Christina Karadimitriou

PhD researcher

Department of tourism management, University of Patras, Greece

Email: Karadimitriouchristina@gmail.com

Eleni Michopoulou, Associate Professor

College of Business, Law and Social Sciences

University of Derby, United Kingdom

Email: e.michopoulou@derby.ac.uk

**Extended Reality Technologies as a tool for managing crises and shaping tourism safety perceptions.**

**Abstract**

New technologies are considered by different industries as a useful tool for having an efficient emergency and crisis management. For tourism industry in particular (that involves and is interfacing with multiple other industries), it is critically important to act proactively to a risk situation, to effectively face a disaster, and to reduce the impact of a crisis. This book chapter provides an overview of the Extended Reality (XR) technologies (Augmented Reality [AR]; Virtual Reality [VR]; Mixed Reality [MR]). It discusses opportunities of using XR in tourism, and it provides contemporary examples of XR applications. It also focuses on emergency management via XR in tourism. Finally, it provides specific recommendations for XR use before, during, and after a crisis in order to better prepare for, manage and recover after emergencies and crisis.

**Key words:** tourism,crisis management, virtual reality, augmented reality, mixed reality, extended reality, tourism safety

**Introduction**

There is no definition of crisis which is globally accepted (Coombs, 2012). According to Pauchant and Mitroff (1992) the meaning of a crisis focuses on the disruption that has an impact on a specific system and constitutes threat for basic assumptions. Concerning tourism, Sönmez et al. (1994) noted that a crisis may have an impact not only on related businesses, but is also capable of destroying the destination. Thiessen (2008) suggests two typologies of crisis based on two dimensions: time and content. Considering the time dimension, Coombs (2012) proposes that a crisis includes three phases: pre-crisis, crisis and post-crisis.  With regards to the content dimension, Rosenthal and Kouzmin (1993) consider intentional man-made crises (terrorist attack) and natural external causes (hurricanes), whilst James and Wooten (2005) focus on sudden (earthquake) or predictable crisis (recession). The notion of stability and safety in economic, health and social terms being a static condition, has been contested in the recent years (Pappas & Glyptou, 2021). Many examples such as the 9/11 terrorist strikes in 2001, the Indian ocean tsunami catastrophe in 2004, the refugee crisis in 2015, and many others only prove that a serious crisis isn’t something rare, but rather increasingly commonplace.

Considering the most recent example of the Covid-19 pandemic, it caused the slowdown of most economic activities, as well as the introduction of radical changes in the global health and safety standards. As a result, many industries were affected including transportation industry, educational institutions, sport industry (Chakraborty & Maity, 2020); but tourism was particularly disrupted. While the impact of Covid-19 on tourism is yet to be fully understood, some facts remain unchallenged. According to the World Travel and Tourism Council lists, at immediate risk remain up to 75 million workers with the possibility the daily loss of jobs in the travel tourism sector to one million jobs. Furthermore, the potential Travel Tourism GDP loss was estimated in 2020 of up to US$ 2.1 trillion (Skare et al., 2021). These are just some of its effects with significant implications for customers, businesses and destinations across value and supply chains.

The lack of risk management for a pandemic situation forced individuals to rapidly formulate and apply disaster management plans in order to handle the pandemic impact, many of which included technological solutions. Compared to traditional communications methods, new technologies such as Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) not only provide a safe environment but also present individuals with the opportunity for interaction and engagement. Technologies such as VR, AR and MR offer a great opportunity for crisis management in pre-, during crisis and post-crisis phases, as they can assist in restoring feelings of safety and security but also revamping tourism and hospitality companies’ and destination’s image.

While the existing literature for XR technologies applications in many fields such as education (Merchant et al., 2017; Cihak et al., 2016; Loureiro & Bettencourt, 2014), health care (Freeman et al., 2017; Cobbett & Shelgrove., 2016; Alvarez et al., 2011, and retail (Park & Yoo, 2020; Fan et al., 2020; Bonetti et al., 2018) is abundant, the literature concerning the use of XR technologies in tourism and especially as a tool for managing crises and shaping tourism safety is predominantly silent. It is therefore necessary to further research on the ways that all these new technologies can be valuable in avoiding or countering tourism crises. Hence, this chapter examines the use of AR, VR and MR technologies in the pre-, main, and the post-crisis phases and discusses potential applications for the tourism and hospitality industries. The theoretical contribution of the chapter lies within the fact that it jointly considers three distinct knowledge areas and explores issues that exist in the intersection of technology, crisis management and tourism. To do so, the chapter first discusses the different XR technologies, in particular AR, VR and MR. It then proceeds to contextualize these technologies within the tourism domain, providing some current application examples. It proceeds to review the use of XR technologies as emergency and crisis management tools. The chapter then continues by considering XR technologies for managing tourism crises. Finally, it offers a summary of key point and concluding remarks.

