especially between dominant and dominated groups [28]. For example, even the long-term objection to the use of the term ‘natural disaster’ acknowledges the power of representation: by adding ‘natural’ we, too, willingly play into mental models of unstoppable and unknowable natural forces at work, which do not encourage or suggest preventive action is possible [29,30]. Nevertheless, there are several reasons why we have explicitly acknowledged and included the use of emotion in remembering and conveying these events. Firstly, the human dimension of disasters, and the trauma and emotions they trigger, are an essential feature of those events and processes. More commonly in disaster education, the physical-technical process of a hazard is divorced from the social and human aspects of a disaster [31,32]; and as we argue above, understanding the complexities of risk demands that these aspects be not treated in isolation. Secondly, people's emotions in DRR can play an important role in people's willingness to act, accept DRR policies or to seek protective measures in the event of a disaster [33]. Finally, by using history to uncover the differential impacts of disaster, and adding emotion to it, we do not only focus on the damage and costs, but also feature the positive human acts, resilience, adaptations, and the value of real-life experience as social learning. An

important aim of this work was to empower those who learn from the exhibits and a transmedia digital education platform to contribute to future sustainable urban planning and development following a critical pedagogy framework [34].

The transmedia storytelling approach to DRR education that articulates a series of interdisciplinary museum exhibits and multi-media digital platforms is an example of how the conversation between public history, science and the arts offers powerful tools for conveying the complexity of risk while empowering citizens and decision makers to enhance risk prevention through better urban planning. We show that through this type of approach, it has been possible to reach diverse audiences (such as students, teachers, activists, and decision-makers) in meaningful ways. Through different complementary activities (exhibit visits, visitor surveys, training workshops and public lectures), we were able to foster public discussion with diverse actors and empower them to action [35].

Historical memory and art-based imagination tools (digital platform, exhibits, and art installations) can play an important role in visualising the complexity of how risk is built for educational and communication purposes. DRR in schools has focused primarily on school safety, but less on understanding the complex causes of disasters besides hazards. Both formal and informal education normally target the idea of preparedness in case of a specific hazardous event: for example, an earthquake or volcanic eruption [32]; [21]. We argue that the opportunity for impact arrives by targeting DRR education from an interdisciplinary perspective, with a narrative that draws from history and memory and that uses art (visual, musical, literary) to communicate and visualise the past to identify root causes of risk and to imagine future scenarios and actions to reduce disasters in the city to be built. Fiction, including dreams and art, are necessary to present the human mind with scenarios that are not present in experience, and thus train our brains to make decisions in situations that are not frequently encountered in everyday life, including intensive hazardous events [36].

Art has the potential to represent situations of risk creation, scientific or community-based understandings of risk, and the social and political constraints in risk-sensitive urban development if it is based on historical testimonies and scientific data of past or foreseeable events (i.e. science fiction time-travel narratives or artistic interventions to science outputs). Also, the STEAM proposal to include the arts and humanities in teaching science, technology, engineering and mathematics is intended to foster interdisciplinary thinking, creativity in problem-solving capacities, and better communication skills [37]. This further links prevention DRR education to ESD by aiming to empower “people with values, skills and knowledge, which will help them become active agents of change in their own lives and in their wider society (...), to collectively transform their realities to envision and create more resilient and sustainable futures” [38].

Just like art, we argue that history can be a powerful tool in scenario building, since many experiences in the past can be related to those of the present, but also because both methodologies look at causation as a process [39,40]. This analytical lens reveals much about the creation of risk and highlights future improvements [41, 55]. Through the exploration of historical memory and art-based tools built on past experiences and interdisciplinary perspectives, we imagine future scenarios with the aim of informing citizens of the consequence of today’s decisions in reducing or building risk for tomorrow’s cities.

Thus, we will first describe the methodology and framing for our educational-based interdisciplinary research. Secondly, we will analyse how these education and engagement tools were: 1) designed to convey the complexity of disaster risk and their root causes uncovered through interdisciplinary research; 2) communicated and mediated through the use of public history and different artistic interventions in an attempt to trigger emotions towards empathy and interest in participatory risk-sensitive urban planning; and 3) produced through collaborative processes and engaged with different stakeholders.

## 2. Methodology and ethical considerations

In this section, we will present the co-production and interdisciplinary methodology to develop the tools, as well as the justification for using arts and humanities for communicating disaster risk. We also present the methods for designing surveys to measure impact as well as guided visits with participant observation.

The GCRF Tomorrow’s Cities Hub in Quito has partnered with the Museums of Quito Foundation (Fundación Museos de la Ciudad - FMC) for this work. This Foundation is a pioneer in adapting its activities to different vulnerable communities that are usually the most affected in the event of a disaster. They work with social, neighbourhood and community organisations, women’s groups, the elderly, schools, the educational community, people with disabilities, and members of the GLBTQI + community. This expertise allowed us to address topics of social importance such as the history of multi-hazard disaster risk in Quito, the critical concepts of the social construction of disaster risk, and the responsibility to build and plan a safe and sustainable city in the future by making evidence-based decisions.

With that aim, we set up a collaborative and interdisciplinary process with these three museums in the city of Quito where memory and art-based tools (art installations, transmedia narratives, immersive narratives) were built on past experiences and scientific explanations of hazards to imagine future scenarios. We worked with different stakeholders (researchers, artists, and museum staff) to co-create the multimedia narratives in the museum exhibits and on the digital platform.

