Articles

Readily Available Technologies for Building Community Resilience: Lessons from India during the Covid-19 pandemic

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Information and communication technologies (ICTs) have played a pivotal role in assisting communities with building resilience by responding to and recovering from crises. For example, ICTs continue to assist with the recovery process during the ongoing COVID-19 pandemic. We focus on a set of these ICTs – Readily Available Technologies (RATs) – and show how they can be used to assist low-resource communities during crises. We develop a community-focused conceptual framework for crisis management that emphasizes the role and impact of RATs. Furthermore, we provide two examples from India to illustrate the applicability of our framework in the current pandemic context. We invite future researchers to build further on our framework and we highlight its potential contributions.

Introduction

Information and communication technologies (ICTs) are known to create wealth, spread access to information, empower communities, promote democracy and literacy, and foster a sense of belonging within and outside a community of users (Fukuyama, 2003). Failure to adopt ICTs can result in lack of technical skills and ICT-enabled social supports for the members of certain communities (Díaz Andrade & Techatassanasoontorn, 2021). Thus, it is critical for communities with limited resources to leverage the power of ICTs to address their needs and build resilience among community members.

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Nonetheless, with the advancement of technologies, traditional ICTs have been overtaken by new technologies that are more readily available and less expensive. Readily available technologies (RATs) such as social media, mobile technologies, analytics, and cloud computing (Ross et al., 2016), 3D printing, interactive voice response (IVR) services, and other technologies are an evolution of traditional ICTs and have been used effectively by communities and individuals[2]. These technologies are characterized by their accessibility, affordability, and availability in comparison to traditional technologies that are generally difficult to acquire, are more expensive, and take significant time and effort to learn (Council, 2014).[3]

Social media was used effectively during Thailand's flooding disaster (2011), mobile technologies during SARS-2003 in Singapore, and mobile technologies, big data analytics and cloud computing are being used effectively to track and combat the spread of COVID-19[4]. These examples provide clarity regarding the power and efficiency of RATs over traditional technologies. For instance, the Singapore government would find it very difficult to rapidly develop its digital infrastructure without relying on the affordability, accessibility, and availability of cloud computing (which is a RAT) services. This is because in the absence of cloud computing, they would have to invest in buying the server hardware, developing the software and middleware, and be responsible for the maintenance and support at extremely high costs. With cloud computing, these services are available at the click of a button, with options to pay monthly for subscription as well as end-to-end service and support.

The focus of this paper is on communities that have access to limited resources but leverage readily available technologies (RATs) to overcome these limitations and contextual challenges. Although the term "community" has multiple potential meanings depending on the context, this paper utilizes a broad conceptualization of community similar to that of both Gusfield (1975) and Chan and Farrington (2018) who refer to community as a set of locally-rooted relationships, local economic activity, and groups of people (physical or virtual) with ties to issues of concern within a particular context.

Communities with limited resources that invest in technologies have been able to use RATs to survive in difficult times. Examples of communities with limited resources range from communities in sub-Saharan Africa to indigenous communities in the Northern regions of Canada as well as the native American reservations in USA. These communities are known to encounter the digital divide – a lack of digital services and Internet infrastructure due to heavy costs of deployment (Díaz Andrade & Techatassanasoontorn, 2021). We see a clear opportunity for RATs to play an even more significant role before, during, and after crises, given their pervasiveness, low costs, and previous, and current, innovative uses. Our paper develops a community-focused conceptual framework of crisis management leveraging RATs. While it is encouraging to see how often communities and individuals create innovative technology-enabled responses to crises (e.g., with ham radios in hurricanes), we see a gap in the literature in terms of community-coordinated responses. Community development scholars have

[2] https://yourstory.com/2020/04/karnataka-launches-home-delivery-app-bengaluru

3 RATs have also been defined by other authors too, but this definition is the best fit for our perspective in this paper. Our goal is not to argue regarding the validity of the definition but to simply showcase the use of RATs.

[4] https://www.forbes.com/sites/ciocentral/2020/03/30/big-data-in-the-time-of-coronavirus-covid-19/#10f7fce658fc

raised concerns regarding the bypassing of local, community-based responses to the pandemic, as governments, medical experts, and public health officials devise and implement policies that can lead to erosion of the resilience and ability of communities to face such crises in the future (Kenny, 2020). There is also limited related research (Sakurai & Murayama, 2019) on how communities can leverage RATs to develop grassroots resilience.

In particular, our framework is designed to build community resilience, in the face of a crisis. We focus on detecting the potential crisis, mitigating its negative effects, and learning from it to prevent future crises (Imperiale & Vanclay, 2016). We address the following research question: *How can RATs help communities with limited resources build resilience during crises?*

COVID-19 continues to spread even as communities around the world reopen their economies[5]. In light of the ongoing pandemic and in line with Agerfalk et al. (2020), our goal is to address the broad question of how communities can take advantage of technologies that are readily available and deployable to build crisis response mechanisms and resilience within their own contexts (Meade, 2020). As Hale et al. (2005) note, information flows are critical to crisis detection and response; decision-makers must identify signals and communicate rapidly in order to respond quickly. RATs enable exactly this. Many scholars are calling for research to address this ongoing crisis (Agerfalk et al., 2020; Rai, 2020; Sein, 2020). We highlight the role of RATs in two low-resource communities in India and show how governments and members of different communities can build resilient solutions to address a crisis (Ahuja et al., 2020).

The remainder of this article is organized as follows: First, we present the background literature, then we introduce our proposed conceptual framework followed by two illustrative examples. Finally, discussion, implications and our conclusion follow.

Background Literature

Technology-Enabled Crisis Management

Studies have examined the role of ICTs in communities responding to emergencies and crises (Leidner et al., 2009). In order to fully understand the role of ICTs in crisis management, we must also understand the interactions between ICTs and the social structure of communities. Researchers have developed two main (and sometimes opposing) ways of conceptualizing how social structures interact with technology: 1) a top-down (centralized) approach where government agencies make decisions for the society (Li et al., 2019). The main advantage of this approach is effective use of resources and coordination of responses; 2) a bottom-up (decentralized) approach where members of society interact with each other through emerging technologies to coordinate and self-organize to respond to crises (Nan & Lu, 2014; Venkatesh et al., 2020). This approach leads to faster information and resource sharing as well as addressing the needs of individuals in the society.