**XR technologies**

According to Fast-Berglund et al. (2018) the term extended reality (XR) refers to all combined environments (real and virtual) and includes different types of technologies i.e Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR).

AR technology offers the user the opportunity to overlap virtual objects to the real world (Peddie, 2017). This is done through a variety of devices, usually grouped into three categories: (i) the Head Mounted Displays (HMD) which includes the optical see-through form and the video see-through (Karadimitriou & Trichas, 2020), (ii) the use systems that the real world is joined with through a coupled camera and a connected computer projecting the virtual image in equipment screen such as smartphones and tablets (Nishihara, 2015), and (iii) the Spatial Augmented Reality (SAR) which allows the user to interact with the virtual object by utilizing projectors which directly project digital information onto the objects of the real world (Azuma et al., 2001). According to He et al. (2018), AR technology is considered as a revolutionary invention and its use has increased rapidly over the past few years. AR can be very effective in enabling interaction with the real environment (Tussyadiah et al., 2018). The most popular AR application which made AR technology widespread to the general public was the Pokémon Go (Rauschnabel et al., 2017). The AR market is expected to increase from US$5.91 billion to US$198 billion by the year 2025 (Shah, 2019).

VR technology can be defined as an immersive-interactive technology in which the users immerse into a digital environment and interact with the digital elements. (Milgram & Kishino, 1994; Zhou, 2021; Zhang, 2021). Visual immersion according to Goedert and Rokooei (2016) and Bowman and McMahan (2007) is defined by how similar a system’s visual output is to reality. VR technology has many applications in different fields such as military training (Chen et al., 1999) entertainment (Zyda, 2005), education (Merchant et al., 2017), research (Meißner et al. 2017), retail (Bonetti et al., 2018) and healthcare (Freeman et al., 2017), due to the immersiveness that it offers (Berg & Vance, 2016). Lucas et al. (2007) note that VR technology is a very useful and safe alternative when the individuals must be trained in dangerous occasions. It is also very effective in phobia therapy (Cohen et al., 2005) and in speech therapy (Goedert & Rokooei, 2016). According to Dascal et al. (2017), VR technology in hospital inpatients was not only safe for the inpatients but it also increased customer satisfaction factor in different medical settings. The presentation of VR content can display through desktop, Cave Automatic Virtual Environment (CAVE) and HMD (Manjrekar et al., 2014). It is worth mentioning that in 2019 the VR market size was valued at US$10.32 billion and the expectation of growing rate is 21.6% from 2020 to 2027 (Market Analysis Report, 2021).

In MR technology (unlike VR) the virtual objects and the real world are merged (Pan et al., 2006; Tamura et al., 2001; Syal & Mathew, 2020). The basic characteristic of MR is visual coherence (Collins et al., 2017). Essentially in MR the user can interact with both real and digital elements, with the differentiating factor being that the elements can also interact with each other. Physical factors, imaginary factors and virtual factors are contributing to the final MR experience involving multisensorial responses such as hearing, sight etc. (Konttinen, 2005). The main difference between the XR technologies is that in AR the user has direct contact with the physical environment and he remains present. In VR technology the user experiences a full digital environment and he is totally cut off from the surrounding environment whereas with MR technology the user coexists with the digital and the real word.