We prepared interventions at the permanent exhibits of three museums: 1) Museo del Carmen Alto (MCA) (<https://fundacionmuseosquito.gob.ec/museo-del-carmen-alto/>), dedicated to religious art and culture; 2) Museum of the City (MDC) (<https://fundacionmuseosquito.gob.ec/museo-de-la-ciudad/>), focused on the history of the city of Quito, and 3) the Interactive Science Museum (MIC) (<https://fundacionmuseosquito.gob.ec/museo-interactivo-de-ciencia/>), focused on explaining science topics to young audiences. In parallel, researchers from the Tomorrow’s Cities Hub collaborated with the Sindicato Audiovisual collective and two Public Schools to produce a digital platform for education purposes called *Reducir Riesgos en Quito* (“Reducing Disaster risk in Quito” in English). It addresses multi-hazard risk from an interdisciplinary and cultural perspective, including volcanic, seismic and rain-triggered risk. The platform contains 16 thematic stories, 1 interactive historical map, 1 interactive timeline, 6 podcasts, 2 songs, 3 pedagogical guides, 1 historical images archive, and 3 stories about the character “Andesita” who guides you through the navigation

experience. It can be accessed freely on the URL [reducirriesgosenquito.com](http://reducirriesgosenquito.com).

This article is based on the reflections of the authors (Tomorrow's Cities researchers, Sindicato Audiovisual, and FMC) on the process of creating the three interrelated museum exhibits and the online platform. Additionally, to understand whether our outputs enabled a greater understanding of DRR in the general population of Quito, we collected evaluation data documenting this interdisciplinary and collective process both in the museums and through the online platform contributing to secondary school education following the Monitoring, Evaluation and Learning methodology to apply critical thinking in designing, implementing and evaluating research projects that seek social impact and change [42].

Visitor surveys were conducted in all three museums where the exhibition took place (104 respondents in the City Museum, 32 in the MIC, and 93 in the Carmen Alto Museum). A Learning workshop was conducted among the museum visitor engagement staff to

**Table 1**  
Index of stakeholders and their role and involvement in both projects.

Groups	Institutions	Contributions/expertise
Tomorrow's Cities Hub Quito	Universidad San Francisco de Quito	- Research in history for contents and approach. - Curation and direction. - Production or supervision of artistic works and displays. - Co-organising side events and special visits
	FLACSO	- Co-writing of papers. - Research in social sciences. - Public relations with the Municipality.
	Instituto Geofísico - EPN (Geophysical Institute)	- Earth science research. - Risk management and civil engineering research. - Drone images and maps. - Co-writing of papers.
	University of East Anglia	- Evaluation design, interdisciplinarity, citizen science, art-based PAR and ethics. - Co-writing of papers.
	University of Leeds - COMET	- Earth observation images and analysis of historical urban expansion. - Co-curation of exhibitions.
Fundación Museos de la Ciudad (Foundation of City Museums)	Museo del Carmen Alto - MCA (Carmen Alto Museum)	- Promotion and communication on digital media.
	Museo de la Ciudad - MDC (Museum of the City)	- Co-organising side events and special visits
	Museo Interactivo de Ciencia - MIC (Interactive Science Museum)	- Work of museology teams to develop the exhibitions. - Co-writing of papers.
Quito Municipality	Secretaría de Educación (Education Secretary)	- Promotion of the use of DRR education tools in public schools. - Participation in the inaugurations of the exhibits.
	Secretaría de Seguridad y Gobernabilidad - Central de Gestión de Riesgos (Secretary of Security and Governance - Central Risk Management)	- Revision of digital platform contents
	Secretaría de Territorio, Hábitat y Vivienda (Secretary of Territory, Habitat and Housing)	- Collaboration on training of museum staff - Lending of the "shaking house" for the exhibit in the MIC.
Public schools	Juan Montalvo School	- Participation of teachers and students in the co-production of the digital platform. - Visit to the museums to link both communication tools. - Participation in training for the use of the platform - Participation in the public launch of the platform.
	Quito School	- Validating the digital platform. - Visit to the museums to link both communication tools.
Organised neighbourhoods	Two organised neighbourhoods in high-risk exposure areas.	- Visits to the museums and workshops. - Participation in public talks.
Sindicato Audiovisual		- Visual anthropology and pedagogical design for the digital platform and workshops with schools. - Character and storyline design. - Planning, design and implementation of the digital platform. - Work with the local educational community (2 public schools) for the planning of the web platform. - Generation of complementary transmedia content for the platform (Artwork, podcasts, social media posts, YouTube videos, timeline, interactive time-map, pedagogical exercise proposal). - Workshops for teachers on the use of the web platform as a pedagogical tool for the classroom. - Co-writing of papers.

gather their perceptions of how the exhibits impacted them as well as the visitors, and offer a space for feedback. This data will be analysed in depth in another publication. We also performed three guided visits with people from at-risk neighbourhoods where we were conducting participatory action research. With them, we used participant observation methods to see how the exhibit enticed reflection towards action [43,44].

