INCLUSive Disaster Education

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Output 4: Case Studies with the use of Disruptive Technologies for Disaster Risk Reduction

Opportunities of using disruptive technology in online distance learning education in DRR

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Executive Summary

This report presents an overview of disruptive technologies and the opportunities for utilizing them in online distance education in Disaster Risk Reduction (DRR). It begins with a general introduction of disruptive technologies and brings up Artifitial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), the Internet of Thungs(IoT), drones, big data, robots, blockchain and many others as some examples. In relation to DRR, the use of Unmanned Aerial Vehicles (UAVs) and big data analytics are discussed as disruptive technologies in pre, during and post-disaster management contexts, thus showing their benefits and challenges in their respective applications. In terms of the benefits, UAVs and big data analytics improve real-time and near real-time decisions through greater use of automation, and when combined with other technologies such as AI, AR/VR, and IoT, they provide the necessary impetus to enhance mitigation, preparedness, response, and recovery processes. In this regard, two case study examples are presented to give an insight into their applicability from different perspectives. The first case example centres on how AI and the Internet of Things (IoT) are used to reduce wastewater network blockages and pollution in Yorkshire in the UK, while the second case example is immersive learning of disaster risks and management through Metaverse in Japan.

Upon review of the case examples, it is established that disruptive technologies in DRR activities are vital because they provide accurate results, and are accessible, affordable, reliable, efficient, reachable and flexible. These are seen as essential elements that can offer opportunities for online distance education in DRR judged by the various challenges identified in Output 1 of the project. Therefore, we ask the question as to whether such attributes could be accrued in online distance learning education in DRR. To aid future discussion on such a holistic approach, two examples are given to this effect. The first example suggests the incorporation of many disruptive technologies into an augmented reality environment where educators, learners and other interested partners can attend to experience the practical attributes of DRR education. This is devoid of time zone, gender, and other differences that hinder regular online participation of students because it has AI, and other technologies that are able to customize the preferences of participants. The second example, a text-mining model is presented as another case study to assist students' academic and research work on DRR.

1. Introduction

Disruptive technologies such as big data, Internet of Things (IoT), social media, robotics, blockchains, drones, 5G wireless networks and many others, have proven to be effective in various endeavors, including healthcare, trading and banking, agriculture and disaster risk reduction. In risk reduction, they have been useful in disaster prevention, preparedness, mitigation, response, recovery, and rehabilitation activities. Despite their resourcefulness, the COVID-19 pandemic also opened new opportunities for disruptive technology innovation in the context of swift endevors required to meet the needs and aspirations of societies in sudden and emergency crisis management. Thus, the need to prevent COVID-19 infections through contactless engagements, as well as the urgency to develop COVID-19 vaccines pushed innovations in AI, big data, VR, AR, and 5G among others to determine progressions, infection rates and initiated a shift to paperless activities, remote work, remote policing, etc.

The above indicates the flexibility and versatility of disruptive technologies in both traditional disaster risk reduction and management, and emergencies. For this purpose, this report looks at the opportunities of using these disruptive technologies in online distance learning education in DRR via case studies identified by each partner institution. It comes against the backdrop of the fact that the nature and dynamics of disaster are evolving and coupled with the sudden onset of the COVID-19 pandemic, lifelong learning is an appropriate way of ensuring continuous education to stay abreast with disaster and risk management activities (Siriwardena, Malalgoda, Thayaparan, Amaratunga, & Keraminiyage, 2013). Looking at the sudden change in teaching and learning during the pandemic, it is vital to exhaust all opportunities to ensure that, there is continuity of DRR education even in the event of sudden emergencies or crises.

This report first gives an overview of disruptive technology, uses case study examples to explain their applications in DRR and reflects on key elements as opportunities for online education on DRR. All these are done in reference to the results of the survey conducted in Output 1 and the framework components of Output 2.

2. Overview of Disruptive Technology in DRR

The role of technology in addressing disasters has always been prominent. New technological advancements over the last three decades can provide disaster managers, officials, and the public with new ways of engaging in disaster preparedness, response, and recovery (Rathore, 2016). It is widely acknowledged today that disruptive technologies such as big data, IoT, social media, robotics, blockchains or drones come with a wide spectrum of transformative new opportunities for disaster risk reduction (Minges, 2019; Fontes de Meira & Bello, 2020) and as the Sendai Framework for Disaster Risk Reduction (UNDRR, 2015) indicates, there is a need for the development of new technologies for a long-term and solution-driven research in order to address gaps, interdependencies, social challenges and risks (Izumi et al., 2019). As indicated above, there are several disruptive technologies applications in various fields, including disaster management. However, critical observations of their application suggest that, the technologies could broadly be identified in three areas for DRR activities. The first is the information gathering disruptive technologies which are very useful in all stages of disaster preparedness. For instance (Sharma et al., 2016) demonstrate the use of sensor-fitted drones to monitor and detect flammable gases, carbon dioxide levels, and smoke levels in an area. Additionally, there are other drones that are further fitted with high-definition cameras to collect important environmental data. After the information-gathering process, the next stage is the analysis of the numerous data (big data) collected in the first stage. Again, disruptive technologies have shown extreme reliability in making meaningful outcomes of big data on disasters and alternative countermeasures. In this regard, (Hu et al., 2021) give an extensive overview of AI as an example of analyzing complex datasets. However, users are also important elements of these processes because they have to be engaged in the gathering, and analysis, as well as are expected to take meaningful actions based on the content, output or the prevailing situation. Therefore, the last stage is the utilization of the information and this may again require the assistance of disruptive technologies. (Sharma et al., 2016) explore immersive disaster preparedness experiences where VR and AR are utilized to give people real-life scenarios on disaster preparedness and the action needed. It must be emphasized that most of these technologies complement each other and are mostly used in parrallel.

To enhance the understanding of how some of these technologies work in the context of DRR, in the next section we first discuss the relevance of disruptive technology in DRR using big data and UAVs as examples to explore their use in pre, during and after disasters. Then, a case study example in the UK is given to provide insight into the aspect of using AI and IoT disaster prevention. As indicated above, a stage in the application of disruptive technology often has user experiences, therefore, using a case study in Japan, we explore the opportunities of using VR and AR for disaster preparedness and disaster resilience activities as a second case study example.

3. Big Data and UAVs as Disruptive Technologies in DRR Activities

3.1. Pre-Disaster

In this review, big data is defined as large amounts of different types of data produced from various types of sources, such as people, machines, or sensors. This data includes climate information, satellite imagery, digital pictures and videos, transition records or GPS signals. Big data may involve personal data: that is, any information relating to an individual, and can be anything from a name, a photo, an email address, bank details, posts on social networking websites, medical information, or a computer IP address" (see, European Commission, 2018). Before disasters such as flooding or droughts, big data from large-area sensor networks can reveal patterns to aid with risk identification before the disaster occurs. To support this development, big data from sensors, cellular devices and cloud services is crucial in providing data used for water assessments, evaluations, operations, foresight, design accountability and education.

Global warming or climate change can have devastating effects, affecting food production and supply chain disruption, which leads to increased levels of poverty and hunger. Big data can be used to predict crop yield, helping to effectively plan the food procurement process and allocate resources to the regions accordingly (Kaur, 2019). Utilizing sensors at various stages of the supply chain to extract real-time data for decision-making enables a more efficient supply chain monitoring system, which, in turn, improves supply chain visibility (Bag et al., 2022). Big data is not only important for food production but is also able to enhance visibility and coordination among different members of the supply chain. Moreover, improved visibility enhances operational efficiency and overall market performance. However, the creation of such an enormous dataset to prevent calamities depends on several methods and modes of data acquisition. One such source is the use of UAVs or drones.

UAVs (Unmanned Aerial Vehicles) also commonly known as 'drones', 'Unpiloted Aerial Vehicles', 'Remotely Piloted Aircrafts' (RPAs), or 'Unmanned Aerial Systems' (Restas, 2015) are usually defined as aircrafts that are not flown by a pilot but by a ground-based operator or through an automated flight (Mohd Daud et al., 2022). They come with a wide range of applications and potentials in all stages of disaster risk reduction (Izumi et al., 2019), and with various types of natural and man-induced hazards, from landslides to volcanic eruptions to earthquakes, floods, forest fires to dam failures, spread of hazardous material and nuclear accidents (Glantz et al., 2020; Restas, 2015).

Relevant literature indicates that a wide application of UAV technology are used for monitoring activities and have been crucially relevant in the face of the recent rise disasters occurances. Thus, they are utilized in different activities concerning the various stages of disaster management. Estrada & Ndoma (2019), distinguish three levels of UAVS or drones involvement in disaster management activities, which can be summarized into mission stages 1, 2 and 3. Mission stage -1 involves the use of Quadcopters that generate high-resolution images in real-time to quickly evaluate infrastructure damage after a disaster occurs. Mission stage - 2 involves the deployment of Smart Platforms (SP), which can carry light cargo such as water, food, medical supplies, and other equipment during a disaster. These are still in the experimental and trial stages now (Estrada & Ndoma, 2019). Finally, mission stage - 3 revolves around the post-disaster aerial evaluation of the situation in an area hit. As literature suggests, and as elaborated further in the coming section, these different types of UAVs can be used interchangeably in different stages of disaster management, especially when it comes to Quadcopters and can be a very important component in disaster preparedness.

Disaster preparedness involves measures that are taken to reduce the effects of disasters (IFRC, 2000). IFRC (2000) distinguishes nine main elements of disaster preparedness that are interconnected and constantly feed into each other. UAVs can be utilized in several scenarios of the nine elements and contribute to disaster preparedness. The data that is collected through monitoring can be used to feed into hazard, risk, and vulnerability assessments. At the same time, as Izumi et al. (2019) indicate, UAVs and their ability to gather information can contribute to the development of Early Warning Systems (EWSs). UAV-based photogrammetry applications have been explored for hazard monitoring emphasizing the role of UAVs for a multiple-hazard approach to disaster risk management for slower-onset and more predictable hazards like volcanic eruptions and landslides by gathering and generating three or even four-dimensional-imagery-data for changes on the ground. At the same time, UAVs can assist in the topographic mapping of watersheds and basins as well as in the creation of flood risk models. When it comes to community-based disaster preparedness, participatory mapping is a tool which utilizes local knowledge for disaster preparedness by involving local actors in the risk and vulnerability analysis process and is becoming widely accepted by international organizations and governments (UNDRR, 2021). UAVs have the potential to assist in providing scaled and georeferenced images of and expanded geographical coverage as a basis for participatory mapping processes to be initiated (UNDRR, 2021). All in all, UAVs generate important datasets from different sources as well as types and such big data bears a significant potential in improving contingency planning in pre-disaster events. In such cases of contingency planning, we present some examples in disaster situations.

