Preparing for the Next Pandemic: Geospatial Information for Enhanced Community Resilience

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This chapter presents a high-level synthesis of the knowledge and perspectives shared in the chapter contributions in the book. We suggest strategies to apply the geospatial and techno-social lessons learned to date. We also present proposals to develop new capabilities to build resilience in local communities and reproduce them worldwide, especially in preparation for the next pandemic or global crisis.

47.1 Introduction

Throughout human history, pandemics have caused major societal upheavals and impacts. While there have been a few global pandemic threats in the last twenty years, the emergence of SARS-CoV-2 in late 2019 and throughout 2020 and 2021 (i.e. the COVID-19 pandemic) has been one of the most significant disasters in the last 100 years. The extent of its impact to individuals, people groups, nations and the world will not be fully known for many years. Already, COVID-19 has set-back the UN's Sustainable Development Goals (SDGs) [1].

Even as we present and reflect on the technical and techno-social applications of geospatial information and the broader lessons in response to COVID-19 from around the world in the diverse chapter contributions in this book, the evolving global environmental and climate changes coupled with the increasing globalised settings in economics and trade, population growth, migration and movements, the potential for the next pandemic occurring in the not-so-distant future is not a far-fetched idea. We may not only have to deal with the continuing threat of the SARS-CoV-2 lingering on – despite the availability of a number of vaccines – but also with new equally if not more fatal viruses.

In this concluding chapter, we seek to bring together the knowledge and perspectives shared in the different chapters in the book. Our objective – beyond identifying common themes, differences or trends – is to synthesise and suggest a way forward to apply the geospatial knowledge shared and the techno-social lessons learned to date in this book into building community resilience worldwide, especially in preparation for the next pandemic. A well-considered and robust set of strategic and operational capabilities need to be in place long before the outset of a pandemic. We certainly will learn a lot more in the next few years about what worked and what did not work in the public health and wellbeing management of COVID-19. More data and research will surely follow, but this is still an opportune time to pause and take stock.

The rest of this chapter is organised in three parts. First, we summarise the key lessons learnt to date from the COVID-19 pandemic for the geospatial and allied industries from the chapter contributions in this book. Then we discuss some key considerations about an ideal or desired

future. Finally, we present an overview of the core strategies that we can embark on today so that we can strengthen our capabilities against, and build community resilience in, future pandemics.

47.2 Key Lessons from COVID-19

“What we learn from history is that people don’t learn from history.”
American investor and philanthropist Warren Buffet (1930-).

The first affirmation to make is the critical importance of geospatial information, and the supporting technologies that underpin them and the software applications and web platforms that make them useful for a variety of stakeholders and decision-makers in managing COVID-19, as first outlined in [Chapter 1](#). These are evident across the diverse contributions in this book. A wide range of geospatial and digital technologies has been featured, including remote sensing, drones and mobile applications. Countries in the Americas, Europe, Africa, Asia and Oceania are using maps and GIS dashboards as the key graphical interface to display data around COVID-19 infections, and to disseminate information. This will likely continue in planning and managing the logistics of vaccine distribution and guiding the recovery phase from COVID-19 and other disasters. But as noted by Kraak in [Chapter 34](#), there are effective and ineffective ways of presenting data. Much more consideration needs to be given to this.

Data and understanding what they mean (and what they do not say) are the foundations for sound decision making. This topic has many dimensions. Beyond geospatial information, many types of data needed to be sourced and analysed in a dynamic way, often in fast-changing situations. One of the early difficulties with COVID-19 was the scope of uncertainties in knowledge about its epidemiology. But the unprecedented scientific local and global collaboration amongst medical and public health researchers and with those in a wide range of disciplines across the physical and social sciences, including geospatial experts, system modellers, computing and data scientists and social scientists, have produced unprecedented COVID-19 related research. This book is an example of this cross-disciplinary effort.

The need for open data empowering open science has been raised by several authors. Both scientific research and the authorities’ decision-making have been either aided or hindered by the availability of, or access to, data of appropriate quality and resolution. The latter is not just a challenge for small developing countries (e.g. in the Pacific Island Countries and Territories, [Chapter 26](#)) but also in developed countries (e.g. in the UK, [Chapter 18](#)). All types of information – quantitative and qualitative – and those obtained by surveys (e.g. [Chapters 27](#) and [28](#)) and social media feeds ([Chapter 11](#)) are especially important. These approaches allow understanding and monitoring of community resilience, engaging the public and understanding their attitudes, behaviours and actions.