As an example of top-down (centralized) management of a crisis, Singapore emerged as an exemplary country that controlled a public health threat during SARS (a pandemic in

[5] https://www.who.int/news-room/detail/03-04-2020-digital-technology-for-covid-19-response

the early 2000s) by investing in technology resources to develop capabilities to serve its citizens in the volatile crisis. The Singapore government used technology to quickly control the outbreak. According to Pan et al. (2005, p. 385), 'the government's IT infrastructure streamlined communication, information exchange, and data flow' to facilitate 'collaboration among government agencies, private businesses, foreign agencies, and the public'. The Singaporean government developed a case management system by gathering information from hospitals, ministries of health and education, general practitioners, and traditional Chinese medicine practitioners into a central database. Also, the government developed another database on contact information of the Singaporean population. This case management system helped the government and citizens remain connected via the Internet. Also, this system helped the government to better track the spread of the virus in the country and notify people who were at risk of getting infected. In addition, the government used video conferencing, radio frequency ID, and infrared fever scanning to develop the capability to monitor and communicate with citizens who received home quarantine orders, track patients' contacts, and detect citizens who were infected early. Leidner et al. (2009), using a resource-based view (RBV) lens, identified technologies required in crisis response by studying Singapore's response to the SARS and Asian Tsunami disasters.

The literature also provides studies on the bottom-up (decentralized) approach to crisis management. Recent studies looked at how these accessible and affordable technologies helped members of society share the latest news about a crisis (e.g., J. Li & Rao, 2010; Palen et al., 2009; Salathé et al., 2013). For example, Tim et al. (2017) examined the emerging roles of social media during crises. In particular, they studied how social media emerged as a powerful crisis response platform during the Thailand flooding in 2011 and facilitated communication and connection as major crisis responses. In another example, Leong et al. (2015) studied how social media can empower communities during natural crises.

Digital Divide and the Role of Readily Available Technologies

The concept of the digital divide focuses on an existing gap between those who have access to information and communication technologies (ICTs) and those who do not. The information systems literature identifies three levels of digital divides: 1) access divide that looks at existing inequalities to availability and access to information technology, 2) use divide that looks at inequalities in effective use of the existing ICTs and capabilities to exploit resources to achieve desired goals, and 3) outcome divide that looks at inequalities of the outcomes (e.g., knowledge or skills) emerging from exploiting resources (Díaz Andrade & Techatassanasoontorn, 2021; Gurstein, 2003; Wei et al., 2011). However, recent literature highlights that ICTs alone may not be enough to bridge the digital divide and that people with access to ICT need to have specific capabilities (e.g., familiarity with different features of the technologies or how to effectively use the technologies) to address their needs (Chan et al., 2019; Cheikh-Ammar, 2018; Volkoff & Strong, 2013). In this study we examine the role of affordable and accessible technologies, including both Internet and non-Internet-based technologies, in communities during a crisis (Díaz Andrade & Techatassanasoontorn, 2021).

Contextual factors, such as political, social, or economic conditions, can have an impact on the extent a community may encounter a digital divide (Vassilakopoulou & Hustad, 2021). While the United Nations declared Internet access as a human right, only 19% of

individuals in least developed countries used the Internet in 2019 (ITU Publications, 2019). As a result, uneven access to digital infrastructure is still an important issue in many communities all around the world. This issue can become more critical when communities in developing countries face crises such as the Covid-19 pandemic and they are required to shift from face-to-face interactions to digital interactions. For instance, the move toward digitalization in the health sector resulted in people in marginalized populations (e.g., low-income families or those in rural areas) having limited access to their essential health-related services (Faraj et al., 2021).

The digital divide not only exists in developing countries, but also in developed countries. A recent survey in the US shows that there is a gap between people's access to broadband based on their ethnicity (Fishbane, 2020). ICT investment is associated with productivity gains in developed countries like the US (Dewan & Kraemer, 2000; Oliner & Sichel, 2000). A study by Dedrick et al. (2013) shows that this relationship is moderated by different political, social, and economic factors, such as openness of economy to foreign trades, skill-based technological education, or quality and cost of telecommunication infrastructure. As digitalization continues in developed countries, communities in these countries need to update their skills and abilities regarding how to leverage emerging digital technologies in their work and everyday lives. When use and outcome divides are visible in communities, they may result in a inadequate digitally-enabled capabilities even in developed countries (Díaz Andrade & Techatassanasoontorn, 2021).

With technology advancement, RATs are commonly dispersed throughout communities. Having the capability to quickly configure and deploy ICTs as an important technological resource has been identified as a potential immediate crisis management method (Calloway & Keen, 1996). Within the context of communities with limited resources or poor infrastructure, there are many examples of non-digital or non-Internet-based technologies that have still been deployed successfully to assist during crises. With critical information and communication infrastructure damaged during most crises, communities have relied on ham radios and other technologies for broadcasting essential information and coordinating responses (Trivedi, 2018).

Basic Internet connectivity is a huge everyday challenge in many areas of the world, including rural areas in advanced countries in North America and Europe. Lack of Internet connectivity also creates problems during crises. However, constructing infrastructure for Internet connectivity is expensive and complex. Therefore, a more affordable and simpler solution is to use community-driven, co-operative Internet access via untapped TV white band (unused frequencies and channels that run on regular, local TV antennae) (Masonta et al., 2015). The digital divide literature highlights challenges that communities with limited resources face due to the lack of Internet connectivity. As a response to this situation, a number of global efforts to address lack of Internet connectivity have been launched. This includes Alphabet Inc.'s Project Loon - balloons designed to extend connectivity to billions of people around the world without Internet access. This is accomplished through a network of balloons traveling on the edge of space, delivering connectivity to people in unserved and underserved communities around the world (https://loon.com/). This leads to accessibility of the Internet at affordable costs for communities that previously did not have access to the Internet.

Access to a geographical location is important to lay digital and Internet infrastructure, regardless of the occurrence of a crisis. The costs of installing fiber optic cables or signal towers can be exponentially higher if the terrain is remote or physically challenging. In

such situations, Fixed Wireless Access (FWA) can be a useful solution, where a single source of wireless connectivity serves an entire community without the need for separate infrastructure for each individual household within the community (Chontiner, 2021). FWA can bring connectivity to rural and underserved communities for activities like working from home, agritech, and telehealth. For example, at the beginning of the pandemic, Rutland, Vermont experienced school closures but within 10 days, next-generation wireless FWA radios were installed downtown, and modems and laptops were delivered to homes in a community with a high poverty rate. Similarly, many communities in rural areas, with no access to high quality and cost-efficient technological infrastructure, use traditional technologies to address their needs at the time of crisis.