**XR technologies in tourism**

AR technology has had a great impact on the tourism industry particularly as a valuable marketing tool (Ukpabi & Karjaluoto, 2016; Sigala, 2018). AR technology offers tourists the opportunity to enhance their experience by exploring many unfamiliar sights (Han et al., 2014). This is particularly true within a cultural heritage tourism context (Cranmer et al. 2016) as, for instance, museums tend to use this technology in order to be more engaged with the visitor and at the same time provide a much more interactive content (Scarles et al., 2016). Tussyadiah et al. (2018) argue that AR enables users to create memorable experiences. One of the most impressive examples of AR applications in hotel settings was launched by Holiday Inn for the London 2012 Olympic and Paralympic Games. Guests were offered the experience of seeing Britain’s 2012 Olympic and Paralympic athletes in action in bedrooms, halls and in the reception (Innotour, 2020). Another AR application in tourism was introduced by the Hub Hotel from Premier Inn which used AR technology as a tourist information tool. Using a wall map placed in hotel rooms, the tourists have the opportunity through a tablet or a smartphone to have access to extra information about local places (Revfine, 2020)

VR technology is becoming increasingly important for the tourism industry (Griffin et al., 2017). According to Kim et al. (2020), VR technology is shown to have a positive effect on tourist behaviour and having a VR experience is more likely to increase tourists’ desire to participate in an activity (Jeng et al., 2017; tom Dieck et al., 2019). More importantly, VR technology has the potential to increase the desire of the tourist to visit a destination (Huang et al., 2016). According to Guttentag (2010), VR environments can be used not only as a promotional tool for destinations by immersing the consumers to new tourism experiences, but it can also be used to educate tourists to respect and protect the attractions, especially the sensitive ones.  It is worth mentioning that VR and MR technologies are used by second chance tourism to assist destinations or sights that are deteriorated or destroyed by helping them to be “reborn” (Bec et al., 2021). A great example of VR technology in museums is the ‘Mona Lisa: Beyond the Glass’ VR project. In 2019 the Louvre (Paris) launched ‘Mona Lisa: Beyond the Glass’, an experience which was based on VR technology and explored the painting as a part of a blockbuster exhibition dedicated to Leonardo da Vinci. Employing interactive design, animated images and sound, the visitors of the museum had the opportunity to discover more details concerning Mona Lisa painting such as the texture of the wood panel and the effect of time in the appearance (Coates, 2020).

The dynamic field of XR technologies offers the tourism industry great marketing and promotion opportunities across the customer journey through various mechanisms such as gamification (Parapanos & Michopoulou, 2019) while evidence increasingly indicates that XR technologies will become more entangled to different tourism aspects. For instance, Flavian et al. (2019) examined the impact of VR on the customer purchase journey, Tussyadiah et al. (2018) focused on the attitude and the behaviour change toward destinations and Disztinger et al. (2017) and Huang et al. (2016) looked into the acceptance of VR technology for travel planning. Hence, Extended Reality enables companies and destinations to interact and engage with tourists particularly before and at the destination, enabling value co-creation for all stakeholders (Cavagnaro et al., 2021).

**Emergency management via XR technologies**

As mentioned previously, emergency management includes three main phases, pre-crisis, crisis and post-crisis (Coombs, 2012). The complexity of the phases of crisis management demands meticulous preparation and organisation in order to avoid escalation to a bigger crisis with much more serious consequences. XR technologies are useful in this way as they can assist with increasing preparedness in the pre-crisis phase, responsiveness during crisis and rejuvenation post crisis.

The utilization of VR, AR and MR technology can be used for emergency management, especially in the pre-crisis phase, offering several potential benefits. According to Lin et al. (2019), it is very difficult to create in real time a disaster scene because of legal and ethical restrictions. With XR technology it is much easier to create a disaster scene and especially due to the immersiveness of Virtual Reality it is easier to simulate a disaster and avoid any real risk for the participants.

At the same time AR, VR and MR can assist in developing emergency communication plans by identifying critical aspects to be considered by these plans that would otherwise not be apparent without prior experience. Hence, these technologies have become mainstream research methods (Lin et al., 2020) as they provide control over the variable parameters and disaster factors which influence emergency management (Lin et al., 2020). In terms of training, for instance, with XR technologies participants experience an interactive training which is easier to memorise and therefore develop better safety knowledge, enabling participants to have a similar response in a real-world crisis situation (Li et al., 2018). According to Meng and Zhang (2014), to improve the quality of an emergency simulation in a VR experiment, additional external environmental factors should be added. For example, a VR environment with fire and smoke is likely to induce higher physiological and psychological stress upon the participants, and therefore generate an improved stimulation of a real fire condition (Smith & Trenholme, 2009). XR technologies can also simulate with success search and rescue work in order for individuals to be trained in search and rescue activities. Lochhead and Hedley (2019) used not only AR technology but also MR technology to create simulations of evacuation in an actual environment of a building.