The methodology that was adapted to the exhibitions is fully in line with contemporary discussions of the new museology, a trend that has been developing since the 1960s and that has had significant influence in and from Latin America, especially through the implementation of a larger concept of heritage by including social inclusion, co-production and interdisciplinarity in an engaged museum [45–47].

The methodology used to develop the digital platform was inspired by co-production mechanisms that involved a series of 10 workshops with the students from the pilot school and representatives from the museums, the Sindicato Audiovisual, and Tomorrow's Cities interdisciplinary research team. The workshops were held from August 2020 to March 2021 and included several creative activities. We documented this process through two surveys at the end of the initial workshops on DRR carried out with the two groups of students, as well as two surveys given to both students and teachers in March 2021 and June 2021 during the design and development of the platform. These qualitative surveys primarily consisted of open-ended questions to gather students' opinions in a structured way while allowing them to express their thoughts with their own words.

In fact, the universality of art and digital educational tools makes it possible to use them to demonstrate the issues and problems in other international contexts. This is one of the major approaches of public history, as indicated by Serge Noiret and Thomas Cauvin: "despite the national composition of public history programs, new bridges are now possible between countries and even more between languages and practices at an international level" ([48]; p. 35). In this way, our aim was to explore a "self-explanatory local case study developed within a single community interacting with its own past" ([48]; p. 26) with the collaboration of artists, graphic designers, educators, physical and social scientists, visual anthropologists, teachers and students from two pilot schools. We also worked with stakeholders in the municipality, especially the Metropolitan Risk Management Office (see Table 1 for a description of how each institution participated).

We decided to work with the concept of what is hidden to our eyes to discuss those forces in the subsoil that drive hazards, together with the root causes of development in an unequal society born from colonial relationships. We also used the arts and humanities, as well as surveys and games, to target the emotions of the visitors and to reflect on the consequences of our decisions in the construction or reduction of future risk.

Since we were addressing distressful subjects, we decided to work with older students (16–17 years old) in the workshops. We conducted informed consent procedures with students and their parents. The guided visits to the museums with at-risk neighbourhoods were part of research that included the same informed consent procedures. Also, as addressed in more detail below, our approach involving the use of humour, history and arts was also mindful of generating psychological distancing to ensure that we were not talking about personal experiences as much as putting them in a broader historical and geographical context. Collective memory can be a source of knowledge to generate actions for disaster risk reduction.

### 3. Digital platform

The democratisation of the Internet and the crisis of traditional media such as newspapers were factors that helped new digital tools emerge since the early 2000s. As historian Alexandre ([49]; § 3) points out, these new digital tools combine different media such as text, images, video, sound and even animation to make content accessible and interactive for a variety of audiences. *Reducir Riesgos en Quito* is a transmedia storytelling platform, since "it is the worldbuilding experience, unfolding content and generating the possibilities for the story to evolve with new and pertinent content," in order to engage the audience in interactive and meaningful ways ([50]; p. 82; [51]). Transmedia storytelling is a relevant tool in education since it targets different learning experiences and styles, and can be designed as an engaging game [52]. The multimedia platform *Reducir Riesgos en Quito*, its podcasts and videos, interactive content, social media channels, and museum exhibits tell a story within a larger, interconnected narrative by using different formats.



Fig. 2. Andesita's Instagram account content – serious physics with humour to lend a hand to reducing disaster risk in Quito. @la\_andesita

Starting in May 2020, the web platform was conceptualised and staged through complex interdisciplinary work. The methodology for producing the web platform was based on the idea of “situated knowledge” proposed by Donna Haraway [53]; in which we recognised that no knowledge is detached from its context or from the subject’s experience and framing. Thus, a process of continuous dialogue was installed between the three main knowledge production groups of the project: the scientists, the creative team, and the intended audience – students and teachers. The collective work of translation between the languages and materials of the three groups was intertwined through humour, surprise and affection for the construction of meaningful content. Curiosity, historical interests, keywords, emotional evocations and even the colour palette were designed as possible triggers for reflection on how we relate as a society to the issues of urban development and risk building or reduction. We created the fictional character of an andesite stone, “Andesita” as a narrative thread. This character acts on the platform as a time traveller who talks, questions, and rebukes historical figures or events through images, texts, podcasts and maps (Fig. 2). We designed it with three audiences in mind: 1) teachers and senior high school students, who pedagogical guides were prepared for, 2) general visitors that use the platform on their own, including visitors to the museums who use the QR links, and 3) people in the neighbourhoods where we worked as Tomorrow’s Cities.

The digital platform *Reducir Riesgos en Quito* can be navigated in a non-linear way; in other words, by selecting one of three different themes that are connected to every story, or it can be navigated using the “site map” (see <https://reducirriesgosenquito.com/mapa-de-sitio/>). The structure of the platform connects the trajectory of urban development and mass movement hazards related to water in the “the city that grows”, with entries to historical discussions on volcanic eruptions and earthquakes from interdisciplinary understandings of root causes. There is another section on “safe housing” using physics and building codes.