Data need to be organised and managed via harmonised terms and definitions, and spatial data infrastructures (SDI) both at the local and national level, in land and in water ([Chapter 9](#)). The success of rapid tool developments to support the COVID-19 public health measures in Korea ([Chapter 24](#)), for example, has been partly credited to its national SDI. As noted in [Chapter 1](#), the UN-GGIM’s efforts to advance an Integrated Geospatial Information Framework (IGIF) across the globe are critical. Issues around core reference data, interoperability, common geographies, integration of statistics and geography, privacy and confidentiality and cybersecurity need to be addressed. Experiences during the pandemic, depicted in many parts of this book, tell us that when complex decisions are needed, there is no time to sign data custodian agreements or to integrate geospatial databases. In a number of case studies in this book, geospatial information effectively supported decision-making when the SDI was operational and not just conceived in a technical report.

Beyond data and technology, the critical role of leadership and governance cannot be overemphasised. In the web portal of endcoronavirus.org, the gallery of countries “winning” or “beating” COVID-19 includes both developed and developing countries, those that are

technology-rich and those without much technology. In some ways, this affirms the importance of the first two of the three core themes of the UN-GGIM IGIF's strategic pathways: Governance, People and Technology. When informed by science and evidence, political leaders can manage COVID-19 using adaptive public health measures. Since the start of the pandemic, there have been multiple reports on how in many instances, government and institutions did not act in the multiple warnings around the need for stronger pandemic resilience at the local and regional levels. The lack of attention by some leaders to risks brought forward by the scientific community has not yielded the desired results.

It is hard to determine if the lack of attention to science was due to scientists not communicating results effectively or political leaders and authorities making decisions based on ideology. Either way, the lesson learnt is that community resilience building should be based on sound science and built on trust between the community and the authorities [2]. The more the authorities rely on science and evidence, the more chances the community will likely support the public health measures (Chapter 27). Cooperation, collaboration and trust across society are needed; in the end, human behaviour was key to the success of COVID-19 public health measures.

The COVID-19 pandemic has demonstrated that in a highly interconnected social, economic and natural environments, a highly contagious virus can become a global pandemic in no time. And from a safety perspective, nobody is out of the woods until everyone is out. It would not matter how strong a particular country is in its response to the pandemic. It requires its neighbours and the rest of the nations to be building resilience before normality can be returned to the natural, social and economic settings. New Zealand, Australia, Singapore and some other countries have had relatively effective responses to the pandemic with limited infections and a reduced number of deaths compared to the world's average. However, full epidemiological, social and economic recovery in these countries will not occur until the world achieves a lasting solution. Without a global solution, the risk of multiple re-infection waves will continue. Therefore, we have learnt from COVID-19 that community resilience is not an isolated concept for a particular community or group of people. Global crises such as climate change and the COVID-19 pandemic demand community and societal resilience that is built from broad stakeholder cooperation at the local, regional and national levels.

Still along the lines of high interconnectivity, cities – as a dense centre of human settlements and socio-economic activities – emerged as natural hot spots for COVID-19. Adapting from sustainability research, it can also be stated that, “Pandemics will be lost or won in cities”. There are many considerations in managing the pandemic in urban centres (e.g. see Chapters 10, 17, 18, 28, 42 and 46), but we can only be successful beating a pandemic if we beat it in our urban centres.

Finally, COVID-19 has sped-up the digitalisation and online transformation of work and education, and in the process also highlighted societal inequalities. The most vulnerable groups of people and regions have been asymmetrically impacted not just health-wise, but also socially and economically [1]. Often, as in the case of people in informal settlements (e.g. Chapters 8 and 15), very little information is available about them even before the pandemic, making it difficult to monitor and support their situation during the pandemic. Recovery efforts, including economic stimulus measures, provide opportunity to re-set the social, economic and environmental conditions of the majority of a nation's populations, and thus make a major advance on many fronts across the SDGs. This requires strategic vision, leadership, political will and effective governance. Data and technology, in general, are just enablers.

Having come full circle, we acknowledge that there are many more lessons not listed in this chapter, and reaffirm the critical role of geospatial information and technologies in managing a pandemic. In the next section, we explore our desired future before the next pandemic and global crisis.

47.3 The Road Ahead: The Only Certainty in the Future is Change

“Prediction is very difficult, especially about the future.”

Danish writer, artist and humourist Robert Storm Petersen (1882-1949).

In this section, we cast our future vision and aspirations on the basis of the observations and lessons discussed in the previous section. In other words, we will attempt to describe a desired future where the lessons are assumed to have been learnt and applied. As we do, it is worth noting that the authorities and our society, more broadly, need to face a future pandemic while facing other concurrent hazards and stresses. For example, in 2020 and 2021, we had to deal with the overlapping challenges and impacts of climate change and COVID-19; these included the wildfires and hurricanes in the US, and the tropical cyclones and flooding in the Asia-Pacific. Thus, we need to recognise also that this could be the new norm moving forward.