The post crisis phase (also considered as a recovery phase) is a crucial phase due to the importance and urgency of rebuilding material structures and restoring feelings of safety of directly and indirectly involved individuals (Pappas, 2019). According to Wiederhold and Bouchard (2014) and Jang et al. (2000), VR technologies are helpful in addressing anxiety disorder due to the immersion factor. Designing a customizable environment according to the user needs and creating a scene that is close to the one that traumatized the person, provides an invaluable tool to the procedure of treating trauma. Pourmand et al. (2017) also suggest that new immersive technologies can be successfully applied to treatment of acute pain and be received as a supplementary psychological support. XR technologies may also be used as a visualization tool to process building information after emergencies such as for damage reconnaissance and reconstitution process (Matini et al., 2019).

**XR technologies for managing tourism crises**

Considering that destinations are amalgamations of tourism products and services (Buhalis, 2000), any potential crisis affects everyone within their respective value and supply chains, although admittedly in varying extents. Hence, it is important for all tourism stakeholders to prepare for the unavoidable fact that a crisis will occur sooner or later, the nature of which is unknown and unpredictable and therefore imbued with the promise of disruption. This very unpredictability of crises demands that emergency plans are in place to ensure minimal disruptions. XR technologies can assist tourism organisations and destinations to prepare for, respond to and revive from a crisis by using different applications appropriate for each phase of the crisis: before, during and after. As technologies develop and are adopted by the tourism sector and destinations paving the way to entire e-tourism ecosystems and smart destinations (Buhalis, 2020), the use and adoption of XR technologies becomes easier due to interoperability and other synergistic effects with existing technological infrastructures. Berglund et al. (2020) suggest that smart environments with extended reality technology will allow a better response in emergency situations.

In terms of pre- and during crises phases, XR technologies and especially AR and VR can be used in several ways. Whilst the applications of these technologies primarily concern tourism suppliers and less so the tourists, tourists should in no way be excluded from the picture. Both technologies (especially VR) due to their immersive advantage can simulate an emergency situation before it happens so that tourism and hospitality staff (or tourists) can assess their ability to perform appropriately under the circumstances.

According to Perlman et al. (2014), using VR can be more helpful than traditional methods (such as photographs) for the participants to understand the emergency situation, as they allow participants to experience an emergency scene before real emergencies occur. Exposure to a simulated environment can introduce some sort of familiarization and therefore yield a more structured and organised reaction, upon which an effective crisis management plan can be designed. Such simulated digital and safe environments are more effective to instill emergency-handling knowledge to learners (Lovreglio et al., 2018). Even if the technology for both tourists and tourism suppliers is the same, the content will be different depending on their needs and the phase of the crises; for example, *pre-crisis* can focus on hazard recognition and prevention or safety training, *during crisis* can focus on human evacuation or search and rescue (Zhu & Li, 2021).  During the pre-crisis phase, VR technology can focus on training simulation systems (i.e. evacuation, contact and supporting families and victims, front-line spokesperson for the crisis) within an immersive environment, which will include many different stages and layers of difficulty to which the user can react by taking ad-hoc decisions and evaluate their impacts. Through this process, the user can define the best suitable contingency plan whist it can also formulate alternative ones. Concerning AR technologies, there can be a use of a specific application enabling GPS with the use of tablets and smartphones in order to help tourists before a potential disaster to define the safety of streets and buildings and to progress to a specific evaluation format during an emergency.

An example of XR technologies during crises is the use of drones with AR capabilities. AR enabled drones can be used to collect real time data, provide visuals with street names or building information overlays at a resort/destination to assess for instance the extent of damage, movement bottlenecks and support on the spot decision-making. VR technology in this phase can be also used as an effective supporting management tool for all the people that are working under high pressure environment conditions and for the families of the victims that will be under stressful conditions. Anxiety and emotional fatigue could be reduced through a software that will use positive memories and an immersive calmness environment.