#### 4. Museum exhibits

Through workshops and collaborative meetings with museum staff, including museologists, curators, mediators and the interdisciplinary team from Tomorrow’s Cities (Table 1), we co-produced temporary exhibits and interventions within the permanent exhibits that adapted to the theme of each of three museums. These included interactive games, timelines, videos, artistic interventions to historical archives and materials, and educational scripts. In the Carmen Alto Museum, with the temporary exhibit “So that the Furious Tremor doesn’t take us by Surprise Again,” we approached risk through dialogue with the religious culture of the city, the role of the feminine figures of care and protection, and a reflection on political responsibility (Fig. 3a.). The title came from a poem written in the 19th century written by a woman asking saint Mariana de Jesus to prevent another disastrous earthquake. In the City Museum,



Fig. 3. Digital invitations for a. The exhibit “So that the Furious Tremor doesn’t Take us by Surprise Again” at MCA, b. The exhibit “On the Broken Slopes of a Mountain” at the Museum of the City, and c. The exhibit ¿Qué onda con Quito? at the MIC.





we presented the long history of human settlements and disaster risk in Quito in the exhibit “On the Broken Slopes of a Mountain”, in allusion to the city anthem, where we replaced “immense slopes” with “broken slopes” to refer to its many ravines and socio-economic inequalities (Fig. 3b.). There, we opened the discussion on the key role of urban development, scientific and experiential knowledge, and social capital on how the city has managed, reduced or built more risk over time. Finally, in the Interactive Science Museum, using maps, artistic interventions based on the concept of a core sample (in Spanish “testigo” or “witness”), and the physics behind building codes, we examined the relationship between the development of the city and its subsoil. The “¿Qué Onda con Quito?” exhibit was aimed at young audiences. This title was a play on the Spanish word “onda,” which means both “wave” and a colloquial way of asking “how’s it going?” (Fig. 3c.).

The exhibits were open for 6–8 months. Besides normal visits, we organised special visits with different stakeholders, including the municipality, schools and at-risk neighbourhoods where we were performing other parts of our research. We also offered panel discussions with the participation of experts from different backgrounds and disciplines, coming not just from academia but also from local communities and government.

## 5. Interdisciplinary research to convey the complexity of risk causes, drivers and trajectories

Both the museum exhibits and the digital platform “*Reducir Riesgos en Quito*” reflected these multiple opportunities for deepening knowledge about DRR, discussing risk and proposing ways to avoid building more risk in the city we live in from an interdisciplinary standpoint. We conveyed the results of the research done in the forensic analysis of multi-hazard risk in Quito using history the social and the physical sciences. This research including multi-hazard assessments, historical event databases, historical research on testimonies of past events and their representation in art, video, photographs and literature, the history of DRR related policies, images of urban expansion seen in historical urban maps, historical satellite images, theories of the earth including plate tectonics, historical newspapers, political and socio-economic analyses of historical urban development, etc. Thus, this education work was already based on our interdisciplinary research, but the aim of sharing it with wider audiences entailed greater collaboration between disciplines to explain something very complex in simple terms using a coherent common language. This was possible by promoting curiosity between the members of the team around each other’s disciplines, as well as acknowledging normal misunderstandings and epistemological clashes. We also participated in interdisciplinary field trips to volcanoes and at-risk neighbourhoods, visits to museum collections (both art history as well as science), exchanges of documents and data, and joint translation of technical language to more accessible texts, and a final revision of texts by the experts of all disciplines.

All of the content in the exhibits and on the platform consists of historical situations that illustrate past events explained through the lens of both the social and physical sciences. For example, the platform explores the history of how Quito has coped with the recurrent eruptions of the Pichincha volcano. The story starts factually, stating that the volcano had 4 major eruptions in the last 2000 years, then goes on to show how close the city is to the volcano in a satellite view of Quito (Fig. 4a). Through Andesita’s special ability to travel through time, she takes us to the eruption that occurred in 1660 both through a historical document that you can read and listen to (Fig. 4b), and through a “little souvenir that it left behind:” a picture of a stratigraphic column showing the ash strata of that eruption (Fig. 4c). Then, she travels through time again to the latest eruption in 1999. Using video footage and a podcast, she explains the complicated economic and political crisis the country was going through when that event happened (Fig. 4d and e). Finally, we discuss how local governments and the national government handled this multiple crisis at the time, to show both the complexity of disaster risk, its recurrence, and the importance of planning to avoid major disruptions or catastrophic consequences in the future (<https://reducirriesgosenquito.com/ceniza-guagua-pichincha/>).

We also introduced interdisciplinarity by including teachers from different school subjects in our workshops. Through these workshops with pilot schools, we made sure we proposed contents and materials that addressed disaster risk from different subject areas like history, social studies, mathematics, natural sciences, art and language/literature. These tools discuss the root causes of risk and propose ways to avoid building more risk in the city we live in, and to popularise scientific knowledge, renew teaching methodologies and promote new research.

Interdisciplinary research has a great potential for conveying the complexity of risk causes, drivers and trajectories. The challenge of communicating this to wider audiences entailed deep collaborative work between disciplines to explain very complex subjects in simple terms. The development of a coherent common language is a key factor of success that, in our case, was built around the power of curiosity as a tool for learning. Promoting curiosity between the members of the team and the different audiences we worked with allows for the building of the confidence necessary to carry out the project’s objectives and an enrichment learning through dialogue ([34]; [58], p. 15). The aim was to promote discussion between history and personal perspectives about a difficult topic: disaster risk.