RATs can help grassroots communities in building resilience and accomplishing time-sensitive tasks to meet immediate needs without requiring a high degree of technical knowledge. These technologies can support a variety of capabilities for different community actors (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013). Use of RATs can enhance the quantity and quality of data (e.g., big data) that can ultimately facilitate decision-making processes and desired outcomes (Agarwal & Dhar, 2014; Bharadwaj et al., 2013; Chen, 2012). During pandemics, governments can use technologies, such as social media (e.g., Twitter) to communicate emergency information to the public (Rao et al., 2020). Communities can also use RATs to develop important capabilities to help them survive and even thrive (Leong et al., 2015). The literature discusses how social media can be used during crises to recruit volunteers, or as a communication channel among members of communities to increase their situational awareness (Leong et al., 2015; Tim et al., 2017). Mobile technologies can also be used for their contact tracing applications (Trang et al., 2020). Analytics can help to analyze historical data to identify early crisis indicators or analysis of real-time data on contact tracing (Pietz et al., 2020). Finally, there are different cloud-based services for video conferencing or for knowledge repositories for post-crisis use (Nan & Lu, 2014; Pan et al., 2005).

Conceptual Framework: Sensing, Responding and Recovering in the Age of Pandemics

Traditionally, a crisis was managed through a centralized / top-down approach (e.g., decisions from government), since a small group of people can effectively share resources and coordinate among each other to make decisions. Accordingly, many existing models focus on describing the different stages of crisis management from an organizational perspective (Calloway & Keen, 1996; Fink, 1986; Mitroff, 1988; Rice, 1990). However, recent studies suggest that due to the unexpected natures of crises and advancement in digital technologies in facilitating social interactions among societal members, traditional centralized crisis management approaches are now best combined with decentralized/bottom-up approaches where members of the society use different, readily available technologies such as different social media platforms (e.g., Twitter, online forums, or Wikipedia) to self-organize. Recent studies have looked at how these accessible and affordable technologies help members of the society to share crisis information (e.g., J. Li & Rao, 2010; Palen et al., 2009; Salathé et al., 2013).

One of the most seminal models in organizational settings is Mitroff's (1988) model that has a socio-technical perspective and is suitable to explore the role of RATs (Brouard, 2020). Although the Mitroff model is generally used as an organizational model, previous research has shown its relevance in embedded socio-economic contexts such as those of

communities, networks, regions, etc. (Mason et al., 2017). The Mitroff (1988) model facilitates exploration of opportunities to apply different technology interventions with different capabilities at different stages during a crisis. Mitroff (1988) identified five phases of crisis management: 1) signal detection: long before the occurrence of a disaster and subsequent crisis, there can be early warning signals, 2) prevention/preparation: prevention and preparation mechanisms probe for any sign of weakness, and managers and leaders respond quickly to any weakness that is uncovered, 3) containment / damage limitation: limitation mechanisms prevent the damage from spreading and engulfing other parts of the organization, 4) recovery: crisis-affected organization reinstates normal activities based on planned procedures and key activities, and 5) learning: the organization and its stakeholders must critically examine the lessons learned from experiencing a crisis and integrate these lessons back into their crisis management processes.

The Mitroff model was designed to examine how organizations respond to crises and therefore the literature on crises management considers it insufficient in explaining how communities respond to crises. In contrast, Nan and Lu's (2014) model is one of the few models that go beyond the organizational level and try to broaden the perspective by examining multi-level responses to crises. Nan and Lu (2014) created a multi-level model that examines the relationship between individuals' online actions and interactions (micro-level) and organizational crisis management (macro-level). In order for organizations to act intelligently (Nunamaker Jr et al., 1989), the crisis management process must involve sensing, understanding, deciding, and evaluating. In the sensing phase, organizational crisis can be recognized by gathering and analyzing data to notify the organization about potential future crises. In the understanding phase, organizations focus on potential causes and impacts of a disaster and resulting crisis to help to design coping methods. This phase can be facilitated by the "data encryption, transmission, and manipulation capabilities of an IT system" (Nan & Lu, 2014, p. 1139). Considering the uncertainties associated with organizational crises, decision-making is another key phase needed to design response actions effectively. For example, technology can be used to support simulation-based analyses that in turn facilitate decision-making (Nan & Lu, 2014). Finally, the evaluating phase consists of learning that can then inform future planning as well as organizational reformation or transformation facilitated by technology.

In contrast to the Mitroff model and Nan and Lu's model, the Jacques Model (2007) contests the fact that crisis management is a linear process of sequential phases in which you manage issues one at a time. Instead, it argues that important processes and activities often overlap or occur simultaneously, such as crisis prevention and preparation, and may not always proceed in one direction. As opposed to other lifecycle models such as Mitroff's, the Jacques Model proposes that crisis management can learn from the discipline of issues management to create systems to deal with problems. It is built on the notion that issues are more routine than crises and they overlap. The Jacques Model has four primary elements — crisis preparedness, crisis prevention, crisis incident management, and post-crisis management — each with clusters of activities and processes. Understanding the relationship among these elements and putting them in the context of a crisis can help reduce crisis-related losses.

In most of the crisis management models, we see common approaches and phases that provide the following:

1) Sensing of an oncoming crisis or disaster based on signals or information from various sources

2) Gathering resources and information to respond to the crisis to reduce its impact or prevent it altogether

3) After the crisis, building on available resources, information, and knowledge to recover from the crisis and focus on a return to normalcy

4) Learning from previous crises and integrating the knowledge into everyday tasks to be prepared to respond to future crises

5) Building overall resilience based on the above steps in an iterative manner.

Figure 1 shows our conceptual framework based on the above analysis of existing frameworks in the context of communities leveraging readily available technologies to respond to crises. Technology spans both social and technical structures and capabilities, so we do not limit our discussion to the simple use of machines and tools, but also discuss management procedures, policies, practices, and routines (Pearson & Clair, 1998). We explore how technology can be meaningfully applied to manage information and develop capabilities before, during, and after a crisis. We acknowledge that the use of technology can also have negative consequences (Pearson & Clair, 1998). Therefore, we carefully investigate the application of technology, its capabilities, and its outcomes within the context of crisis management.