3.2. During Disaster

During disaster events, the interplay of UAV, big data are usually indispensable. For instance, UAVs play a vital role in the stage of disaster response and relief operations by providing various sets of datasets on different types of disasters including fires, floods, earthquakes, and landslides. Besides the collection of data, UAVs play additional roles during disasters. MEASURE and the American Red Cross (2015), identify 6 main ways through which they do so: they can provide relief workers with a better sense of the field of operations, they can locate survivors in damaged infrastructure, deliver supplies to survivors until they can be rescued, perform structural analysis of the damaged infrastructure, detect or even extinguish fires, without risking the lives of firefighters on the ground (MEASURE & American Red Cross, 2015). Li et al. (2022), indicate that different types of UAV hardware ought to be used for different types of disasters and some examples are mentioned below.

During a landslide in Shuicheng County, Guizhou Province, China in July 2019, quadcopters were used to obtain photographs from the impact zone, assess possible buried locations, destroyed buildings, and monitor potential secondary landslides through the production of three-dimensional models, thus, providing rescue teams with valuable information and more accurate situational awareness (UNDRR, 2021). UAVs have also been used in the case of nuclear accidents such as the Fukushima incident in 2011 in the aftermath of the Tōhoku earthquake and the tsunami that followed. A Honeywell RQ-16 T-Hawk drone model was used to measure radiation levels and carry out an inspection of the structural integrity of the power plant (MEASURE & American Red Cross, 2015). Japan and China are two countries that are pioneers in the deployment of quadcopters in the response phase (Estrada & Ndoma, 2019). As highlights, UAVs have the technical capacity to monitor environments where manned operations cannot be deployed due to high concentrations of hazardous materials such as radioactive or chemical-contaminated environments. Furthermore, big data from sensors and healthcare databases were used to produce statistical models on the COVID-19 outbreak and were helpful to limit the effect of the pandemic across the world. The reports generated from data obtained during the pandemic were used by governments to manage and prevent the virus from spreading further.

3.3. Post-Disaster

In a post-disaster stage, big data can be critical to saving lives. Data gathered through cellular services, used by smartphone users and organizations can support decision-making after a disaster. Thus, the use of big data can help to save lives after a disaster by delivering information to aid in responding to and recovering from both natural and man-made disasters (Bag et al., 2022). As well as helping to save lives, big data can be used to detect socioeconomic recovery and resilience after a disaster. UAVs are mainly utilized in the assessment of affected areas and infrastructure systems (Li et al., 2022).

The main tools for performing this UAV-assisted structural assessment are not just visual imaging but also other sensor systems such as laser imaging, thermal and radiation detectors, or humidity/temperature sensors (Li et al., 2022). However, another significant function in this stage revolves around communication. Selim & Kamal suggest UAV-based communication to provide 4G/5G cellular coverage in areas that are struck by disasters. Studies suggest that this communication function is also important both for humanitarians working in the field without having to rely only on satellite communication (satellite phones) but also for survivors who will use the emergency Wi-Fi network to, for instance, locate camps or other aid.

4. The Benefits and Challenges of Big Data and UAVs in DRR

One crucial benefit of preventing and managing disasters is the ability to rely on insightful information to make critical decisions. In this regard, using big data for disaster management has the potential to increase available information for decision-making. The increased amount of information available through big data can improve timeliness and accuracy, and real-time and near real-time decisions through greater use of automation and rapid and reliable communications. In supply chain management, for instance, big data accelerates the processing of information and, when combined with analytical tools, enhances the decision-making processes (Bag et al., 2022). The use of big data also enhances the predictive analysis capability of supply chain management, leading to enhanced supply chain visibility. As well as improving decision-making, Harshadeep and Young (2020) identified several benefits of adopting big data for disaster management. These benefits include reducing the cost of planning and management; benefiting end-users through better information and decision support as well as enhanced mechanisms to connect stakeholders and global good practice; and enhancing trust and cooperation across sectors and regions, supporting open and equal access to data.

In terms of UAVs, their application with related technologies is associated with sufficient benefits in different modes of disaster risk reduction, thus from a pre-disaster stage of preparedness and planning to post-disaster stages of recovery. All in all, as summed up by Izumi et al. (2019), UAV technologies offer a lot when it comes to monitoring, contingency planning, forecasting and early warning system development, information sharing, communication, situation awareness, assisting in search and rescue missions and infrastructure damage assessment without risking the lives of humanitarian workers. However, as argued other researchers, the combination of UAVs with other technologies can lead to a breakthrough when it comes to disruptive technologies for disaster risk reduction. They suggest that UAV technology is combined with deep learning, contributing to a fast, flexible, and scalable means of identifying potential disasters through processes of monitoring. UAVs combined with deep learning techniques contribute to enhanced disaster modelling. This highlights the potential of integrating and combining Artificial Intelligence (AI) technologies, assisting in providing more accurate images and identifying objects and people, Virtual and Augmented Reality (VR, AR) and the Internet of Things (IoT) with UAVs. The combined applications can enhance mitigation, preparedness, response, and recovery processes (Velev et al., 2019) and assist in risk-informed governance with the integration of multiple actors such as action forces, authorities, citizens, and volunteers paving the way for improved communication, coordination, and collaboration between them (United Nations, 2022). These are made possible by the fact that; enormous data are generated, and this gives alternative causes of actions.

Despite these benefits, there are challenges or issues associated with big data in the way they are generated or collected, as well as how they are used. Adding UAVs also brings further issues as to the deployment of UAVs in collecting data. Examples of the issues are listed below.

a. Ethical and Privacy Concerns

A significant part of the literature highlights regulatory issues and ethical concerns when it comes to the topic of privacy and personal data management as two main recurring issues when discussing the wide implementation of UAV technology for disaster management either for data gathering, or reconnaissance of humanitarian purposes. Wang et al. (2021), draw attention to the social considerations around drones raising issues of participation in humanitarian programs concerning drones, issues of accountability as well as the military origins of UAV technology. Htet (2016) points out that in several cases, in countries where humanitarians operate, there is a lack of legal and regulatory framework for drone technology, giving the example of Typhoon Haiyan in the Philippines and the Nepal Earthquake of 2015 as two disaster cases where the national authorities restricted the use of drones in response efforts. Fontes de Meira and Bello (2020) also discuss the issue of the lack of legislative framework on personal data sharing and guidelines for privacy protection as fundamental cornerstones for the establishment and wider dissemination of new technologies for disaster risk management. However, when it comes to these concerns about the use of big data, this risk can be somewhat minimized by following the ethical guidelines set out by Yang et al. (2019). Using big data collection and usage in the health sector as an example, Yang et al. (2019) propose that the risk of data leakage can be minized through the encryption of personal information, smart duplication of personal data using ciphertext techniques, among others.

b. Cost

One challenge with the use of big data for disaster risk reduction is the need to update or improve the infrastructure to successfully handle the large amount of data needed during a disaster. A particular challenge for updating the infrastructure is the initial installation cost as well as maintenance costs yearly. The cost implications of disruptive technologies are not limited to the maintenance of big data but also to the wider implementation of UAV technology in DRR. Thus, the lack of materials and in certain cases funding, especially when it comes to the construction of remote sensing data processing centers are the many associated costs (UNDRR, 2021). Besides the cost of the infrastructure, there is also the cost associated with the training. Even when the infrastructure is updated, individuals need to familiarize themselves with the new technology, which is crucial for the benefits of achieving maximum utilization. A further constraint remains with the training of humanitarian workers and other professionals on the use of different types of drones (Fontes de Meira & Bello, 2020). Finally, Estrada & Ndoma (2019) conclude that the balance between the hardware and software of UAVs is key to the development of efficient drones for disaster risk reduction efforts.

The challenges of disruptive technology in general do not necessarily prevent its use of them in many situations. In the next section, case study examples of disruptive technologies are presented.

5. Case Study Examples of Disruptive Technology in Disaster Risk Reduction Activities

5.1. Case Example: Using AI and the Internet of Things (IoT) to reduce wastewater network blockages and pollution – Case of Yorkshire Water – UK

a) Overview

Yorkshire is the largest county in the United Kingdom, spanning over 2.9 million acres. Yorkshire Water is the main water supply and wastewater treatment service provider for most of the region. The utility company services West Yorkshire, South Yorkshire, the East Riding of Yorkshire, part of North Lincolnshire, most of North Yorkshire and part of Derbyshire, in England. Figure 1 is a map of service areas covered by Yorkshire water.

In the UK, the Environment Agency is, a part of the United Kingdom government's Department for Environment, Food and Rural Affairs (DEFRA) is the public body responsible for regulating major industries and waste treatment of contaminated land, water quality and resources, fisheries, inland river, estuary and harbour navigations, and conservation and ecology in England. The Environment Agency's annual Environmental Performance Assessment (EPA) assesses the performance of the 9 water and sewerage companies in England and their 2019 report highlighted serious pollution incidents (Environment Agency, 2019). This suggested the water and sewerage companies develop and implement an effective Pollution Incident Reduction Plan (PIRP) to aim for a significant reduction of pollution incidents. To meet the needs of PIRP, the Yorkshire Water developed its pollution incident reduction plan that included the employment of AI and big data as an innovative blockage predictor solution to improve the performance of the sewer network. This helps the company to identify the problems in the sewer network, quickly, enabling them to attend to them and rectify any issues before they escalate. This ultimately minimised the flooding and pollution risks. This innovative solution won the 2021 Water Industry Awards under the category 'Data Analytics, Cloud and AI Project of the Year' (Highly commended - UnifAI Technology - AI for Enhanced Water Quality Monitoring - Poole Harbour).

The solution was cocreated by Yorkshire Water, the University of Sheffield and Siemens Digital Industries and the wide benefits of the applications are largely for the environment and community that is covered by the Yorkshire water supplier. The usual practice in the event of heavy rainfall is to adopt Combined Sewer Overflow as a relief valve to reduce pressure on the sewage system. In this mechanism, the wastewater/greywater is diverted to the waterway resulting in them being polluted and eventually leading to flooding. However, the proposed solution identifies the blockages in advance and helps take action before the system is overwhelmed. This helps to reduce flooding and pollution largely.