Following the structure of the previous section, we imagine a future where a multi-scale SDI is in place in most countries around the world. The maturity and adoption levels may be uneven across different countries but the core definitions and reference data are harmonised, with high interoperability and linkages with other data infrastructures and platforms. A diverse range and type of data contents can come from established and new sources – including those from new technologies and from the crowd – with trusted provenance and quality indicator and that protects individual and corporate privacy. The geospatial information of most data is preserved. The infrastructure and the contents are supported by sensible data governance regimes and appropriate cybersecurity measures. The supporting physical infrastructure is robust, in the face of an extreme event, and highly resilient in case of disruption. In other words, it is able to be made operational again swiftly; that is, a fail-safe system. Political appetite and societal expectations regarding cybersecurity risks and privacy – that vary from one country to another – could be a significant factor here. Putting these issues aside, the ultimate aim is to eventually realise the concept of a Digital Earth ([Chapter 32](#)).

With a solid data infrastructure in place and in operation, when the next global crisis occurs, new information can be readily managed and made widely available. New mobile and digital applications and solutions can be developed rapidly to meet the specific needs of a future crisis, allowing data to be used more effectively for a coordinated response and decision-making by different stakeholders, including the public. Information management protocols guide these stakeholders in an environment of information glut and where “infodemic” is widespread.

And so, as highlighted in the previous section, the most consequential factor remains the human factor, or the people’s capabilities and ability to make sound decisions. This is a future that is challenging to describe because this is value-laden. What is a “sound decision” and who is even able to make this judgment? How do we shape critical thinking and innovation? What are acceptable and unacceptable moral values? Who decides? We can only generally hope that most people will aim for the “greater good”.

Despite the above dilemma, identifying the critical role of human factors is important. From a top-down perspective, these are usually identified as vision, leadership and governance. From a bottom-up perspective, the complex nature of human behaviours and actions can lead to highly unpredictable emergent outcomes, which is a truly complex system. In an ideal future, we certainly hope that these behaviours are better understood and harnessed, again for the greater good, especially in times of crises.

In other words, we are describing herein a future where the UN-GGIM’s aspirations for IGIF are in place in many countries around the world. In these aspirations, the performance settings for governance, technology and people are continually improving based on new knowledge and lessons from field experiences, including pandemics and other crises. In this future, the geospatial sector and allied industries and disciplines, collaborate widely and effectively to serve the needs of society and, in times of crisis, adapt our efforts to enable different stakeholders to manage the crisis and communities to bounce back better.

47.4 Strategies to Face the Next Crisis and Build Community Resilience

“The best way to predict the future is to invent it.”

American computer scientist and pioneer Alan Kay (1940-).

The gap between lessons learned to date (present state) and our aspirations (future state) is how to get to the latter. Herein, we organise the strategies to fill this gap over time according to the general knowledge development and maturity curve in [Figure 47.1](#). The main curve in this figure follows a Sigmoid (or simply, “S”) curve. The concept being that new knowledge (early in time, left of the curve) grows and matures over time according to this curve, until such time that it is fully adopted and widely applied in industry or practice.

Knowledge topics in any area or discipline can be placed in this curve, according to its maturity. At the lowest levels of maturity are the topics that will typically be undertaken as PhD thesis projects in universities. Those at the middle may require a combination of research and development. Over time, some of these topics would have been developed into demonstration prototypes, field-tested and eventually deployed. Some of the knowledge may be adopted as industry guidelines, standards or regulations.

FIGURE 47.1

Knowledge development and maturity curve and the four strategic pathways to improved geospatial information capability in the future: (A) Research and development, (B) Demonstration and deployment, (C) Frameworks, standards and regulations, and (D) Training and human resource development.

The core strategies are, thus, organised as shown in [Figure 47.1](#) and elaborated below.

A. Research and development

It was evident in this book and in the general COVID-19 literature that lack of knowledge, or epistemic uncertainty, hampered the early efforts to assess risks and manage the pandemic. Although the bulk of the research that needed to be undertaken about the virus and its epidemiology fall into the hands of experts in the medical and public health disciplines, it is clear now that interdisciplinary and transdisciplinary research collaborations have been significantly valuable. In other cases, questions raised by researchers from one discipline have led to collaborations and have enriched the understanding of key issues. For example, research by N.N. Taleb and his associates [3] on pandemic risk management based on the probability distribution’s tail properties raised many salient points and helped identify common errors and fallacies when using point forecasts

for fat-tailed variables like pandemic deaths. Together with the research gaps identified by various contributors in this book – across disciplines – it now seems that there are many more areas that demand deep research or serious research and development (R&D) efforts, especially where geospatial and temporal information are critical.