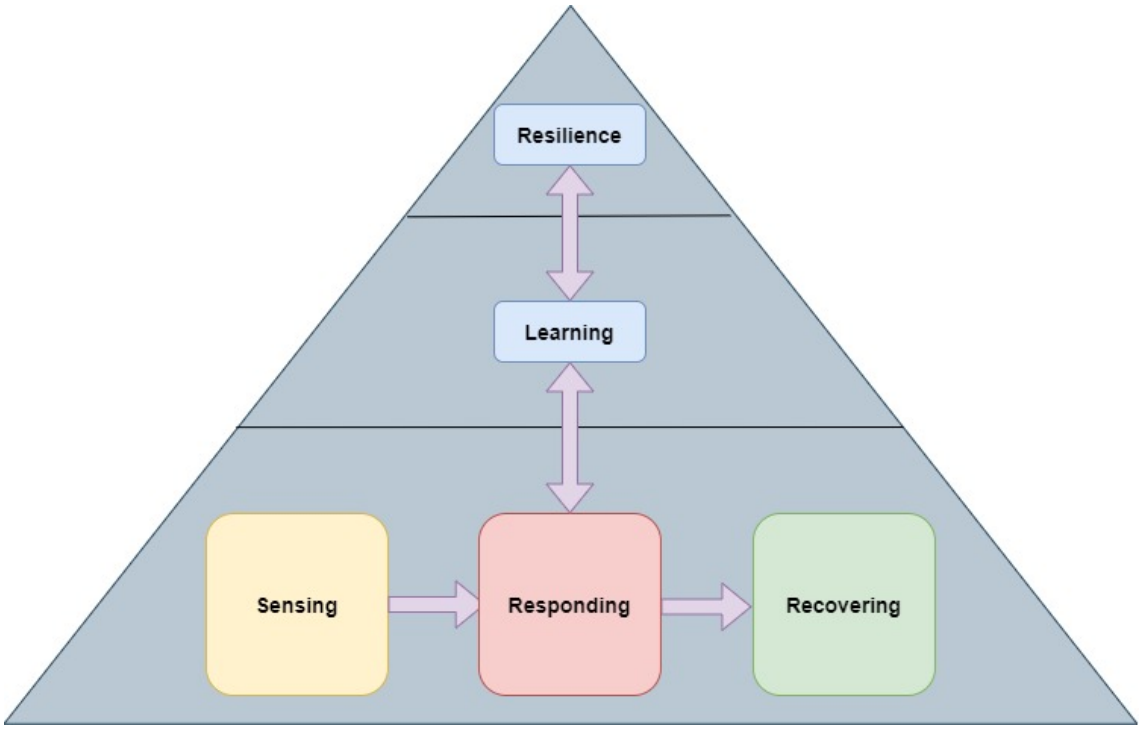

Figure 1 – Conceptual Framework

Sensing

Effective crisis management involves minimizing potential risks even before a triggering event. Constant technology-facilitated analyses of data (potential signals) and social,

technical, and cognitive assessments are crucial for uncovering potential threats. The community plays a significant role as an agent of awareness when dealing with crises (Mason et al., 2017). This ranges from individual word-of-mouth communications to social media and influencer groups leveraging their networks to provide sensemaking of the various signals that are transmitted over several channels and via different media (Gomez & Turoff, 2007).

Recent research has focused on how the community leverages RATs for awareness and sensemaking while also using traditional methods and non-digital media based on the needs and the capabilities of the community (Sakurai et al., 2014; Sakurai & Murayama, 2019). In particular, research has focused on the role of social media, mobile apps, and various digital communication tools by communities pre- and post-crisis for 'situational awareness' (Dufty, 2012). In the current COVID-19 pandemic, initial weak Coronavirus signals coming from China could have been amplified with the right technology, information sharing, and analyses. This involves but is not limited to information systems monitoring of real time data and trends on multiple media and channels. Recent AI technology developments can enable national, community, and organizational leaders to analyze signals and create an alert. To provide an example, during the 2015 floods in Chennai (India), various groups on social media were actively involved in detecting geographical areas of flooding and were creating situational awareness by providing information diffusion services, geo-spatial tagging, and enabling search and rescue operations (See Figure 2).

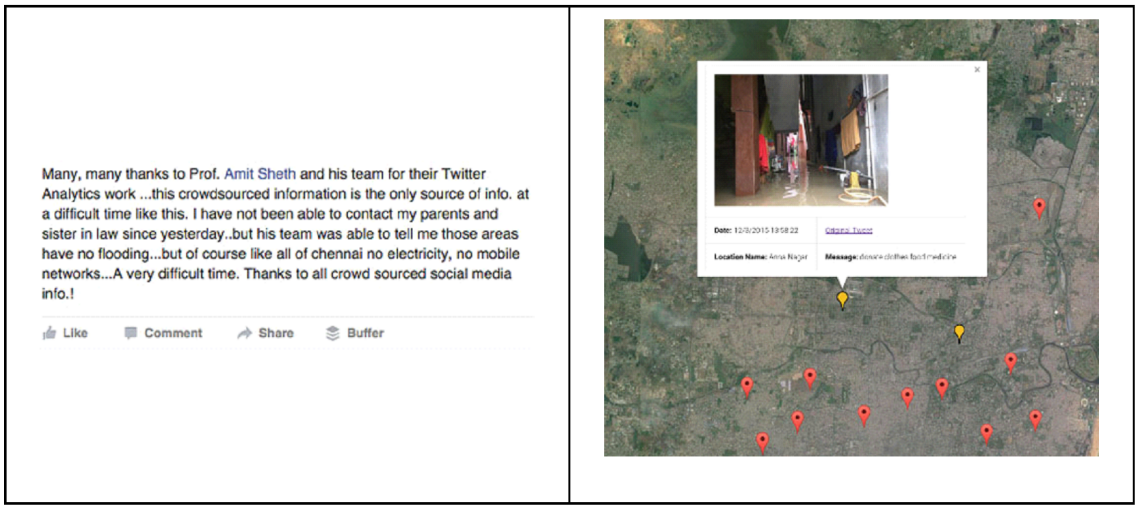

Figure 2 - An example of social media geotagging

Responding

By envisioning, forecasting, and practicing responses to various incidents, communities can build agility and response readiness (Pearson & Clair, 1998), create recovery plans (Carmeli & Schaubroeck, 2008), increase the resilience of processes, and foster a strong sense of belonging. To prevent crises, it is important to be prepared for them by leveraging the resources and capabilities that are available within the community. One way to achieve preparedness is to train, collaborate with, and coordinate community volunteers. Local residents and groups are in a position to best identify their immediate needs, coordinate preparations, supplement official response efforts, implement emergency response programs, and contribute to local decision-making for future events (Waldman

et al., 2018). Similarly, the social and economic capital invested in local communities can act as a medium for bonding, decrease isolation, and increase interactions among members of the community. These community services can be cultivated and should be encouraged by empowering local communities to be prepared for disasters. Local, regional, and national governments must coordinate and collaborate with volunteers to determine the function and roles that community volunteers will play and how selection, formation, and deployment of volunteer forces will take place (Waldman et al., 2018).