Source: https://www.yorkshirewater.com/bill-account/how-we-work-out-your-bill/york-waterworks/

Figure 1: Yorkshire Water Service Area (in blue)

b) *Description of the Disruptive Technology*

In the Yorkshire water solution, AI technology is applied to water level data to detect Combined Sewer Overflows (CSOs) or manholes providing an indication of a blockage. The AI application is hereinafter referred to as SIWA blockage predictor. To identify the sewer blockages, the SIWA blockage predictor needs level data (level readings from each site) including historical data, asset location, local rainfall data, web browser and configuration. Initially, the smart sensors feed water level data into SIWA Blockage Predictor, an application on Siemens' cloud-based, and an open Internet of Things (IoT) operating system, MindSphere (Yorkshire Water, 2019). The analytics are embedded within a web application which enables remote access on Computers and mobile devices, notifying users in advance of any issues (Yorkshire Water, 2019). The AI assesses the performance and characteristics of the sewer network in real-time and allows foreseeing problems (i.e. network blockage) before they actually take place, prompting the Yorkshire Water to deploy engineers to inspect and resolve issues. This prevents flooding in gardens, homes, and rivers with wastewater and minimizes intermittent discharges from CSO that lead to pollution.

The first trial was conducted across 70 sites, involving a range of sewage assets in the region providing up to two weeks advance notice of blockages. The AI in the SIWA blockage predictor tool was able to find 9 in 10 potential issues (University of Sheffield, 2021). This was three times more successful than the existing Yorkshire Water pollution prediction mechanism which relied on statistical methods (Yorkshire Water, 2019). The AI also reduced the number of false positive alerts by half (University of Sheffield, 2021). The co-creators of this application further compared the AI findings against the prevailing mechanism, over 21,000 days of operation and concluded the better relative better performance with the AI application (Yorkshire Water, 2019).

5.2. Key Lessons andChallenges

As mentioned above, the first-ever trial of this initiative exceeded the expectations of the stakeholders involved. However, there are both benefits and challenges to using AI for disaster prevention and mitigation. In terms of the challenges in implementing this technology in the selected field, given that this is a pilot project, publicly available data does not discuss the said aspect in detail. However, the challenges this field encountered before the use of AI can be looked at. Thus, in terms of the need for the use of AI in handling flooding and pollution in relation to Yorkshire Water, the integrated planning and central control manager of Yorkshire Water suggests that the nature of the existing water system was in fact a major challenge. It has been pointed out that the existing network is combined to collect water from toilets, sinks and rainfall. During heavy rainfall, this combined system caters for a heavy risk towards flooding. Moreover, rapid urbanisation, population growth and climate change have further accelerated environmental pollution (van Loosdrecht and Brdjanovic, 2014). Conventionally, the remedy for the CSO pollution had been to establish separate sewers and storage retention tanks. However, these initiatives required a lump sum of investments and in addition, had other challenges such as land availability and issues of handling community grievances (EPA, 2015). Therefore, advanced technology is recognised as the most suitable remedy to address this issue of flooding and pollution of CSO (Sun, et al., 2017; Sun, et al., 2018).

This indeed is a financially viable initiative rather than investing in overall large-scale infrastructural initiatives (Sun et al., 2020). Initially, in the existing Yorkshire water system, false leakage alerts had always been recorded due to background noises (Yorkshire Water, 2021). However, with this given intervention, it has been reported that the false alerts are reduced by 50% (Water Industry Journal, nd). In terms of the policy priority front, this initiative tends to accelerate the achievement of a key goal of the Pollution Incident Reduction Plan 2020-2025 by reducing pollution by 50% (Siemens, 2021). This would further assist the authorities to achieve the target set by the Storm Overflows Taskforce in terms of transparency and open data. The AI also caters towards efficiency in the water systems as it can notify Yorkshire Water of potential threats two weeks ahead and can recognise 9 out of 10 potential issues in comparison to the existing system (Siemens, 2021). This makes the response and mitigation towards the potential flooding and pollution effective.

The challenges in implementing this technology in the selected field, given that this is a pilot project, the publicly available data does not discuss the said aspect in detail. In terms of the need for the use of AI in handling flooding and pollution in relation to the Yorkshire water, the integrated planning and central control manager of Yorkshire Water had claimed that the nature of the existing water system was in fact was a major challenge (Water Industry Journal, nd). It has been pointed out that the existing network is combined in collecting water from toilets, sinks and rainfall. During a heavy rainfall, this combined system caters a heavy risk towards flooding (Water Industry Journal, nd).

5.3. Case Study Example: Immersive Learning of Disaster Risks and Disaster Management Through Metaverse in Japan

a) Overview

Japan as a country is prone to many disasters and this makes it important to take all possible actions to prepare to reduce the impacts of disasters. Therefore, disaster drills and other disaster prevention exercises form the core component of risk reduction activities. In Japan, there are two dimensions of disaster drills namely, 1) the drills for disasters and 2) the drills for disaster management. The first dimention looks at the actions one needs to undertake to prevent the direct effect of the disaster. This is usually based on some basic guidelines of how one should act if any particular disaster occurs. The second dimention is to actively engage oneself with the act of mitigating disasters. In explaining the relevance of disaster drills, Arima and Kawamukai (2022) point out that the necessity of disaster drills for Japan is defined by its topography, geology, weather, and other characteristics because the Ministry of Land, Infrastructure, Transport and Tourism, Government of Japan, estimates that there is a 30 to 70% possibility of a mega earthquake (Nankai Trough earthquake) occurring in the country and estimates devastating consequences. Therefore, the government, people and other stakeholders conceive the urgent need for (1) "hard" disaster prevention measures which entail constructing and strengthening structures such as embankments, dams, and buildings to be resistant to especially earthquakes, and (2) "soft" disaster prevention, such as sophistication of disaster prediction, establishing evacuation systems, and urban development that avoids disaster-risk areas. Thus, disaster risks that cannot be addressed by "hard" disaster prevention measures must be catered for by enhanced "soft" disaster prevention measures through non-structural means (Arima and Kawamukai, 2022).

In this regard, the Government of Japan in 2017 envisaged a plan known as Society 5.0 to incorporate knowledge and technology to make a human-centric society (Cabinet Office, 2023a). It defines new value in the field of disaster prevention in Society 5.0 context that emphasises vital information about the disaster itself, conditions of infrastructures, evacuation shelters and relief information to everyone via individual smartphones or other gadgets. These are hoped to reduce disaster impact and facilitate early recovery from the disaster (Cabinet Office, 2023b). Thus, by incorporating and utilizing the application of technologies such as "AI analysis of big data on observations of disaster-affected areas by satellite, by terrestrial weather radar, or by drones" as well as extracting "damage information based on structural sensors, and road-damage information from automobiles" would enable "optimum delivery of relief materials through drones, self-driving delivery vehicles". The process would also assist in locating "victims immediately through assist suits, rescue robots, etc." (Cabinet Office, 2023b). To enhance public knowledge of the application of these technologies, several sensitization programs have occurred across the country. Furthermore, there will be a dedicated exhibition of Disaster-Prevention DX where utilization of AI and Chatbots and disaster prediction are going to be presented along with disaster simulation experience through VR, Metaverse, etc. in June 2023 (Fire Safety Tokyo, 2023). This notwithstanding, the government is again promoting the conversion of town development to DX (Digital Transformation) as well as building 3D city models for disaster-resistant city development. All such activities involve deep commitment and engagement on the part of participating stakeholders. The focus of the Government of Japan is to enhance Metaverse-based engagement that will define the future of Japanese society. It is anticipated that Metaverse will further facilitate and explore to define the way of living and working better. Metaverse is expected to play the role of catalyst to remove barriers that have been putting restrictions and limitations in terms of transactional activities and physical engagements in various spheres of social interactions among individuals.

b) Description of the Disruptive Technology

In the next section, an example of the application of Metaverse in disaster prevention is presented.

(i) Metaverse in Japanese Context

Metaverse is a coined word that consists of two words, "meta" (transcendent) and "universe" (world), expressing a three-dimensional virtual space where people are connected through avatars using AR (augmented reality) and VR (virtual reality) technology on the Internet. Avatars, or virtual self, can communicate and move through virtual space on the Internet. The world of Metaverse is considered to have (1) enhanced communications and (2) facilitated movement via the presence of avatars. The primary usage of Metaverse in DRR is to make it possible to experience disasters through the presence of avatars as the virtual self that represents an individual. Disaster resilience in Japanese society has immensely benefitted from regular disaster drills that have been diligently implemented. However, Metaverse brings new dimensions that take advantage of the strength of being able to communicate and move through avatars in space on the Internet. For instance, wearable motion sensors and a Head Mounted Display facilitate the synchronization of the intended motions of users and depict their activities as avatars in cyberspace. Such activities go beyond just the avatars but give a real experience of disaster scenarios and a reaction by an individual through practising and learning.

Learning Metaverse evacuation drill, for example, is self-trainable and could include many participants to simulate actions in disaster events. In 2018, Tokyo Fire Department-led Tokyo International Fire and Safety Exhibition showcased VR enabled fire evacuation drill. This exhibition is one of the largest fire and disaster prevention exhibitions in Japan and it is held once every five years (Fire Safety Tokyo, 2018). In June 2023, there will be a dedicated exhibition of Disaster-Prevention DX where utilization of AI and Chatbots and disaster prediction are going to be presented along with disaster simulation experience through VR, Metaverse, etc. (Fire Safety Tokyo, 2023).

While corporate investments supporting such Metaverse construction involve major players in the Japanese economy, its knowledge acquisition and application have extended to educational institutions as well as municipalities in Japan which are steadily evolving Metaverse as a platform for imparting inclusive participation in disaster management. In the education sector, it includes engaging educational institutions from primary schools to high schools where mostly disaster drills are an important part of school education. On the other hand, DRR education has been practically pursued with community participation, administered by local governments with the cooperation/participation of local industries.

In the next section, we present a case example of visualization of DRR activities through the analysis and projection of disaster-related activities on AR capabilities.

(ii) Case of Project PLATEAU: AR Visualization in Metaverse

In 2020, the Ministry of Land Infrastructure, Transport and Tourism, Government of Japan, initiated a project called Project PLATEAU. It builds and utilizes 3D city models for disaster-resistant city development. This is a project that promotes the development and utilization of 3D models of cities to DX. Forty-eight cities all over Japan have got superimposed maps that indicate simulated structural inundation or other events in their respective areas on 3D city models. This gives a real-life perspective of disasters to the public to explain what to anticipate in times of disaster and simulate their possible ways and means of disaster mitigation (Metaverse Souken, 2023).