## 6. The arts and humanities as tools to communicate through engaging emotions

For the process of preparing and creating multimedia art about historical trajectories of urban development and disaster risk, we collaborated with Sindicato Audiovisual, a multimedia collective consisting of graphic designers, artists, audio-visual anthropologists, musicians, educational experts and web programmers. This transmedia project articulated with the museum experiences following the idea of convergence culture [62]. The aim was to research the memory of past events to prevent future disasters and share them with young audiences targeting positive emotions such as awe and curiosity. The emotions and ideas that were triggered through memory or future scenarios were always geared towards positive actions for change and avoiding catastrophic scenarios or creating fear.

The preliminary workshops conducted with the pilot school enabled Sindicato Audiovisual to adapt the design the content of the platform according to students’ expectations and language. For example, the design of character of Andesita took into consideration the students’ input, and their familiarity with animated content (both Asian anime and American cartoons) and Youtubers. Following



Fig. 5. “The way of the lahars” narrative on the *Reducir Riesgos en Quito* digital platform, based on the 1877 Cotopaxi eruption with historical images artistically connected to the platform’s guide character, “Andesita” and a podcast of fictional time-travel to listen to the testimony of her “friend” Theodor Wolf, the Ecuadorian state geologist at the time.

workshop conversations as the platform was being built, Sindicato Audiovisual adapted the structure of the platform to the students’ needs, keeping the non-linear and exploratory elements, but adding a menu and other tools to simplify the learning experience.

We also used surveys to incite reflection about political action, and we presented “future scenarios from historical examples,” such as utopian (or dystopian) situations like a fictional eruption of Cotopaxi volcano in 2042, based on data from the 1877 eruption and population projections (Fig. 5). In the utopia scenario, we would have avoided building the city in the paths of the lahars, people would be educated on how to verify information and know what to do, and society in general would be more solidary. In the dystopian scenario, political corruption, neglecting the most vulnerable, and not considering the paths of the lahars when developing the city would have disastrous consequences in this imagined future eruption. The user can leave feedback on what they would like to ask a political authority to avoid the dystopian situation. In the “Urban development” and “Historical trajectories of risk” section, these mini surveys prompt the user to imagine being the future Mayor and planning how to make the city a safer place.

We proposed three different classroom projects in the “pedagogical section” of the platform. After working on one of them, the students at the pilot school learned to do a podcast about their family histories of migration into the city and relate them to the testimonies of experiences of risk from the archives. It was a significant experience, being their first time learning through a problem-based approach involving different disciplines, i.e. “using maths and history to learn,” as one student said in her speech in the platform launch event.

The mediator’s work was a key dimension for communicating about DRR. This type of cultural actor, mostly self-taught, activated visitor participation through questions and curiosity. The integration of imaginative and creative approaches from museums allowed us to challenge and change scientific approaches to represent hazards. We wanted to make the museums a space where visitors could “test, practice and experiment” risk, following the concept of total interactivity described by Jorge Wagensberg as including hands-on, minds-on and hearts-on experiences ([56], p. 114).

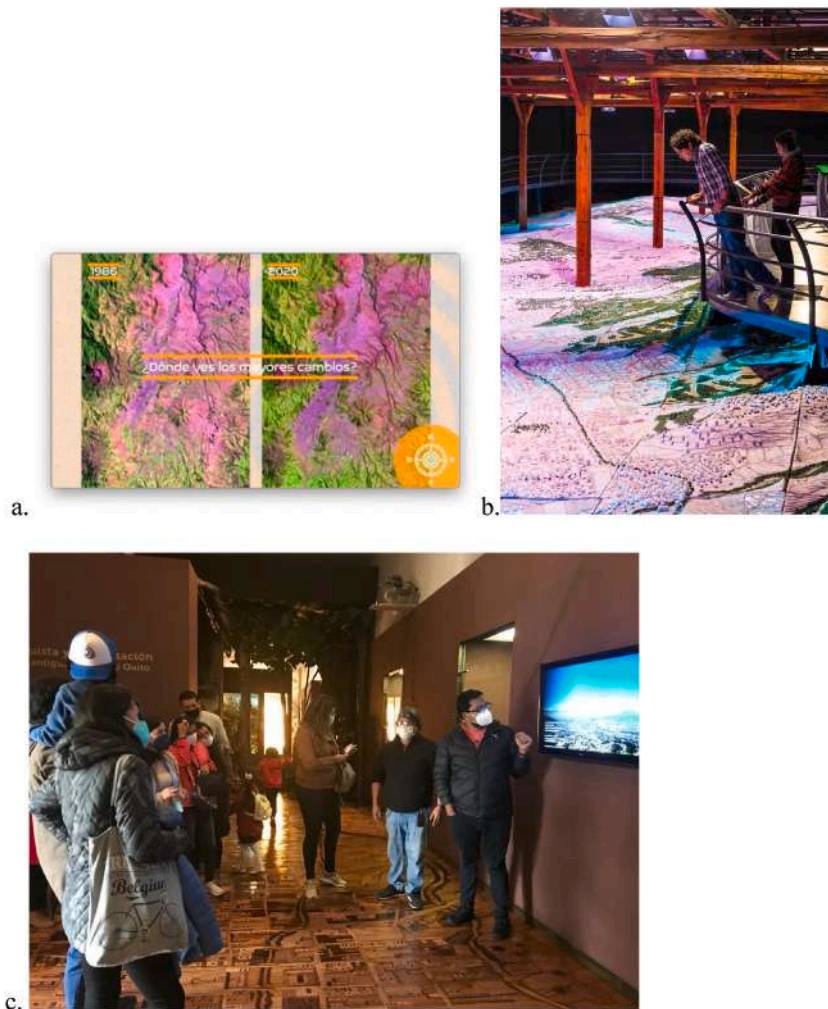
Consequently, the devices we used were characterised by their artistic, scientific, and pedagogical potential. These included timelines of disaster events and cultural interpretations presented in an artistic format and in dialogue with each specific museography (Table 2). For example, in the Carmen Alto Museum, we used an ex-voto format to recreate religious culture and baroque aesthetics. An ex-voto is a painting or another object left as an offering in fulfilment of a vow or in gratitude, such as for recovery from an illness or injury; therefore, using this was also a way of portraying the resilience of the city to past events.