Information technologies provide opportunities for scenario simulation in a living-lab style, and support modeling exercises prior to a real disaster, while coordination and collaboration technologies can be used to provide a sense of alertness, readiness, community strength, and belonging (Sakurai & Murayama, 2019). RATs that support this phase range from volunteer coordination portals to training and simulation services to heighten the level of community preparedness to face a disaster situation. Figure 3 shows a screenshot of such a portal; it allows collaboration between local authorities and groups of volunteer citizens and also assists with role and task assignment and reporting/dashboard capabilities.

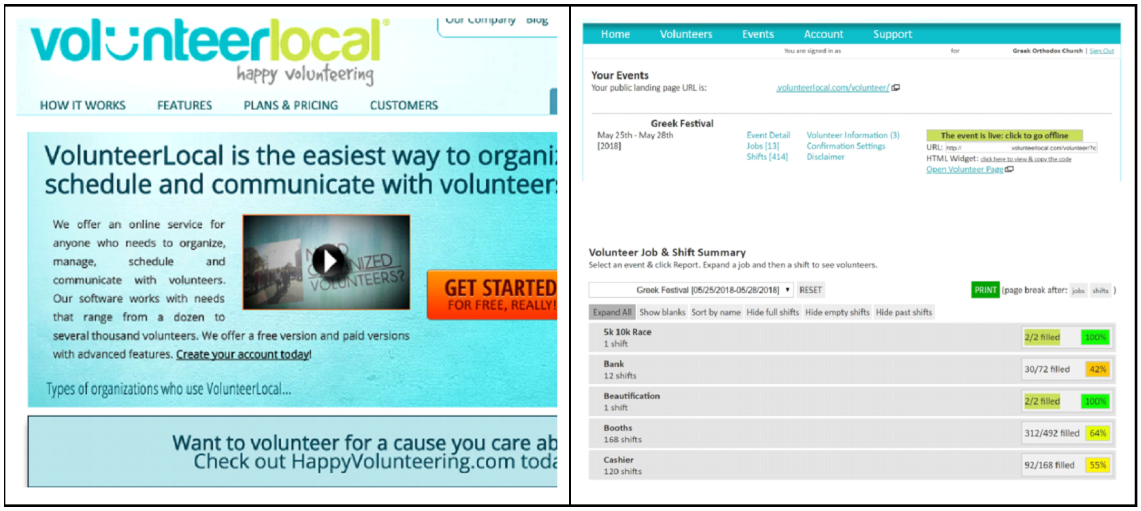

Figure 3 - An example of a volunteer management portal

A community should have damage limitation mechanisms in place. Ideally these would be re-examined and tested periodically with a focus on containment of crises. In the current COVID-19 pandemic, many national, community, and organizational decisions have been taken to limit the destruction of the coronavirus. Limitation mechanisms prevent the damage from spreading and engulfing other parts of the community. Key information must be shared quickly with important stakeholders so that decision-making can occur quickly, and damage containment measures be put in place as planned (Pearson & Clair, 1998). Even if there was no previous preparation, information sharing remains key. In a crisis, if the leaders neither confirm nor deny information about critical incidents, rumors may fill the void and amplify the threat (Pearson & Clair, 1998).

Previous research has shown that community-based disaster risk reduction plays a very significant role in limiting damage during disasters such as pandemics, floods, earthquakes, and wildfires. (Räsänen et al., 2020). Disaster risk management is a comprehensive approach involving the identification of threats due to hazards, processing and analyzing these threats, understanding people's vulnerability, assessing the resilience

and coping capacity of the communities, developing strategies for future risk reduction, and building up capacities and operational skills to implement the proposed measures (Bobrowsky, 2013). RATs such as social media can be used to improve situational awareness and expedite decision-making (Sakurai & Murayama, 2019). Risk mitigation through advanced data analytics as well as remote data storage and retrieval provided by cloud services can also be very helpful during the damage limitation phase. In the context of the Covid-19 pandemic, isolating hotspots (with the highest incidence of infection) and super-spreaders (individuals who transmit the virus to unusually large numbers of people) based on big data and predictive analytics has proven quite useful in limiting exposure of large populations to the virus, thereby containing the spread through shelter-in-place/stay-at-home or "lockdown" orders from local governments (https://ourworldindata.org/coronavirus).

Recovering

During this phase, the crisis-affected community reinstates normal activities. It benefits from planned procedures which identify key activities that must be performed. These activities may include replacing damaged infrastructure or installing new infrastructure, such as technology.

Recovery means that a collective attempt must be made to bring the post-crisis situation to some level of acceptability which may or may not be the same as the pre-crisis level. Previous research has emphasized social capital, personal and community networks, and a shared experience of post-crisis sensemaking as essential factors for the recovery process (Aldunce et al., 2014; Mason et al., 2017; Räsänen et al., 2020). It is important to facilitate engagement with government authorities, restore critical infrastructure, coordinate resources, personnel, plans within and outside the location of the crisis, and promote physical, social, emotional, and psychological well-being (Cutter et al., 2008). Given their inherent knowledge about and familiarity with local issues, the community is often better positioned than external first responders in coordinating and managing both internal relief operations and external communication with aid agencies (Cox & Perry, 2011).

RATs can assist communities that do not have tested short-term and long-term recovery mechanisms in place. For instance, affected entities may benefit by the communication of how key stakeholders are reacting to the crisis; what resources and information stakeholders have available to assist in the recovery; how stakeholders are being impacted by the crisis; and the available digital, social, and physical resources and capabilities as the entity attempts to manage the crisis (Pearson & Clair, 1998). Recovery may sometimes require new virtual systems that emerge from collective sensemaking, and it may require a new, collective sense of leadership and followership, as well as the technical and organizational capabilities to execute the procedural and administrative tasks involved (Vallaster, 2017). Virtual and remote services enabled via cloud services, tele-conferencing, and mobile communications can enable quicker recovery even when community members may not be able to meet physically for decision-making and social interactions (https://www.unicef.org).