Project PLATEAU has created 3D city models with a web system that functions as a damaged housing visualization system to automatically detect buildings damaged by landslides and other disasters. A smartphone application visualizes the results at the disaster site with an AR application. A damaged dwelling visualization system is developed by adding functions to a Symmetry Digital Twin Cloud (SDTC), a GIS data integration and visualization system developed by Symmetry Dimensions Inc. based on CesiumJS. SDTC as a web application integrates and visualizes various data of a city, building a digital twin. It also has functions that include uploading point cloud data obtained from drones. Based on the SDTC, this system performs spatial analysis of point cloud data acquired by drones and 3D city models to detect buildings damaged by for instance sediment runoff. Using this system, the output's accuracy and usefulness are verified with the cooperation of Kakegawa City Hall and Kakegawa City Central Fire Station/Fire Brigade in Shizuoka Prefecture by the Ministry of Land, Infrastructure and Transportation (Ministry of Land, Infrastructure, Transport and Tourism 2023). *Figure 2*~~*Figure 2*~~ shows the application of PLATEAU in Kakegawa-city in a simulated mode of disaster assessment.

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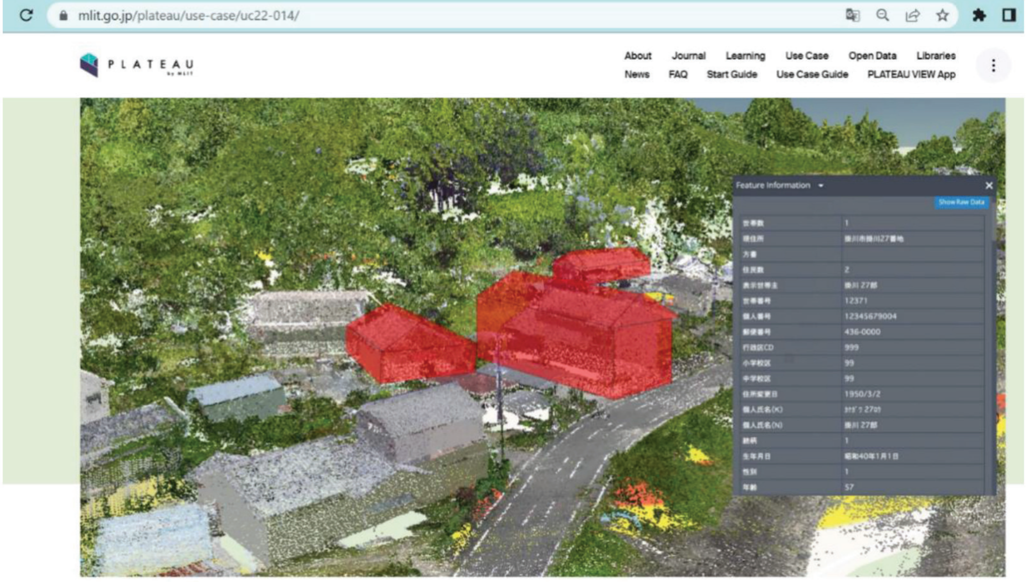

世帯数	1
現住所	掛川市掛川27番地
方書	
住民数	2
表示世帯主	掛川 27郎
世帯番号	12371
個人番号	12345679004
郵便番号	436-0000
行政区CD	999
小学校区	99
中学校区	99
住所変更日	1950/3/2
個人氏名(K)	[illegible]
個人氏名(N)	掛川 27郎
続柄	1
生年月日	昭和40年1月1日
性別	1
年齢	57

*Source: Project PLATEAU web page (*https://www.mlit.go.jp/plateau/use-case/uc22-014/, accessed on 15 March 2023)

Figure 2: Promotion of Sediment Disaster Countermeasures Using 3D Data: Case of Kakegawa-city, Shizuoka Prefecture, Japan (Project PLATEAU)

Furthermore, there is an AR visualization app which gives information on disaster situations and works in conjunction with the disaster-damaged dwelling visualization system to display a 3D city model. Buildings judged as “damaged dwellings” are displayed on an AR screen. This enables the location and resident information to be confirmed at the disaster site. The system further builds a database linking "building IDs" of the 3D city models assigned to the building model in advance with the residential information. This information includes lot numbers and residential addresses, as well as other information gathered from the basic resident register at the city government offices. Thus, the "damaged residence" can be identified by the number, residence, name, age, etc. of residents who may have suffered from the event.

In the analysis process, an AI algorithm is applied in order to detect whether a house is moving in a certain direction, or the roof has disappeared. The algorithm determines whether is safe or should be identified as a "damaged house". Part of this decision is determined by the condition of the roof of the building. Thus, a roof is measured by a drone as a clue to detect building differences, using the area ratio of each roof as a threshold to determine whether the roof of the point cloud data is horizontal/vertical to the ground surface. The modelling is built based on the game engine called Unity, and the location of the building is determined using a smartphone camera which is built using the ARCore Geospatial API provided by Google as a Visual Positioning System (VPS). Additionally, positioning using GPS is also determined, considering the fact that in the event of a landslide or other disaster, changes in the surrounding environment may make it difficult to estimate location information using a VPS. From all these analyses, buildings that are estimated to be “damaged dwellings” are colored in red and projected to improve visibility (Ministry of Land, Infrastructure, Transportation and Tourism 2023). Figure 3 show the colorization of the buildings based on modelled scenarios.

ted:

ふりがな 氏名	シンメトリー たろう Symmetry 太郎
住所	〒000-0000 東京都○○区○○町1-1-1 電話(000) 00 − 0000
生年月日	1990年10月 1 日生
性別	✓ 男 □ 女
住民票コード	0 0 0 0 0 0 0 0 0 0 0

Source: Project PLATEAU web page (https://www.mlit.go.jp/plateau/use-case/uc22-014/, accessed on 15 March 2023)

Figure 3: Damaged Dwellings: Case of An Individual's Residential Details in Tokyo (Project PLATEAU)

Overall, it can be found that the detection of damaged houses which compares point cloud data taken by drones with 3D city models enhances effectiveness in grasping the status of damages. The open city models provided by Project PLATEAU seamlessly integrated with the building model precisely, enabling AR/VR-based fire evacuation training to cover the inside and outside areas of a high-rise building in Tokyo, for example. However, not all municipalities in Japan are covered by the project. Thus, since the processing load in visualizing a virtual world based on Project PLATEAU requires a huge amount of data, some means of optimizing the visualization are required to extend the application to other areas (Mitsuhara and Shishibori, 2022).

5.4. Key Lessons andChallenges

a) Benefits of Metaverse Application in DRR

Experiential Learning Beyond Physical Commitments

Experiential learning is envisaged to be carried out through virtual individual beings in the form of avatars. By entering the virtual space as an avatar, you can communicate with other avatars since the metaverse activates virtual interactions with distance. Metaverse allows actions such as ``going" and "touching" through avatars (Liplonext, 2023). Thus, Metaverse can remove many hurdles and restrictions which physical interactions would place, encouraging stakeholders to join from other educational institutions within the country as well as from abroad. Active experiential learning enables to widening of the circle of the participants on Metaverse. The individuals who would take part in disaster drills could be able to experience close-to-real virtual disaster drills effectively. Practising and improving their assessment of the threats and dangers of the projected disasters can be simulated based on the disaster profile of the concerned area, region and country. They will be able to get themselves self-educated through Metaverse to learn to make decisions quickly for necessary evacuation, sometimes on their own, and some other times as a community.

b) Challenges with Metaverse Application in DRR

(i) Fusion of Real and Digital Technologies and New Challenges

Industrial DX aims at "Realizing the development of entire industries by utilizing a wide range of industry knowledge and DX functions to connect industries, companies, and communities and solving social issues through the fusion of real and digital technologies (Fujitsu Limited, 2023)." Such social engagement will impact society while posing some new challenges.

(ii) Privacy Issues and Prior Consent

Metaverse can, by entering a pseudo-real world, collect private and personal information in comparison to conventional IT services. It could be difficult for users to correctly recognize the risks. User security features need to be provided beforehand with a full understanding of security risks in specifications and services provided through Metaverse (Nomura Research Institute, 2022). While it is necessary to define the priorities for proper planning of (1) education for disaster risk reduction before the disaster as well as (2) evacuation and emergency rescue operations during and post-disaster, the individuals' rights and privacy need to be protected. This is especially true when multiple agencies could be allowed to have access to the personal details of the residents. It should be also noted that disaster mitigation and emergency rescue operation could be a potential source of business opportunities for private entities.

(iii) Evacuate or Not: Behavior of Participants

Evaluation of an evacuation process still needs to be established. The emergency time mode has both the participants who opt for evacuation and those who opt for not evacuating. Participants' evacuation behavior, the impact of the visuals of avatars upon the co-participants, the utterance of the participants and associated emotions, etc. still needs to be studied (Mitsuhara and Shishibori, 2022)

From the case study examples, it becomes clear that disruptive technologies can provide opportunities to course designs, training and learning experiences. Nevertheless, this report (Output 4) proposes that, such an initiative look at the adoption of disruptive technology in a holistic manner to address online distance DRR education as identified in Output 1 of the project, while also considering the assumptions of effective online DRR education proposed in Output 2.

6. Establishing Vital Elements and Attributes of Disruptive Technology in DRR

The application and use of disruptive technologies not only show the various benefits but also depict flexibility in various areas of utilization. Based on the case study examples and the discussions so far, the following attributes can be derived as vital components that drive the relevance of technology in DRR activities.

a. Accuracy *(e.g. Kang, 2021, OECD, 2020)*
b. Accessibility *(e.g. Estrada & Ndoma, 2019, OECD, 2020, Kang, 2021*
c. Affordability *(e.g. Estrada & Ndoma, 2019)*
d. Reliability *(e.g. OECD, 2020)*

e. Efficiency *(e.g. OECD, 2020, Harshadeep & Young, 2020)*
f. Reachability *(e.g. Kang, 2021)*
g. Flexibility *(e.g. Kang, 2021)*

In relation to the application of the various tools of disruptive technology from the case examples, the attributes are described below.