In all three exhibits, we used historical and contemporary photographs, including satellite images and unmanned aerial vehicle (UAV) videos, to represent the change in the urban landscape and its relationship to disaster risk in dialogue with historical floor plans or present-day 3D models (Fig. 6). With these visualisations, visitors were asked to project future development and its relationship to

**Table 2**

Summary of types of interactive displays, their interdisciplinary content, artistic communication, and the use of history and survey/mediator questions to elicit reflexivity.

Resources	interdisciplinarity	arts	history	games	surveys
<b>Interactive historical maps (MIC, platform)</b>	Information about geology, geography, urban expansion trends	Colour filters to highlight different features. Overlaying information to Interconnect root causes. Using video of drone images, satellite images, photographs	Timelines of past events. Contextualising historical events.	Interactive features	Questions to locate your neighbourhood in the map.
<b>Timelines (MCA, MDC, Platform)</b>	Information about past disaster events, state of scientific knowledge, urban development, natural hazards	Watercolour paintings of religious figures and past events. Memes of “Andesita” and historical images.	Connecting past disaster events in the city with its religious culture. Putting the recurrence of events and policy in historical perspective. Using historical data for designing the game.	Interactive features	Questions related to how we can prevent disasters in the future
<b>Decision games (MCA, MDC, MIC, Platform)</b>	Information about DRR good practices and policies, Hazard information.	Design of the game board, pieces as houses. Design of turning tables and translating technical information into images.		Answering questions, turning tables, throwing dice, writing on the wall. Reflecting on how making informed decisions changes the outcome during a hazardous event.	Questions related to what they learned in the games.



**Fig. 6.** a. Snapshot of video installation “The expansion of Quito as seen from satellites” presented as part of the exhibit “¿Qué onda con Quito? Paisajes Profundos del Riesgo” at the Interactive Science Museum where we asked about what major changes visitors could see between a satellite picture taken in 1986 compared to one taken in 2020. 6b. 3D model of the city that is part of the permanent exhibit. (Photo by MIC). 6c. Video installation “Water has memory” using aerial photographs and drone videos of Quito’s city centre, historical photographs and TV news of recent mudflows. It talked about the relationship between the city’s expansion over ravines and multi-hazard disaster risk. It is in dialogue with the wooden floor plan of colonial Quito made in the 16th Century that shows the close interaction between the city and its then-open ravines, which are now filled. December 2021. (Photo by Jonathan Menoscal).

risk. The inherent relationship between topography, hazards and urban growth is an important concept, and these representations of the landscape are important translations of spatial risk [54].

Through artistic exhibits, decision-making games, and the use of technological devices such as QR codes, visitors had immersive and didactic experiences, facilitating learning through the engagement of diverse sensations while faced with scientific knowledge. The immersive experience of the “The Rubble that Speaks” artistic exhibit is one example where visitors listened to a dramatized audio testimony taken from a poem of “Quito’s Earthquake of 1859” while exploring an artistic intervention on historical photographs of the damaged churches and epigraphs printed on rubble in the Carmen Alto Museum (Fig. 7a and b). This was a very compelling experience to many visitors, especially when they realised that they were inside of one of those reconstructed churches that is now part of the convent and museum of Carmen Alto.

In all three museums, there were interactive displays that involved decision games (Table 2). We asked visitors to write on the wall what they would ask Saint Mariana of Quito, a political leader, or their community to prevent future disasters by using a popular saying attributed to this Saint: “Ecuador will not be destroyed by an earthquake but by bad government”. We designed a board game on urban planning and neighbourhood and community care decisions (Fig. 7c), as well as a “real estate” game that elicited discussion about getting informed about compliance with building codes, urban planning and exposure to hazards when buying a home.

As we’ve discussed in this section, artistic media and history can be used to communicate about the complexity of disaster risk by translating technical and socio-political aspects of risk into narratives on both visual and audio material.