Learning

The community and its stakeholders must critically examine the lessons learned from experiencing a crisis and integrate these lessons back into their crisis management processes. Crisis management is sufficiently complex that communities ideally should have a permanent, trained crisis management team.

Following a crisis event, effective crisis management entails individual and community readjustment of basic assumptions, as well as behavioral responses aimed at recovery (Pearson & Clair, 1998). Stakeholders, including crisis management teams and community managers, must reflect on whether the right opportunities to exit the crisis were taken and whether the community and surrounding entities (or ecosystems) require repair and rehabilitation (Vallaster, 2017). The process to re-align the post-recovery learning with the pre-recovery crisis management procedures is then undertaken. It is important to rely on community wisdom in times of crises as the collective knowledge of the local community may be rooted in traditions, cultural norms, and a sense of local belonging that can be difficult to codify and capture through approaches that are rooted in differing norms and perspectives. The social aspects as well as the tacit nuances developed within such community-embedded knowledge systems usually provide local solutions in times of crises and build collective memory for future hardships (Mercer et al., 2010). While integrating such knowledge into a community response strategy, it is important to recognize potential vulnerabilities such communities encounter, and to address them appropriately through engagement and empowerment (Mercer et al., 2010).

Learning occurs through contextualization and the transferability of community knowledge, promoting trust of different knowledge forms, and recognizing that communities are not homogeneous (Kelman et al., 2012; Mercer et al., 2010; Rudolph & McLachlan, 2013). This can require thinking about the potential negative effects of technology deployment and use, as well as the limitations of RATs in locations that suffer from poor infrastructure, lack of usable data, low levels of literacy, limited connectivity, etc. For example, during the Fukushima nuclear reactor crisis, predictive analytics proved to be of limited assistance due to the unprecedented nature of the disaster itself as well as the lack of data regarding communication and collaboration between citizens and the government in the event of a catastrophic event (Chatfield & Reddick, 2017). However, combining local knowledge with RATs can offer potent solutions to a crisis. For example, a community in middle India recently revived ancient water harvesting and channeling techniques to overcome a multi-year drought. To address a similar issue, a startup in India has developed a solar thermal-based device to produce drinking water from air. The device absorbs water vapor at night as the humidity is higher in many places. During the day, the solar collector heats up the device to around 80-100°C, releasing the saturated water vapor back. The vapors are then passed through an air-cooled condenser and transformed into liquid (http://www.uravulabs.com/).

Resilience

Community resilience can be described as the ‘capacity’ of a community to absorb, cope, ‘bounce back’, withstand or resist the impacts of hazards (Aldunce et al., 2014). Although the discussion of resilience has general applicability, we focus on the community level due to the community-based prevalence of the Covid-19 pandemic and calls for community-focused solutions (Cadogan & Hughes, 2020; Ebrahim et al., 2020). Furthermore, community resilience is dependent on a number of factors and is part of a

complex adaptive system that requires leveraging resources, technologies, infrastructure, people, and innovation to develop community-driven solutions (Cutter et al., 2008).

Community resilience can serve both as an input and an output to building effective crisis management processes and procedures in society (Sherrieb et al., 2010). Building resilience depends on the availability and collective memory of past incidents and relevant coping mechanisms. Learning is a key input and output, and crises can provide opportunities to review the capacity of people and communities, based on what worked and what did not during the crisis management efforts.

In the existing literature resilience has been shown as an outcome of antecedent processes like sensing, responding, recovering, and learning (Mitroff, 1988). Furthermore, community resilience can be built by the following principles (many of which can be supported by RATs) (Aldunce et al., 2014; Imperiale & Vanclay, 2016; Sherrieb et al., 2010):

1) *Participation (being involved in decision-making and action)*: a widespread will to share in the work that needs to be done, with many stakeholders making considerable contributions. RATs, especially during a pandemic with limited face-to-face interactions, can enable community participation through social media groups, polling and decision-making platforms, audio-visual and virtual meeting software, cloud and mobile driven engagement platforms, etc.

2) *Social cohesion (promoting well-being)*: creating a social environment of purposefulness and cooperation and planning shared solutions for overall well-being. RATs can enable social cohesion by connecting community participants through apps and other tools to enable formal and informal engagement.

3) *Equity (sharing and belonging)*: creating networks of solidarity that address the needs of each affected group. There is little if any place for surplus accumulation or hoarding in a crisis, and ideally stakeholders share generously and equitably, knowing that everyone's survival (including their own) depends on this sharing. However, during the current pandemic, we observed hoarding behaviors of food, essential supplies, and drugs not just by individuals but also by countries. Furthermore, we also observed unequal access to resources as well as much needed medical services resulting in negligence and tragedy, for example for seniors in long-term care homes. In order to avoid negative scenarios, it is important to follow measures of transparency within organizational, governance, and community spheres. RATs that provide transparent information services such as analytics-based, data-driven dashboards and real-time updates are especially useful in promoting equity and well-being for the vulnerable. Apps and portals that enable information pathways to connect vulnerable populations to critical care, resources, and infrastructure services are especially useful in a pandemic.

4) *Public awareness of sustainability (knowing what to do to increase the chances of survival)*: promoting a sense of public duty and social responsibility and increasing the awareness of social risks and vulnerabilities. Resilience can be built through sharing and learning by doing that occurs in everyday activities. Enabling spaces that provide access to open source and shared infrastructure for creating solutions to everyday problems can prove to be very useful in promoting public awareness, survival behaviors and skills, and sustainability. For example, Maker Spaces or Fab

> Labs are spaces that share tools and training for 3D printing and other expensive infrastructure that can be difficult to access by individuals, but that can help create a collective sense of survivability and awareness in communities. In a pandemic scenario, makerspaces can quickly pivot to creation of masks, face shields, and other personal protective equipment (PPE) needed by the community within which the makerspace is located. This enables distributed manufacturing of PPEs based on community needs without the need to set up heavy infrastructure at unaffordable costs. Ultimately, the visibility of such spaces increases awareness and promotes community-focused efforts towards becoming self-dependent and sustainable.