6.1. Accuracy

An important element of all the case examples given in the report is that irrespective of the disruptive technology type, the accuracy of the results is paramount. This is understood to be enabled by its iterative nature where many of the processes carried out by the deployed technology are able to run repeatedly by acquiring huge datasets to predict the best scenarios and options. Be it AI, UAV, AR or VR, its final output often shows results that are close to real situations. This enhances better planning against disasters and makes countermeasures that best-fit situations that avert disaster impacts.

6.2. Accessibility

Climate change and increased risks of large-scale disasters have made preparatory education more meaningful and crucial to ensuring the survival of human lives. However, due to the different characteristics of living people that live in risk-prone areas, some people are unable to access vital information and knowledge. Yet, the example of using 3D models in virtual space in Japan allows different stakeholders such as city authorities, fire brigades, and residents in many cities to access risk analysis and disaster simulations via their smartphones or with AR or VR headsets. It also offers them access and experiences that come close to near or real-life situations should disasters occur.

6.3. Affordability

Taking steps towards disaster is important, especially in disaster-prone countries. However, the use of technologies has always been associated with a high cost of production and utilization. For example, when developing disaster drills exercises with an immersive experience, it is necessary to pay attention to newly available options to cut down the cost. Producing interactive operations in VR with a high-quality CG experience generally costs more than 10,000 USD. Head Mounted Device screen update speed slower than 30 fps would make the user uncomfortable. Also, complicated 3D-CG models in VR space tend to make the frame rate slow. Hence, disaster education with VR needs 3-5 minutes for each participant, so it is not feasible to involve many people at a time . However, once an initial set-up is made (for instance the creation of 3D cities, an AI algorithm is programmed, or the right drone is procured), it becomes affordable per the consequences of what would have happened without it. (Hesseldahl et al., 2016) also, reiterate that the price of new technologies is reducing and would continue as they become widespread.

6.4. Reliability

By definition, reliability is “the extent to which an experiment, test, or measuring procedure yields the same results on repeated trials” (https://www.merriam-webster.com/) and this is why a reliable process is important in risk management. Stakeholders need to be sure that, outcomes of situations are reliable and can be trusted to make informed decisions. (Bible et al., 2017) have demonstrated the reliability of blockchain technology, (Pokorni, 2021) has also given that of AIs perspective. Further the adoption of the combination of IoT and AI in the Yorkshire water to key decisions on sewers in the UK reassures how reliable disruptive technologies are.

6.5. Efficiency

One attribute of disruptive technology that can increase efficiency is its ability to receive automated commands and workflows. Things that would have taken time to produce can be automated and the output would produce excellent results that are reliable for decision-making. Again, with the example of Yorkshire water, the AI algorithms are able to detect potential sewer blockages even before they occur because the system is built by training the AI in the best and worse cases of operation. Realizing the best and worse scenarios based on training examples is important for the aspect of realizing efficiency.

6.6. Reachability

Studies show that the population of internet users across the world has increased over the years from 32.7% of the world's population in 2011 to about 66% of the population as of 2022 (Shankaraiah, 2022). The significance of these figures is the fact that most disruptive technologies run on the internet, indicating that their application and dissemination of results have a wide audience. In risk reduction and management, timely information on scenarios, progress and outputs is crucial to prepare for any eventualities. In the case of Metaverse in Japan, people can receive disaster early warning information on their smartphone. Such information is delivered based on the analysis of various measuring instruments which through AI, IoT, and other technologies, detecting environmental anomalies to predict potential disasters or give alerts before disasters occur. Furthermore, using AR or VR with 3D-modeled cities provides the opportunity for different stakeholders to experience, understand and assess countermeasures in disaster events. What is important here is that the availability of the internet is vital for disseminating information to a wider audience.

6.7. Flexibility

One aspect of disruptive technology that keeps occurring in their application is flexibility. Flexibility is where the technology is able to adjust its characteristics to the context in which it's been deployed. As evidenced in the discussions above, disruptive technologies can be customized based on the needs and aspirations of the user. For instance, it is realized that UAVs have multiple uses depending on when and at what stage of the disaster preparedness process. Furthermore, various algorithms are running different scenarios on different platforms to provide accurate and reliable information. Therefore, depending on the prevailing situation, each technology can be adjusted to perform specific tasks and requirements.

Therefore, how can these attributes to utilized in online distance education in DRR? The next section explores such opportunities.

7. Exploring Opportunities of Disruptive Technology in Online Distance Learning Education in DRR

DRR education is an experience-based, and action-oriented learning in which schools serve as central learning hubs (Shaw, Takeuchi, Ru Gwee, & Shiwaku, 2011), as such disruptive technologies can be adopted in online distance education on DRR. As discussed in the Lund University Report for Output

2 of the INCLUDE Project, when it comes to disaster risk reduction education, UAVs can be used to familiarize students and professionals with the technology and use of drone technology through relevant courses and trainings.They can also be utilized as a means to enhance the effectiveness of DRR education itself. The documentation and analysis of data collected by UAVs are also useful for education, research, and training purposes (Khan et al., 2021). What is more, UAVs can assist in disaster education for children while at the same time integrating their perspective into DRR knowledge and practice. Drone mapping and the use of its outcomes as basis for the recreation of spatial characteristics by children using Minecraft and LEGO can be seen as a creative way of familiarizing children with the topic of DRR while integrating their own unique view (Le De et al., 2020). Children are considered amongst the most vulnerable groups during a disaster (UNICEF & UNISDR, 2011). This can be especially meaningful in hazard-prone areas. These notwithstanding, in Output 1, it was established that the COVID-19 pandemic changed the system of teaching and learning from face-to-face to online education. In this context, online education is explained to mean all activities relating to teaching and learning that are performed at a distance and online in a formal study context, or more precisely through schools. This supposedly means that, once there is a continuation of educational activities initiated through the schools, then DRR education and learning can be achieved.

Therefore, from the interview and online surveys conducted in Output 1, it was realized that for general online education, the COVID-19 pandemic opened new opportunities to broaden teaching and learning to a broader audience, especially for people who by their work didn’t have time to pursue face-to-face education but through online studies, can attend schools. However, when it comes to DRR education, it becomes obvious from Output 1 that certain elements were lacking due to the practical nature of DRR education. Furthermore, other challenges that arose from online distance learning education in DRR included issues of a digital divide and social injustice, technological insufficiencies, emotional disturbances and health issues, and lack of privacy and security concerns. Therefore, to explore the opportunities of adopting disruptive technology in online distance learning education in DRR, the following questions are asked.

a. Can online distance learning education in DRR provide an accurate understanding of DRR issues to educators and learners to achieve mutual consensus on issues?
b. Can online distance learning education in DRR be readily accessible to all stakeholders?
c. Can online distance learning education in DRR be affordable?
d. Can online distance learning education in DRR be reliable?
e. Can online distance learning education in DRR be efficient for both educators and learners?
f. Can the players in online distance learning education in DRR be easily reached?
g. Can online distance learning education in DRR be flexible to meet the needs and aspirations of the payers involved?

It is believed that the answers to these questions would strengthen online education in DRR and reduce the challenges identified. However, the answers to the above questions could be first established from the content of Output 2, which sets a framework to reimagine online distance learning education that can support the diverse DRR. In the context of fundamental elements for building online distance learning education in DRR, the following assumptions were made in Output 2;

1. DRR is a highly multi- and inter-disciplinary field
2. Programs are highly practical
3. There is an equal focus on skills and knowledge in programs
4. The interaction between students is critical to the overall learning experience
5. Students learn from each other as much as, if not more than, knowledge imparted by tutors
6. Tacit knowledge is critical for DRR education and needs to be factored into any learning platform design and functionality
7. Students tailor their learning experience and activities in an individual and unique way informed by their background and future career plans
8. In DRR education students can't be funnelled through a narrow mould and come out identical replicas of each other
9. Learning platforms need to allow for flexibility and an individualized approach to learning
10. In certain cases, online learning and its functions cannot replace the benefits of classroom-based learning or field training

With the above in mind, a holistic approach is required to broadly take advantage of the merits of disruptive technologies in online distance learning education in DRR. For this matter, we propose the following assumption to serve as the backbone of any approach or strategy.

Assumption: *..that the holistic approach should be able to take advantage of the vital attributes of the disruptive technologies (such as the examples given in section 6), consider the fundamental assumptions regarding online education (Output 2) and must be able to address the identified challenges of online distance learning education in DRR (Output 1) so as provide an improved teaching and learning oriented solutions (see summary in Figure 4~~Figure 4~~). This needs to provide a new model of collaborative learning with the aim to offer high-quality, efficient, and social learning-bsed education for universities, industry, local communities, NGOs and other relevant parties. consideration (Output 3).*

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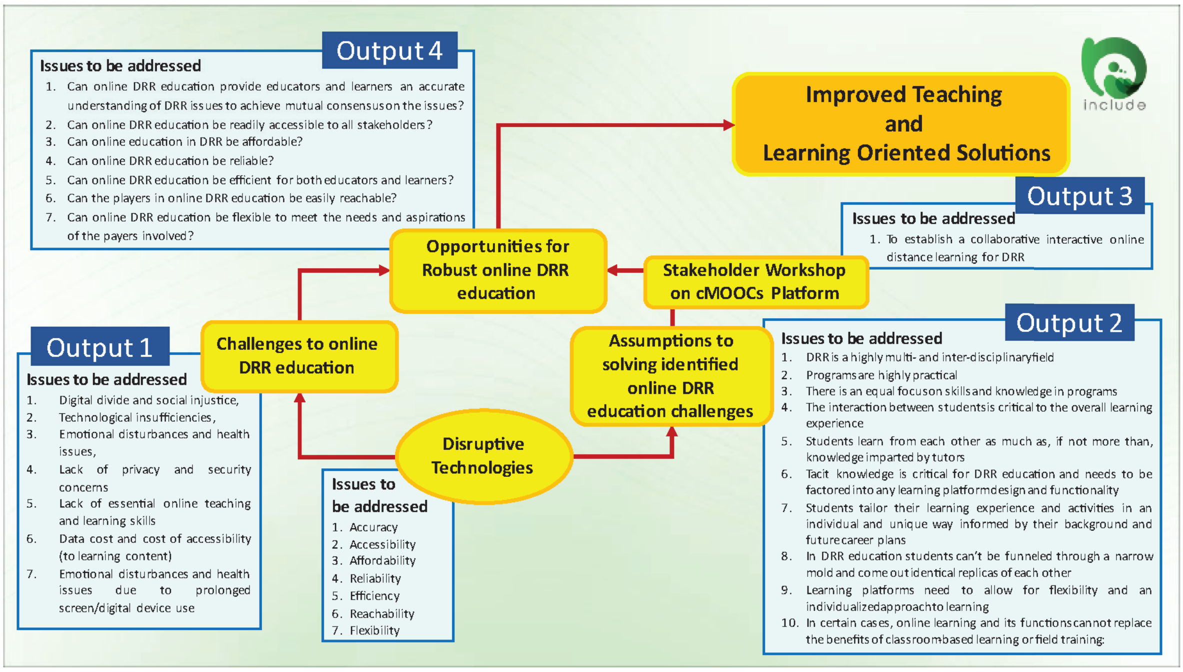
Figure 4 below shows the relationship of each output to lead to offer improved teaching and learning oriented solutions.