Hence, XR technologies offer prime opportunities for instance to hoteliers, event managers or attraction sites to better prepare for and respond to different types of crisis (i.e. fire, flood, earthquake or terrorist attacks) and test and employ different procedures (i.e. health and safety protocols, evacuation routes or communication chain of command).

The use of XR technologies for the post-crisis phase is even more critical for tourism, as the recovery phase includes not only the restoration of physical space (i.e. building reconstruction or damage detection) but also entails the repositioning of the destination image (or rebranding) in the minds of both locals and tourists. Central to achieving the later is the ability to restore feelings of safety and trust that the destination’s new condition resembles its pre-crisis condition. Unless this positive attitude is embraced and displayed by the locals and accepted by the tourists any attempts to stimulate tourism demand are futile. VR technology can help to treat post-traumatic stress disorder (Geraldi et al., 2010) experienced by either locals or tourists.

With regards to the physical space, combinations of AR, VR and MR technologies can also be used to digitally ‘rebuilt’ a damaged or destroyed attraction site or heritage monument and recreate the environment. For example, Toubekis et al. (2009) with VR technology allowed tourists to see and interact with the destroyed Buddha figures in Afghanistan. The Roman Baths in Bath UK also developed an AR mobile app to allow visitors to experience reconstructions of the Baths at key moments in history, as part of their 5G Smart Tourism project (Thomas et al., 2019). Hence, XR technologies may be used not only to enhance the tourism experience (Beck, Rainoldi, & Egger, 2019; Guttentag, 2010; Wei, 2019) but also as a strategic emergency management tool.

**Conclusions**

Crises are inevitable and, as witnessed over the last few years, they tend to occur alarmingly more frequently. Dealing with crises is therefore an unavoidable reality that tourism businesses as well as destinations need to come to terms with. Fast and accurate decision-making is paramount when handling a crisis as it may be the very thing that ensures survival, in some cases literally. Hence, the examination of different scenarios and the development of emergency management plans is not optional. It is essential to maximise preparedness pre-crisis, optimize responsiveness during crisis, and minimise negative impacts including perceived safety of the destination or organisation post-crisis.

Extended reality technologies could be a great assistive tool in all the crisis management stages. For example, with XR technologies an emergency scene can be produced with safety and the mock-experience can be repeated indefinitely. This allows participants to spend as much time as is needed to examine all the possible complications that can occur and develop an appropriate plan to avoid or face them. This technology enabled mock experience can also be sharable so it can be offered to multiple participants, allowing a greater number of people to acquire the relevant skills and knowledge not just to prevent but to also face a crisis (i.e. the totality of a hotel’s staff could be trained rather than few that would lead the others). The use of the right type of XR technology or a combination of them could be vital to control the disaster and to tackle issues that were not possible to foresee in the first stage. XR technologies can therefore be used as a strategic tool that cannot only minimise the negative effects of a crisis on a destination in the short term, but also enhance the destination image to project readiness and safety in the long run.

Yet, as new technological developments come to light, new applications will become available to facilitate crisis management. Further research is therefore required to address a number of issues including for instance: how to assure technology acceptance from tourism stakeholders; which technologies are more appropriate and useful mapped across the three stages of crisis; and in what ways does destination smartness enable crisis management.

In conclusion, it is important to examine the use of XR technologies as quintessential tools in preparing for, handling and recovering from crises. This provides a new perspective on how to manage crisis within the tourism domain. By exploring the links between crisis management, tourism and XR technologies, it becomes clear that there are synergies that can assist tourism and hospitality to better cope with the challenging years ahead.

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**Discussion Points**

**Highlights**

* With the advancement of XR technologies, new opportunities become available for emergency and crisis management in tourism and hospitality.
* Compared to traditional communication methods, XR technologies are more efficient in shaping safety feelings in tourism industry.
* In the near future, XR technologies are set to play a key role in enabling a more effective strategy for crisis and emergency management. XR technologies could be very helpful in accelerating recovery for tourism and hospitality after a crisis while XR technologies could play a vital role in pre-crisis phase due to the efficient training programs that can be reproduced several times in a safe environment and help identify and prepare for possible dangers.

**Key Questions**

* What is the role of XR technologies in emergency and crisis management in tourism and hospitality industry?
* What is the importance of XR technologies in shaping tourism safety perceptions?
* In what ways XR technologies can contribute to gain the required knowledge in order to efficiently handle a crisis?