In this section, we have shown our conceptual framework. Next, we provide two illustrative examples (using pseudonyms) to highlight how RATs can be applied within the conceptual framework to help communities address challenges during a crisis.

Illustrative Examples

eEducation

According to UNICEF (2020), "two-thirds of the world's school-age children (i.e., 1.3 billion children aged 3 to 17 years old) have no Internet access at home". UNICEF encourages investing in this area to bridge the digital divide that prevents children and young populations from having access to quality digital learning. eEducation (a pseudonym) is a non-profit enterprise designing educational programs through its Internet-based and non-Internet-based technologies to help children in rural parts of India to gain access to home-based learning opportunities.

eEducation started to leverage technologies that can help children between the ages 3 to 10 and their parents in under-resourced communities of India to connect with trained educators. eEducation initially started its business back in 2014, fully dependent on physical interactions between children and educators.

As a result of COVID-19 pandemic, in April 2020, eEducation redesigned its business model by partnering with the state government to leverage non-Internet-based technologies to connect educators with low-income families with limited access to smartphones and the Internet. Similarly, eEducation leveraged Internet-based technologies such as its educational platform to enable educators to serve communities. Now, eEducation is active in over 400 villages across one state in India.

eEducation offers activity-based learning content through parents' feature phones for free. The activities are delivered through pre-recorded descriptive automated calls and interactive voice response solutions and text messages in their local language to parents' phones. In addition, eEducation provides a toll-free number for parents for audio instructions. Also, trained educators will call each family two times per week to supplement the initial call. The provided activities focus on arithmetic and language skill

development. According to eEducation's latest impact report, their approach significantly helps children to improve their targeted skills.

In addition to the non-Internet-based technologies provided, eEducation also leverages a mobile application to help educators track identified learning goals through the application. This application can help eEducation's managers to monitor the performance of educators by tracking their weekly activities. Table 1 presents how eEducation used RATs to address educational challenges during the COVID-19 crisis based on our conceptual framework.

Table 1 – Use of RATs in eEducation

Sensing	eEducation tried to understand needs of community/parents and students in order to effectively deliver lessons to them. eEducation tried to use WhatsApp and online modules for a short period of time to assess their impacts. As a result of this approach, eEducation realized parents did not have smartphones and non-Internet-based technologies needed to be used.
Responding	Educators who were a part of this approach needed to be on-boarded and trained properly as this was new for them. Non-Internet-based technologies were deployed for students/parents while simple mobile-based web/app solutions were deployed for educators and field managers. Communicating via schools and community leaders helped spread the word. Students' database in partnership with schools' teachers helped to a large extent. eEducation modified its strategy where field managers' on-boarding, training and support were given the 1st priority as they were the ones directly supporting educators. Only after they were properly equipped, eEducation started devoting its time and energy to educators' up-skilling and support. Database updates by educators helped to reduce dropouts. Low-tech solutions that were used for reaching out to students/parents became effective after continuous communication and follow-ups. Decentralized processes for online meetings and follow-ups by field managers supported the roll-out.
Recovering	Parent's involvement improved after 2 to 3 months of product roll-out. Similarly, educators became equipped after 2 months of follow-up and support. Adding more functionalities like 2-way communication to the home-based learning program is being done to scale up this program in newer geographies. A blended learning approach for training educators has also been devised. Parents have become more comfortable with the approach and in fact have realized that eEducation is supporting their children when schools are closed. Educators have become more confident and are communicating with the management team to continue the program
Learning	Activity-based learning has become a product that will be implemented even after the lockdown. Non-Internet-based technologies will only work with in-person support and interaction. Educators and managers need to be initially supported to obtain the desired results. A blended learning approach using Internet-based technologies for training educators is cost-effective and can be deployed at scale.

Resilience	eEducation realized that non-Internet-based technologies can help low-resource communities to build new capabilities at the time of crisis. This approach increased the social cohesion among and within communities, parents, and children. eEducation realized that following of processes and effective communication with team members is key at the time of crisis. This can ultimately increase public awareness. eEducation knows what to do for its community in future crises.

eGrocery

When India went into lockdown in March 2020 due to the Covid-19 pandemic, it faced significant challenges with respect to organizing the last-mile supply chain and delivery for essential items for citizens who were unable to get groceries, medical supplies, and other items delivered to them. The last-mile supply and delivery of goods and groceries in India exists largely within the unorganized sector and is run through neighborhood "mom-and-pop" small stores called Kiranas. Kiranas operate on an informal, sometimes cash-only, basis and cater to smaller localized communities and neighborhoods. These stores are largely unorganized, small, and often stacked with goods without any walkable aisles. The owner/operator follows manual processes and knows customers by name and address, and customers need to physically visit the store to get groceries. However, during the pandemic these stores were challenged as they had no means to deliver goods at scale even though demand for delivery was at its peak. Table 2 presents how eGrocery (a pseudonym) used RATs to provide access to essential goods during the COVID-19 crisis based on our conceptual framework.

Table 2 – Use of RATs in eGrocery

Sensing	This is when a community worker and Member of Parliament (MP) intervened as he was flooded with requests and complaints from citizens about how the lockdown had created challenges for buying medicines, groceries, and other essential items. Identifying the warning signs that this problem was about to become uncontrollable, the MP decided to create a digitally-enabled solution that would be readily available, easy to use, and affordable for ordinary citizens.

Responding	The MP started preparing by actively reaching out to citizens in his constituency and the Kirana store owners. He then collaborated with the many delivery app companies like Shadowfox, Swiggy, and Dunzo to arrange for an on-the-ground delivery personnel force to help the Kirana stores. There was still another problem with this setup. The stores were mainly receiving phone calls from customers and there was no way to aggregate the calls or to direct people to other stores that might carry inventory of out-of-stock items at a particular store. To contain this issue which would eventually give rise to hyper demand of certain goods in certain stores while other stores struggled, the MP called into action an IT development company that developed a helpline chatbot based on WhatsApp. Kaleyra (the IT Company) provided the WhatsApp chatbot for the helpline, which is manned by call center employees of [24]7.ai (a call center company). A citizen can call the call center volunteer to place his or her order or simply chat on WhatsApp.
Recovering	To enable recovery, the ecosystem that had been established needed to be sustained. The service was then scaled to several areas within the city and those who wanted to join as customers had to pay 10 rupees monthly ($0.07 US). This revenue was used to cover the infrastructure costs and service fees to delivery drivers.
Learning	Learning from the initial experiences of the delivery drivers and seeking feedback from customers, the service was improved and launched across the city during the lockdown. The platform is India's first integrated voice and messaging platform, providing citizens with services to order groceries, fruits, vegetables, medicines and essentials through an ecosystem of 16,000 merchants and delivery partners to bring products right to an individual's doorstep.
Resilience	With this service, the supply and last-mile delivery of essential goods, medicines, and groceries has been established as necessary infrastructure within the city. Public awareness has been created about the use of the service and future lockdowns will be managed with much more resilience without disrupting the revenues of the stores or causing inconvenience and anxiety to citizens.