Output 4

Issues to be addressed

1. Can online DRR education provide educators and learners an accurate understanding of DRR issues to achieve mutual consensus on the issues?
2. Can online DRR education be readily accessible to all stakeholders?
3. Can online education in DRR be affordable?
4. Can online DRR education be reliable?
5. Can online DRR education be efficient for both educators and learners?
6. Can the players in online DRR education be easily reachable?
7. Can online DRR education be flexible to meet the needs and aspirations of the payers involved?

Output 1

Issues to be addressed

1. Digital divide and social injustice,
2. Technological insufficiencies,
3. Emotional disturbances and health issues,
4. Lack of privacy and security concerns
5. Lack of essential online teaching and learning skills
6. Data cost and cost of accessibility (to learning content)
7. Emotional disturbances and health issues due to prolonged screen/digital device use

Issues to be addressed

1. Accuracy
2. Accessibility
3. Affordability
4. Reliability
5. Efficiency
6. Reachability
7. Flexibility

Output 3

Issues to be addressed

1. To establish a collaborative interactive online distance learning for DRR

Output 2

Issues to be addressed

1. DRR is a highly multi- and inter-disciplinary field
2. Programs are highly practical
3. There is an equal focus on skills and knowledge in programs
4. The interaction between students is critical to the overall learning experience
5. Students learn from each other as much as, if not more than, knowledge imparted by tutors
6. Tacit knowledge is critical for DRR education and needs to be factored into any learning platform design and functionality
7. Students tailor their learning experience and activities in an individual and unique way informed by their background and future career plans
8. In DRR education students can't be funneled through a narrow mold and come out identical replicas of each other
9. Learning platforms need to allow for flexibility and an individualized approach to learning
10. In certain cases, online learning and its functions cannot replace the benefits of classroom based learning or field training:

Figure 4: Assumptions of Utilizing Disruptive Technology in Online DRR Education

In view of such proposed assumptions, the following examples are given as some possible strategies.

7.2. Holistic Examples of Utilizing Destructive Technologies in Online Distance Learning Education in DRR

a) *Augmented Virtual Environment for DRR Teaching and Learning: An Alternative to Ordinary Online DRR Education*

Among the many challenges of online distance learning education in DRR, inactive interaction between educators and learning has proven to be a key obstacle to obtaining feedback, exploring peer-to-peer active learning, and experiencing the practicality of DRR education. Elements from the Metaverse example in Japan gave an insight into the realities of providing a learning environment where teaching, learning, exploration, and disaster preparedness activities could be explored using VR/AR. Already, some AR applications have applications invented by Dr Tomoki Itamiya of Kanagawa Dental University (Japan) and have been used in more than three hundred cases in schools, and communities for disaster drills exercises for simulated situations such as fires, smoke, flooding, and earthquakes (Chunichi Shinbun, 11 March 2023). Such demonstration was also showcased during Inclusive Disaster Digital Education Seminar and Stakeholder Interaction on December 1, 2022, in Tokyo Japan. Therefore, exploring similar technology in online distance learning education in DRR could provide the needed interactions and participation of both educators and students. Similarly, creating a virtual environment for DRR education can provide avenues where avatars, model cities and characters could be simulated will not only improve interaction and experience but can also bring people together irrespective of time zones, location, gender, or other elements that could disenfranchise others. It is again worth noting that, the online survey conducted in Output 1 revealed that both educators and students have different preferences as to which teaching and learning type (synchronous/asynchronous/blended) but in a virtual teaching and learning environment many elements can be made according to the preference or choice. Hence, with an augmented virtual teaching and learning environment, many of the challenges can be reduced and the different aspirations could also be met.

b) Student Learning Enhancement Through Text Analytics: Case Study

Several obstacles hinder online distance education, especially for students with different backgrounds. However, since online education may continue even after the end of the COVID-19 pandemic, it is also important to aid teaching and learning that takes advantage of the numerous datasets around us. There are already existing text analytics and text mining approaches but many cannot develop text material alternatives (perform a multivariant design), perform multiple criteria analysis, automatically select the most effective variant according to different aspects (popularity of a text (citation index of papers (Scopus, ScienceDirect, Google Scholar, etc.) and authors (Scopus, ScienceDirect, Google Scholar, etc.), Top 25 papers, impact factor of journals, supporting phrases, document name and contents, density of keywords), calculate utility degree and market value. These features are important in the current setting of higher education.

Here we present a new model that can perform the functions. To the best of the knowledge herein, these functions have not been previously implemented; thus, this is the first attempt to do so.

Text mining, sometimes alternately referred to as text data mining, roughly equivalent to text analytics, refers to the process of deriving high-quality information from text. High-quality information is typically derived through the divining of patterns and trends through means such as statistical pattern learning. Text mining usually involves the process of structuring the input text (usually parsing, along with the addition of some derived linguistic features and the removal of others, and subsequent insertion into a database), deriving patterns within the structured data, and finally evaluation and interpretation of the output. 'High quality' in text mining usually refers to some combination of relevance, novelty, and interestingness. Typical text mining tasks include text categorization, text clustering, concept/entity extraction, production of granular taxonomies, sentiment analysis, document summarization, and entity relation modelling (i.e., learning relations between named entities) (Machine Learning Market 2013).

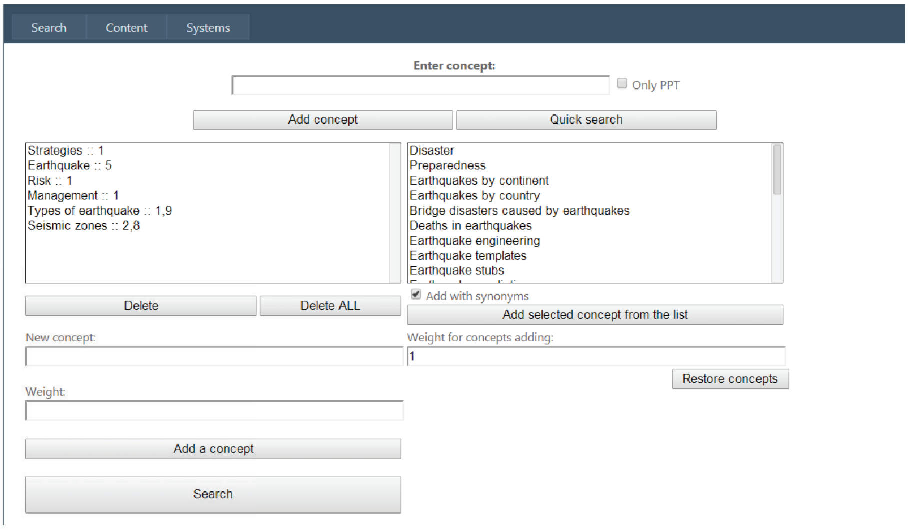
a. The New Model: Text Analytics Model and System for INCLUDE Project

The essence of this model research involves the Text Analytics Model which is designated to select the most rational, integrated text material from a library of documents. It covers the inputting of a bag of concepts space; selecting, processing, and indexing information in accordance with the inputted bag of concepts space and User Model; formulating the results of the retrieval and finally showing them to the user. Further after selecting, processing, and indexing documents, it covers the selecting out of composite parts (chapters/sections/paragraphs) of the documents under analysis and, after that, performing the multi-criteria analysis of the composite parts. This is followed by the designing of alternative variants of the selected information and performing a multi-criteria analysis of the summarized integrated alternatives of the text by which the retrieval results are then formulated. Once the selection processing and indexing of information has been completed, selecting out of the composite parts of the documents and their multi-criteria analysis are performed. Further alternative variants are designed, these are analyzed, and the most rational alternative is selected. All this makes the text analytics system more flexible and more informative since it selects out electronic information as much by area as by coverage.

The multi-criteria analysis of the most rational text materials from a library of documents under analysis covers the complex determination of criteria weights considering their quantitative and qualitative characteristics. It includes a multi-criteria evaluation of the text materials defining the utility and market value of the text materials. Text Analytics Model permits selecting the maximally rational information in the coverage that the user desires. The designing of alternative variants provides the user with an opportunity to supplement and/or correct the already inputted bag of concepts space, modify the weights, and then repeat the search. In other words, the user by using User Model is provided with an opportunity to intervene in the occurring retrieval and to redirect it; thus, the retrieval takes into account the user-selected priorities and the existing situation.

The designing of alternative variants from the selected text materials contained in a library of documents covers the following stages: a) development of a table of codes of text materials from a library of documents, b) rejection of inefficient versions, c) computer-aided development of summarized, integrated text alternatives based on the codes compiled during Stage a), d) development of summarized, integrated text alternatives and the conceptual and quantitative information describing them and e) development of a summary decision-making table of all the obtained summarized, integrated text alternatives and relevant conceptual and quantitative information overall.

At the beginning of a search, a user can submit the following kinds of search requirements: The user indicates the goal or goals for the search – research, practical or cognitive. The user notes the possibilities of interest to him/her while conducting the search: research literature (books, academic articles and the like), practical literature or popular literature; the user requests or selects bag of concepts space (see Figure 5); the user establishes various limitations (volume of the material under search by pages, desired time for reading a lecture by minutes and the like). To limit the number of search results showing the pages that include the concepts in question (or to restrict the search by the duration of reading), tick the option Advanced search options below the button Search. Additional fields appear: Approximately... pages and Approximately for: ... minutes. You will also see round buttons to choose search either by the number of pages (default) or by the duration of the reading.