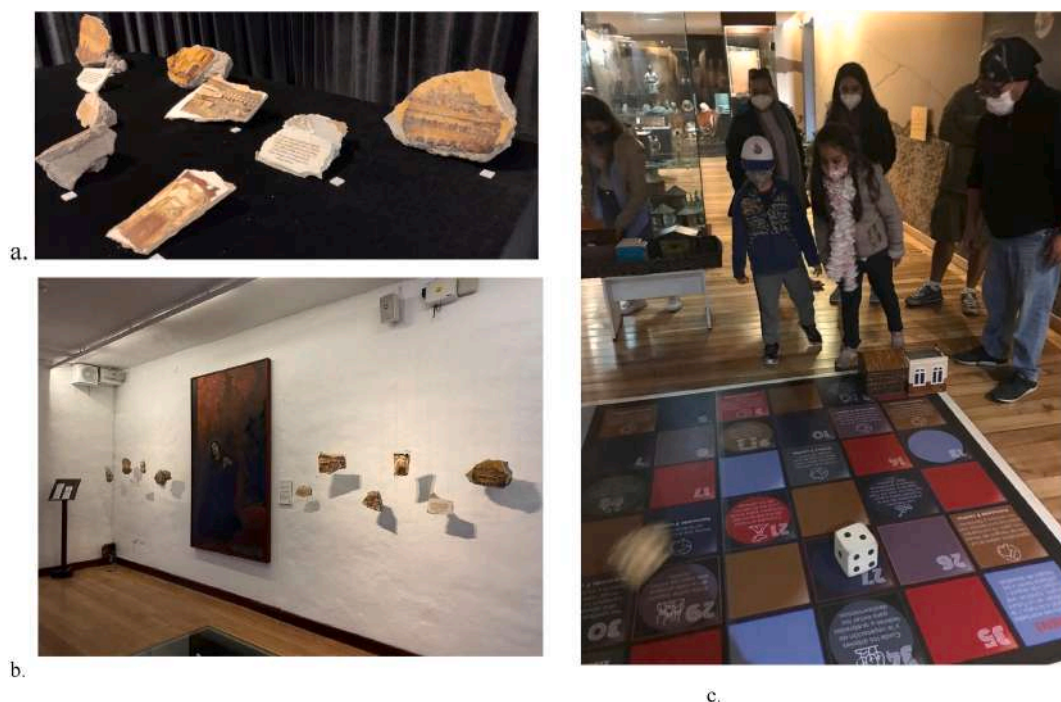


Fig. 7a. Exhibit called “The Rubble that Speaks” at Museo del Carmen Alto. 7 b. Now in a permanent exhibit. 7c. “Urban development decisions and risk game” at Museo de la Ciudad exhibit “On the Broken Slopes of a Mountain”. December 2021. (Photo by Jonathan Menoscal).

## 7. Preliminary impact on DRR

Museums are visited by many people, especially students from the city schools. For example, the MCA exhibit received 6808 visitors, and the MIC exhibit as many as 14,630 visitors. We will present here only a preliminary analysis of the surveys, since this will be discussed further in another paper. Visitor surveys indicated that the exhibitions prompted people to consider changes that they could implement to reduce disaster risk in their neighbourhoods. For example, their responses to our open-ended questions included ideas such as ‘creating contingency plans’, ‘remaining well-informed’, ‘improving contact with my community’, ‘teaching others’ and ‘voting better’. From these surveys, 80% thought that information is key; half of them thought they needed to be better informed about risk, while the other half went even further by saying that they would share what they’d learned with their community to contribute to reducing risk in the future city.

The interdisciplinary approach to root causes might explain why we received answers on different types of actions to be implemented by visitors in their communities. Thus, 48% of the participants answered with actions that combined environmental practices (i.e., planting trees and proper garbage management), preparedness planning and community cohesion. Around a third of all surveyed visitors thought that strengthening the community and doing *mingas* (collaborative work from the Andean tradition for improving the neighbourhood), as the best way to reduce risk in the future. Only 16% mentioned an activity related to better urban planning, and 4% to complying with the laws already in place. However, this changed when using games to discuss risk in urban development and asking visitors to imagine being the mayor and identify three priorities when planning the city. Most people answered a combination of having knowledge about hazards in the city, identifying safe zones for building and informing people about them.

This data shows that the most challenging aspect is to think about urban planning as a good opportunity for DRR, especially for those who already live in at-risk neighbourhoods, since they are more concerned about current risk. This also demonstrates how little these communities have been engaged with urban planning processes in the past. Using games is a way to learn about the consequences of urban development that doesn’t consider disaster risk; only then, urban planning is seen as an opportunity to reduce future risk.

These museum exhibits became “sites” for discussion themselves and, using this type of approach, it was possible to reach diverse audiences (such as students, activists, citizens and decision-makers). For example, we visited the exhibitions with people from one at-risk neighbourhood, and they mentioned *mingas* as an option to clean and consolidate the infrastructure and make it more resistant to risk. For adults, the stratigraphic column and the earthquake house were the interactive activities that most produced awe and curiosity. As one visitor said, “I’ve lived in this city for more than 20 years and didn’t know about the [seismic] fault”. Children enjoyed the more sensorial experiences such as the earthquake house in the MIC and playing with the “Disaster risk game” (Fig. 3c) in the MDC.