Discussion

This article utilizes several models of crisis management such as Mitroff, Jacques, etc. to provide a conceptual framework for the use of RATs during crises within communities. It provides insights into how communities can use RATS to sense, respond, recover, learn and build resilience at the time of a crisis. In addition, it shows that building community resilience is not a linear process but an iterative one with systemic relationships between and among community knowledge, resources, and people. Also, we provide two illustrative examples that highlight how community resilience is built using RATs in different sectors.

In both the crisis management as well as information systems literature, there has been a vibrant discussion of how current and emerging technologies that are affordable and decentralized can be used to provide information and critical services to populations

affected by disasters (Leong et al., 2015; Mason et al., 2017; Pan et al., 2005; Tim et al., 2017). However, with 3D printing, drone technology, blockchain, AI, and non-Internet-based technologies, access to RATs and their capabilities has become commonplace.

Most RATs are dependent on underlying foundational infrastructure such as electricity, transportation, public health agencies, etc. However, in the case of many emerging and developing nations, often such critical foundational infrastructure is inadequate or absent (Manda & Ben Dhaou, 2019). In such cases, we see examples of individual, business, and governmental improvisation or bricolage where communities quickly pivot to work around the constraints imposed by the situation. But improvisation itself does not resolve the problems that are encountered during a crisis. The capacity to improvise must be harnessed and developed into capabilities that are designed for and used by communities during crises. During times of crisis, communities innovatively leverage technology and existing infrastructure in creative, affordable, and ingenious ways by breaking existing barriers and mindsets. Frugal innovation is an example of developing affordable solutions under constraints and making existing solutions simpler, more affordable, and sustainable by reducing resource usage and creating wider impacts (Harris et al., 2020). An example of this type of innovation is the Field Emergency Ventilator (FEV)[6] system, a low-resource ventilator developed and scaled rapidly based on open source knowledge, mostly using 3D printed components and local supplies and materials (Cadeddu et al., 2020). However, even within the frugal innovation domain, there is growing acknowledgement that RATs and digitalization when combined with the right organizational structuring and grassroots-driven efforts can result in game-changing innovations that create business, technology, and social impacts in pandemics as well as in non-crisis times (Ahuja & Chan, 2019).

It would not be prudent to treat RATs as one-time solutions, linear intervention technologies, or silver bullets that can solve all problems related to pandemics and other crises. RATs are emerging as valuable, must-have tools in the technology intervention toolkit if and when a pandemic occurs. However, communities need to be educated and trained to leverage the capabilities afforded by RATs and the right types of public policies, education, and training programs must be created. In a socio-digital world, the social aspects of communities such as self-organizing, grassroots movements, community resilience, etc. are just as important as, if not more important than, the technologies that are deployed (Johal & Wong, 2020).

Implications and Conclusion

This study developed a community-focused conceptual framework of crisis management to build resilient communities. We demonstrated how RATs can help communities to address their challenges during a crisis, such as the COVId-19 pandemic. We invite other researchers to empirically validate our conceptual framework.

Researchers may also wish to use other theoretical foundations as they explore the use of digital technology in pandemic responses (Allen et al., 2014). Crisis management is one of the most interdisciplinary fields that exists (Mitroff, 1988). For example, researchers may consider the collective mindfulness perspective and how it may interact with RATs at the community level. This perspective might be useful because it focuses on

[6] https://opensourceventilator.ie/

anticipating the unexpected and responding to unexpected events (Aanestad & Jensen, 2016; Carlo et al., 2012; Weick et al., 1999). Similarly, affordance theory can also be used to explore how the interactions between goal-oriented communities and their actors with RATs can create affordances that may result in development of important capabilities in communities (Chan et al., 2019; Sadreddin, 2020; Volkoff & Strong, 2013).

Readily available technologies, including both Internet-based and non-Internet-based technologies, will not prevent pandemics. However, they can be used to detect, manage, and recover from them. In particular, in this article, we advocate for the conscious and disciplined use of RATs in crises. As we have illustrated, pandemic solutions often involve rapid technology usage. RATs are already deployed and available in communities and can be quickly accessed and used during crisis management.

During the COVID-19 pandemic, several organizations such as UNDP have been encouraging governments to make investments in digital technologies for development of resilient and affordable solutions. This is particularly important in countries in Africa and Asia that suffer from severe resource constraints as well as infrastructure, technology, and public services limitations[7].

Globally, we have experienced pandemics, such as SARS, H1N1-the bird flu, etc. and now we are experiencing COVID-19. We have learned valuable lessons about the use of ICT during previous pandemics. However, RATs, although pervasive, were largely overlooked. In responding to the ongoing COVID-19 pandemic, there is still time to turn our attention to RATs within communities. In this article we developed a crisis management conceptual framework that can be utilized to build community resilience by leveraging RATs. We acknowledge that many aspects regarding the internal mechanisms within each phase, as well as their interface with RATs, remain to be explored in future research. Our goal has been to demonstrate, as a first step, the feasibility and utility of RATs in a pandemic and post-pandemic context. We ask researchers and practitioners to explore how RATs can help communities to sense upcoming challenges in the context of the pandemic. They should determine to what extent RATs can assist with identifying vulnerabilities within and across communities and facilitate the development and deployment of rapid solutions. We suggest that it is time to consciously involve communities in using tools they already have – RATs – to sense challenges in their environments, respond to opportunities, and create their own solutions (i.e., putting tools, communication, and power in the hands of those who are affected). We encourage researchers and practitioners to envision, lead, and manage pandemic solutions delivered with RATs.

[7] https://www.africa.undp.org/content/rba/en/home/presscenter/pressreleases/2020/undp-and-european-investment-bank-identify-effective-digital-res.html?s=09

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