☐ Only PPT

Strategies :: 1
Earthquake :: 5
Risk :: 1
Management :: 1
Types of earthquake :: 1,9
Seismic zones :: 2,8

Disaster
Preparedness
Earthquakes by continent
Earthquakes by country
Bridge disasters caused by earthquakes
Deaths in earthquakes
Earthquake engineering
Earthquake templates
Earthquake stubs

☑ Add with synonyms

Weight for concepts adding: 1

Figure 5: User window of the Text Analytics for the INCLUDE Project

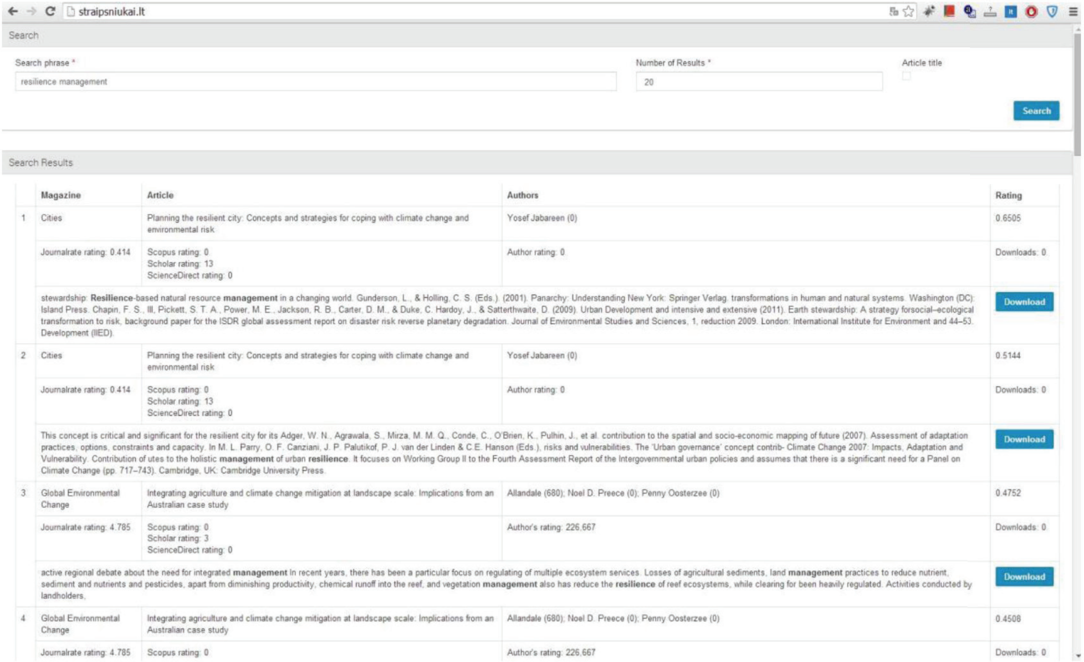
The Agent subsystem accumulates information about a user and stores his/her individual data. This information can be explicit (year of birth or university graduation) or implicit. The main skills of a user are implicit. They consist of informal and unregistered knowledge, practical experiences, and skills. Such data are very important because they describe a user's experience. Information about a user's existing education, needs and the like accumulates in the Agent subsystem. As a user's historical search information is being analyzed, his/her initial search requirements can be refined (or made more specific). In this case, the user's behavior is under analysis; for example, which documents the user does or does not select for review, how often a document is viewed and how much time is spent looking at it along with the use of the drag function are all under observation. This may partially be called the analysis of user-conducted searches, the agent function. The Agent subsystem accumulates statistical information about the previous searches conducted by a user in a matrix form: bag of concepts space of a search; results of a search; how many times a user modified the initial search before suitable results were gained; the most popular resources and Internet website addresses employed by the user; how many times did a user read the selected material and how much time was spent doing so.

This way the automatic search is actually personalized by applying the historical information gathered by the Agent subsystem: bag of concepts space under search is refined (or made more specific); information about the user's education, work experience and search needs are considered; the user's most frequently employed resources, Internet website addresses and authors are considered; the user's opinion regarding the significance of the documents gained by the results of a search are considered.

The following factors determine a rational text:

- Citation index of papers (Scopus, ScienceDirect, Google Scholar) (Figure 6)
- Citation of authors (Scopus, ScienceDirect, Google Scholar, etc.) (Figure 6)
- Top 25 papers

- Impact factor of journals
- Popularity of a text (citation index, number of readers, time spent reading)
- Reputation of the documents
- Supporting phrases
- Document name and contents
- Density of keywords



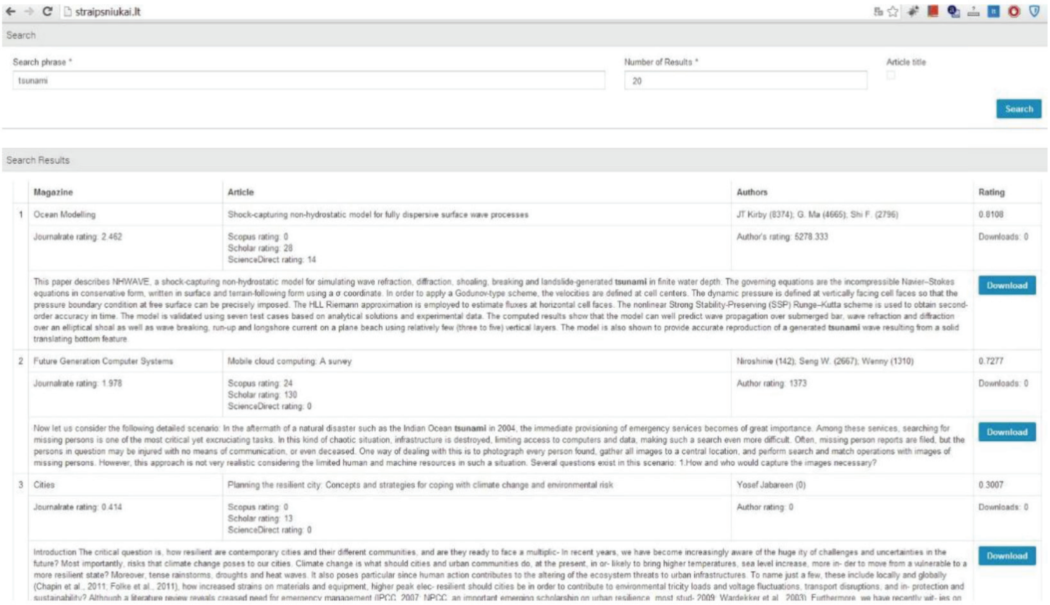
Search phrase *: resilience management

Number of Results *: 20

Article title ☐

Search Results

	Magazine	Article	Authors	Rating
1	Cities	Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk	Yosef Jabareen (0)	0.6505
	Journalrate rating: 0.414	Scopus rating: 0 Scholar rating: 13 ScienceDirect rating: 0	Author rating: 0	Downloads: 0
	stewardship: **Resilience**-based natural resource **management** in a changing world. Gunderson, L., & Holling, C. S. (Eds.). (2001). Panarchy: Understanding New York: Springer Verlag. transformations in human and natural systems. Washington (DC): Island Press. Chapin, F. S., III, Pickett, S. T. A., Power, M. E., Jackson, R. B., Carter, D. M., & Duke, C. Hardoy, J., & Satterthwaite, D. (2009). Urban Development and intensive and extensive (2011). Earth stewardship: A strategy forsocial–ecological transformation to risk, background paper for the ISDR global assessment report on disaster risk reverse planetary degradation. Journal of Environmental Studies and Sciences, 1, reduction 2009. London: International Institute for Environment and 44–53. Development (IIED).			Download
2	Cities	Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk	Yosef Jabareen (0)	0.5144
	Journalrate rating: 0.414	Scopus rating: 0 Scholar rating: 13 ScienceDirect rating: 0	Author rating: 0	Downloads: 0
	This concept is critical and significant for the resilient city for its Adger, W. N., Agrawala, S., Mirza, M. M. Q., Conde, C., O'Brien, K., Pulhin, J., et al. contribution to the spatial and socio-economic mapping of future (2007). Assessment of adaptation practices, options, constraints and capacity. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden & C.E. Hanson (Eds.), risks and vulnerabilities. The 'Urban governance' concept contrib- Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of utes to the holistic **management** of urban **resilience**. It focuses on Working Group II to the Fourth Assessment Report of the Intergovernmental urban policies and assumes that there is a significant need for a Panel on Climate Change (pp. 717–743). Cambridge, UK: Cambridge University Press.			Download
3	Global Environmental Change	Integrating agriculture and climate change mitigation at landscape scale: Implications from an Australian case study	Allandale (680); Noel D. Preece (0); Penny Oosterzee (0)	0.4752
	Journalrate rating: 4.785	Scopus rating: 0 Scholar rating: 3 ScienceDirect rating: 0	Author's rating: 226,667	Downloads: 0
	active regional debate about the need for integrated **management** In recent years, there has been a particular focus on regulating of multiple ecosystem services. Losses of agricultural sediments, land **management** practices to reduce nutrient, sediment and nutrients and pesticides, apart from diminishing productivity, chemical runoff into the reef, and vegetation **management** also has reduce the **resilience** of reef ecosystems, while clearing for been heavily regulated. Activities conducted by landholders.			Download
4	Global Environmental Change	Integrating agriculture and climate change mitigation at landscape scale: Implications from an Australian case study	Allandale (680); Noel D. Preece (0); Penny Oosterzee (0)	0.4508
	Journalrate rating: 4.785	Scopus rating: 0	Author's rating: 226,667	Downloads: 0