Many of the reflexions elicited by the exhibits were related to projecting what they learned to their future decisions. One neighbour said “I thought about building on to my house [a second floor], but now I think it is better to have just one floor” after visiting the Interactive Science Museum and learning about the types of soil and how they respond to seismic waves. Another person concluded that “our neighbourhood should not grow much, since it is on a slope.” They even recognised the importance of institutions in DRR,

when one visitor from a recently formalised neighbourhood argued that “the municipality should be the ones to provide guidance for us on [building] a safe home. The municipality has to follow what the law says.” The historical approach triggered memories from visitors, like when a person mentioned that he had spent 20 years in the neighbourhood and he remembered that it had a deep ravine with clear water sources that they used to drink but is now filled and they’ve built new houses on top. He also mentioned the need to organise the community several times, to work together once again to recover what is left of the ravine to avoid mudflows and landslides in the neighbourhood.

However, it is not possible to see the impact on the visitor’s actions beyond their experience with the platform and the museum exhibits because we have not conducted follow-up surveys.

## 8. Conclusions

Art, memory and the interdisciplinary DRR education and communication are developed in three key themes in this paper: the importance of communicating interdisciplinary research to different audiences and stakeholders, the need to trigger actions through positive emotions, and the necessity of engaging in collaborative processes.

The complexity of disaster risks and their root causes were uncovered through interdisciplinary research. This is a fundamental design strategy: timelines, archives, photographs, or testimonies of past events and their management, as well as urban development trends, can lead audiences to think about their present and project into the future to include risk into their decisions. Incorporating interdisciplinarity into engagement and education tools empowers students who begin to understand the potential of sciences, arts, and history as ways to contribute to the wellbeing of their communities and to feed their curiosity. This critical pedagogy approach incorporates students and teachers in a more horizontal way of learning, and encourages a connection with their own stories and environment. This can produce well-motivated and engaged students, teachers, and citizens in general. This approach can be replicated in other settings, but it is important to 1) incorporate local artists and scientists in the co-design of the educational material, and 2) contextualise the contents to the local culture, history, and concerns for the different root causes of risk and the stakeholders involved.

The second aspect has to do with how the arts and humanities engage our emotions for learning about and preventing disaster risk. The connection between emotions (especially awe, empathy, indignation, and rage) and decisions towards action are important elements for our discussion, as well as the role of museum mediators and schoolteachers as amplifiers of the message beyond the work of researchers linked to a time-constrained project. By talking to people’s emotions through art and science, we can either produce fright and inaction or lead towards empowerment and positive action. Mediated discussion can create positive engagement for reducing risk in the future city of Quito and many other cities around the world. The creation of knowledge about the exposure to risk experienced by the citizens of Quito and the root causes of vulnerability increases the appraisal of community capacities to prevent and/or manage risk. The importance of these multiple types of interactions with the different types of museums or online displays (manual, mental and emotional) is to create a meaningful learning experience. In fact, emotions allow museums to connect with visitors who leave with the tools and questions needed to learn more about the importance of multiple types of interactions that make for a meaningful learning experience. In the specific case of our study, art and digital tools reinvented the communication of scientific and cultural knowledge related to DRR in Quito’s society. It aimed to impact and educate the next generation to solve real-world problems and foresee future ones. Thus, they can begin to act in the present following ESD aims.

The third key aspect is the constant search for collaborative work. This element is of great importance, both in the planning and execution phases. The incorporation of multiple stakeholders and representatives of all groups involved, especially the most vulnerable voices, gives authenticity and empowerment to the process, and is a key element of success. This is closely related to the TCDSE innovation, since it seeks to open urban planning processes to the participation of different stakeholders, including the most vulnerable groups, through sharing their visions for the future city and assessing their development and impact priorities for the construction of a consented urban plan that is inclusive and reduces risk in the future. Placing all of the stakeholders on the same level of acknowledgement, well-informed and aware of the complexities that disaster risk entail, is a good starting point for applying the TCDSE. Thus, we can expect better results from urban planning exercises in cities that include actors with different socio-economic realities and power status. At the same time, these stakeholders also begin to interact with science in a historical and cultural context. Testimonies and memory of past events can lead to actions to reduce risk, but these examples from the past can also help us to understand how we can build knowledge and resilience in vulnerable populations. Psychological distancing from the historical past can be helpful for seeing the “big picture” to plan for the future, as well as detaching people from the anxiety that thinking about future disasters and loss can engender. It may also help stakeholders to avoid short-term “temptations”, like public works that build risk but are good for popular support in upcoming elections, and instead achieve that desired long-term goal of substantially reducing disaster risk for the most vulnerable in the city yet to be built.

Other cities and interdisciplinary teams can apply these methods by including a strong communication and engagement component that integrates the natural and social sciences with the arts and humanities. This entails a conceptual framework that regards participation not only to include people’s future aspirations and what they value most to protect against future hazardous events, but to empower them by promoting understanding of the consequences of their present decisions on future urban disaster risk.

## High resolution backup images

[https://drive.google.com/drive/folders/11XSpR\\_Qn00amC\\_kmUaEkU\\_OBEf-vMJN?usp=share\\_link](https://drive.google.com/drive/folders/11XSpR_Qn00amC_kmUaEkU_OBEf-vMJN?usp=share_link).

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Elisa Sevilla reports financial support was provided by GCRF UKRI Urban Disaster Risk Hub through the University of Edinburgh. Elisa Sevilla reports financial support was provided by GCRF UKRI QR Not just some pretty pictures through University of East Anglia.

## Data availability

Data will be made available on request.

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