With even more data and improved insights about COVID-19 and its spread, impacts and control coming to fore in the next year or two, undertaking more quality research will consolidate and expand our knowledge further. Of special note, where geospatial information needs to have more prominent roles, for example, are in: network epidemiology, pandemic risk management, including perception vs. actual risk, community wellbeing, social attitudes and human behaviours and response (e.g., from public health measures to vaccines), economic and SDG impacts and recovery scenarios, balance of privacy and cybersecurity, amongst others. Some research will be about more fundamental science questions while others will be more applied. Research on addressing the methodological gaps in the use and analysis of qualitative and quantitative data, and developing new integrated approaches that take into account the spatio-temporal patterns in studying the impacts of the pandemic on urban residents' wellbeing, for example, will be worthwhile. Furthermore, R&D that support the full development of a Digital Earth, SDIs and interoperability standards, and strengthen data provenance and governance are needed.

B. Demonstration and deployment

For topics that are near the top of the knowledge S-curve in [Figure 47.1](#), they need to be prototyped and/or their applications demonstrated. These efforts should have the goal of moving beyond proof of concepts and towards broader practical adoption and applications. In the past, pilots have not consolidated into operational applications in crisis response. For example, during the beginning of the COVID-19 pandemic, there was the idea that our tracking systems would be ideal to limit contact between healthy and infected people and help health authorities conduct better contact tracing and quarantine people. In a preliminary review of mobile phone applications used during the pandemic, we found that the role of geospatial technologies was very limited. We did not have proven technologies that could track individuals on a large scale. There were pilots but when they have been implemented on a rush during the pandemic, a limited contribution was provided.

Society will increasingly demand from the geospatial industry operational tools that can be embedded within community resilience systems. Current concepts of digital twins and the use of drones are spatial technologies that could not pass the “pilot” phase unless there is transdisciplinary collaborations and cooperation among practitioners in key areas such as standards and regulations. For the future, we cannot be afforded to be an industry of pilots, but we need to move into an industry of solutions. To be successful, the challenges of scaling and capital funding for technology commercialisation and/or deployment need to be addressed.

C. Frameworks, standards and regulations

There is an urgent need to develop and implement established knowledge as part of SDI frameworks and standards, and to consider relevant results from strategies A and B above for inclusion in future updates of these standards ([Figure 47.1](#)). Over time, issues around core reference data, interoperability, common geographies, integration of statistics and geography, privacy and confidentiality and cybersecurity need to be addressed. International harmonisation is key because the long-term or ultimate goal is to build the Digital Earth, country by country. Collaboration amongst UN-GGIM, the Open Geospatial Consortium (OGC) and ISO, together with national standards bodies, is vital. Broad support from the geospatial sector is needed.

Whether these frameworks and standards are initially voluntary or mandatory (or part of a regulatory regime or policy scheme) will depend on a country by country basis.

D. Training and human resource development

Across the knowledge life-cycle and maturity curve in [Figure 47.1](#), we need to develop and implement intentional and flexible training, education and mentoring programs for personnel with different levels of capability and responsibilities in the geospatial sector and allied industries. Here we note that this is not just the role of academic institutions and professional organisations ([Chapter 12](#)) but it should be a collective goal and responsibility. After all, we have previously noted that, beyond data and technology, the critical role of leadership (at all levels) and governance cannot be overemphasised. Thus, a well-rounded program that goes beyond the technical and that fosters critical thinking and enhances collaboration and communication skills will be ideal. When the next pandemic strikes, a workforce with these attributes will be able to manage it effectively.

In all of the above, the practical challenge for the geospatial and allied sectors is to develop and deploy local resilience-enabling solutions but with global cooperation and harmonisation also in mind. Stronger partnerships and collaboration, even more than those demonstrated in the COVID-19 experience, in addressing a future pandemic will likely lead to successful outcomes. When a society's stakeholders join forces to address an existential crisis, pandemic or not, the greater good is served.

COVID-19 is a clear call to humanity to remind us to care beyond ourselves and about the need to work together to balance our interaction with the natural environment and to act – to save our common future. In this call, many people lost their lives during the COVID-19 pandemic. Their death will not be in vain if we learnt the lessons, particularly around working cooperatively to solve global crises, with a long-term perspective and more equitable societal outcomes in mind.

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