Search phrase *: tsunami

Number of Results *: 20

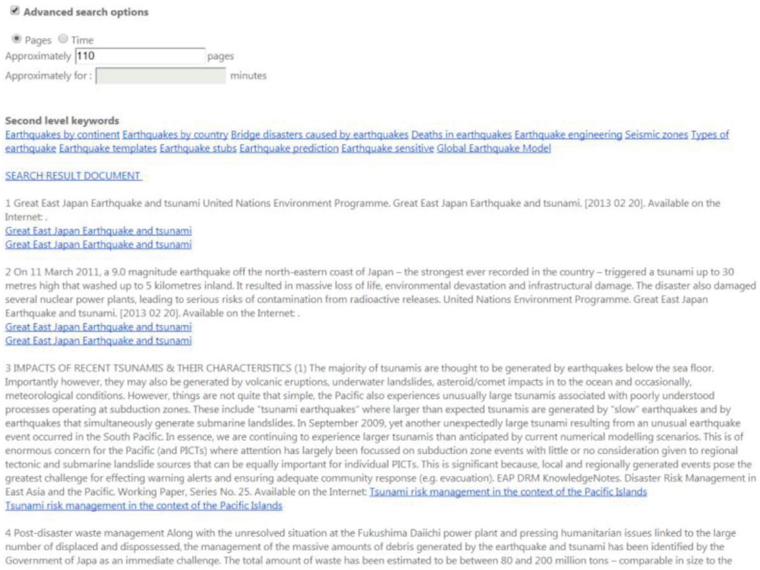
Article title ☐

Search Results

	Magazine	Article	Authors	Rating
1	Ocean Modelling	Shock-capturing non-hydrostatic model for fully dispersive surface wave processes	JT Kirby (8374); G. Ma (4665); Shi F. (2796)	0.8108
	Journalrate rating: 2.462	Scopus rating: 0 Scholar rating: 28 ScienceDirect rating: 14	Author's rating: 5278.333	Downloads: 0
	This paper describes NHWAVE, a shock-capturing non-hydrostatic model for simulating wave refraction, diffraction, shoaling, breaking and landslide-generated **tsunami** in finite water depth. The governing equations are the incompressible Navier–Stokes equations in conservative form, written in surface and terrain-following form using a σ coordinate. In order to apply a Godunov-type scheme, the velocities are defined at cell centers. The dynamic pressure is defined at vertically facing cell faces so that the pressure boundary condition at free surface can be precisely imposed. The HLL Riemann approximation is employed to estimate fluxes at horizontal cell faces. The nonlinear Strong Stability-Preserving (SSP) Runge–Kutta scheme is used to obtain second-order accuracy in time. The model is validated using seven test cases based on analytical solutions and experimental data. The computed results show that the model can well predict wave propagation over submerged bar, wave refraction and diffraction over an elliptical shoal as well as wave breaking, run-up and longshore current on a plane beach using relatively few (three to five) vertical layers. The model is also shown to provide accurate reproduction of a generated **tsunami** wave resulting from a solid translating bottom feature.			Download
2	Future Generation Computer Systems	Mobile cloud computing: A survey	Niroshinie (142); Seng W. (2667); Wenny (1310)	0.7277
	Journalrate rating: 1.978	Scopus rating: 24 Scholar rating: 130 ScienceDirect rating: 0	Author rating: 1373	Downloads: 0
	Now let us consider the following detailed scenario: In the aftermath of a natural disaster such as the Indian Ocean **tsunami** in 2004, the immediate provisioning of emergency services becomes of great importance. Among these services, searching for missing persons is one of the most critical yet excruciating tasks. In this kind of chaotic situation, infrastructure is destroyed, limiting access to computers and data, making such a search even more difficult. Often, missing person reports are filed, but the persons in question may be injured with no means of communication, or even deceased. One way of dealing with this is to photograph every person found, gather all images to a central location, and perform search and match operations with images of missing persons. However, this approach is not very realistic considering the limited human and machine resources in such a situation. Several questions exist in this scenario: 1.How and who would capture the images necessary?			Download
3	Cities	Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk	Yosef Jabareen (0)	0.3007
	Journalrate rating: 0.414	Scopus rating: 0 Scholar rating: 13 ScienceDirect rating: 0	Author rating: 0	Downloads: 0
	Introduction The critical question is, how resilient are contemporary cities and their different communities, and are they ready to face a multiplic- In recent years, we have become increasingly aware of the huge ity of challenges and uncertainties in the future? Most importantly, risks that climate change poses to our cities. Climate change is what should cities and urban communities do, at the present, in or- likely to bring higher temperatures, sea level increase, more in- der to move from a vulnerable to a more resilient state? Moreover, tense rainstorms, droughts and heat waves. It also poses particular since human action contributes to the altering of the ecosystem threats to urban infrastructures. To name just a few, these include locally and globally (Chapin et al., 2011; Folke et al., 2011), how increased strains on materials and equipment, higher peak elec- resilient should cities be in order to contribute to environmental tricity loads and voltage fluctuations, transport disruptions, and in- protection and sustainability? Although a literature review reveals creased need for emergency management (IPCC, 2007; NPCC, an important emerging scholarship on urban resilience, most stud- 2009; Wardekker et al., 2003). Furthermore, we have recently wit- ies on			Download

Figure 6: User window of the Text Analytics for INCLUDE Project for the analysis of the citation index of papers (Scopus, ScienceDirect, Google Scholar), citation of authors and impact factor of journals.

The system was developed as Web application using Microsoft Visual Studio 2010 (.Net Framework 4), C# as a main programming language and MS SQL Server 2012 as a database platform. An example of the fragment of the rational text analytics result is presented in Figure 7.



☑ **Advanced search options**

● Pages ○ Time
Approximately 110 pages
Approximately for : minutes

Second level keywords
Earthquakes by continent Earthquakes by country Bridge disasters caused by earthquakes Deaths in earthquakes Earthquake engineering Seismic zones Types of earthquake Earthquake templates Earthquake stubs Earthquake prediction Earthquake sensitive Global Earthquake Model

SEARCH RESULT DOCUMENT

1 Great East Japan Earthquake and tsunami United Nations Environment Programme. Great East Japan Earthquake and tsunami. [2013 02 20]. Available on the Internet: .
Great East Japan Earthquake and tsunami
Great East Japan Earthquake and tsunami

2 On 11 March 2011, a 9.0 magnitude earthquake off the north-eastern coast of Japan – the strongest ever recorded in the country – triggered a tsunami up to 30 metres high that washed up to 5 kilometres inland. It resulted in massive loss of life, environmental devastation and infrastructural damage. The disaster also damaged several nuclear power plants, leading to serious risks of contamination from radioactive releases. United Nations Environment Programme. Great East Japan Earthquake and tsunami. [2013 02 20]. Available on the Internet: .
Great East Japan Earthquake and tsunami
Great East Japan Earthquake and tsunami

3 IMPACTS OF RECENT TSUNAMIS & THEIR CHARACTERISTICS (1) The majority of tsunamis are thought to be generated by earthquakes below the sea floor. Importantly however, they may also be generated by volcanic eruptions, underwater landslides, asteroid/comet impacts in to the ocean and occasionally, meteorological conditions. However, things are not quite that simple, the Pacific also experiences unusually large tsunamis associated with poorly understood processes operating at subduction zones. These include "tsunami earthquakes" where larger than expected tsunamis are generated by "slow" earthquakes and by earthquakes that simultaneously generate submarine landslides. In September 2009, yet another unexpectedly large tsunami resulting from an unusual earthquake event occurred in the South Pacific. In essence, we are continuing to experience larger tsunamis than anticipated by current numerical modelling scenarios. This is of enormous concern for the Pacific (and PICTs) where attention has largely been focussed on subduction zone events with little or no consideration given to regional tectonic and submarine landslide sources that can be equally important for individual PICTs. This is significant because, local and regionally generated events pose the greatest challenge for effecting warning alerts and ensuring adequate community response (e.g. evacuation). EAP DRM KnowledgeNotes. Disaster Risk Management in East Asia and the Pacific. Working Paper, Series No. 25. Available on the Internet: Tsunami risk management in the context of the Pacific Islands
Tsunami risk management in the context of the Pacific Islands

4 Post-disaster waste management Along with the unresolved situation at the Fukushima Daiichi power plant and pressing humanitarian issues linked to the large number of displaced and dispossessed, the management of the massive amounts of debris generated by the earthquake and tsunami has been identified by the Government of Japa as an immediate challenge. The total amount of waste has been estimated to be between 80 and 200 million tons – comparable in size to the

Figure 7: Fragment of a User window of the Text Analytics for the INCLUDE Project Results

8. Conclusion and Way Forward

This report discussed the opportunities for using these disruptive technologies in online distance learning education in DRR via case study examples. In the beginning sections, we presented the general overview of disruptive technologies and their application in DRR. However, we used case examples of UAVs and big data analytics to explain that, both are important technologies that enhance decision-making processes and assist in disaster management activities. We presented this within the phases of disasters, thus pre, during and post-disaster situations. These two examples are derived from case studies presented by partners from the University of Central Lancashire and Lund University. Furthermore, additional insights are given into the practicality of destructive technology through other case studies. This time, one looked at the Use of Artificial intelligence for Disaster Risk Reduction in the Yorkshire Water Service Area in the UK and Metaverse in Disaster Risk Reduction: an Immersive Learning and Disaster Drills in Japan. These two explored AI, IoT, VR, and AR in disaster risk reduction and were presented by partners from the University of Huddersfield and Keio University. From the discussions of all the utilization of the various technologies, seven elements of disruptive technology were derived as vital attributes that drive their importance and relevance for their adoption in online distance learning education in DRR via case studies. These are their levels of accuracy, accessibility, affordability, reliability, efficiency, reachability, and flexibility. Questions were posed as to whether these abilities could be achieved in online distance learning education in DRR if disruptive technologies are utilized. This was confirmed as possible since for instance, wider application of drones could be integrated as educational tools for improving the learning experience in relation to several aspects and modules in DRR.

However, in reference to the challenges of online distance DRR education identified in Output 1, and the suggested fundamental assumptions regarding online education as given in Output 2, and an initial sample user base regarding 1) usability, 2) relevance of the platform on DRR-related education, and 3) areas of improvement of the model platform (a web application) in Output 3, this report (Output 4) recommends that a holistic approach be taken when incorporating disruptive technologies into online distance learning education in DRR. For this reason, an assumption was given that, that the holistic approach should be able to take advantage of the vital attributes of disruptive technologies (such as the examples given in section 6), consider the fundamental assumptions regarding online education (Output 2) and must be able to address the identified challenges of online distance learning education in DRR (Output 1) so as provide an improved teaching and learning oriented solutions. Based on this assumption, we presented two examples of some holistic approaches. The first is the provision of an augmented virtual environment for DRR teaching and learning as an alternative to ordinary online DRR education. This is because the inactive interaction between educators and learning has proven to be a key obstacle to obtaining feedback, exploring peer-to-peer active learning, and experiencing the practicality of DRR education. However, these virtual environment setting for DRR education can provide avenues where avatars, model cities and characters could be simulated for the experience and practicality of courses and this will not only improve interaction and experience but can also bring people together irrespective of time zones, location, gender, or other elements that could disenfranchise others. The second also presented a case study example of how the learning experience of students could be enhanced through a newly developed text-mining technology proposed by partners from Vilnius Gediminas Technical University.

The entire cases, together with the assumptions given in this report suggest that opportunities for disruptive technologies exist for their incorporation into online distance learning education in DRR but would be much more beneficial when considered in a holistic manner that addresses a wide range of issues and challenges of distance education.

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