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Managing risk, governmentality and geoinformation: Vectors of vulnerability in the mapping of COVID-19

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Abstract

In the wake of the COVID-19 pandemic, a range of technological as well as legislative measures were introduced to monitor, track and prevent the spread of the COVID-19 virus across the world. The measures taken by governments across the world have relied upon the use of geoinformation from satellites, drones, online dashboards and contact tracing apps to render the virus more visible, which has been instrumental in two ways. First, geoinformation has been helpful in organizing efforts for capacity building, in mapping communities living in deprived urban areas (referred to commonly as 'slums') and their response to COVID-19 measures. These efforts have been part of initiatives by the United Nations as well as NGOs, using geoinformation to inform urban policymaking by representing the social, political and environmental issues facing those living in deprived urban areas. And secondly, geoinformation has also been used to control the spread of the pandemic by monitoring and limiting the behaviour of citizens through various technologies. This form of geoinformation-driven governmentality, I will contend from critical geography and surveillance studies perspective endangers ethical values such as trust and solidarity, agency, transparency along with the rights and values of citizens.

KEYWORDS
COVID-19, critical geography, ethics, geoinformation, governmentality, surveillance studies

1 | INTRODUCTION

Risks reveal society to be more precarious than originally thought or recognized, testing the integrity and resilience of communities, cities and nation-states. The sense of precarity that risks create, produces fear, anxiety and a need for risk managing strategies. From the beginning of the year 2020, the SARS-CoV-2 virus (COVID-19) pandemic has profoundly rendered almost all nation-states into precarity politically, economically and socially. Such precarity has led to numerous states declaring states of emergency to deal with the growing pandemic, which has in turn led to critical analyses of the implications of the decisions and strategies used by governments across the world in dealing with the pandemic. Implications that make it necessary to question the efficacy as well as acceptability of the measures taken by governments, especially regarding the use of technologies in monitoring, controlling and penalizing individuals to contain the virus. Throughout this paper, I will be forwarding the argument that many states have treated COVID-19 as a spatial issue that requires an increased reliance on the collection and representation of geoinformation at individual, city and national level. This has resulted in many states implementing efforts in rendering the

virus visible through mapping its transmission, to mitigate further spread at the individual, city and national level.

And the race to contain these points of transmission within and beyond one's own borders (at the bodily and national level) has led to a vast accumulation, processing and visualization of geoinformation data (geo-data) using contact tracing apps, geovisualization dashboards, digital maps, satellites and drones. This paper will be investigating the use of these technologies and their normative implications through a critical lens, informed by insights from vulnerability studies, surveillance studies and critical geography. These three conceptual foundations will be useful in understanding how conceptions of risk, vulnerability and resilience are related in the mapping out of the COVID-19 pandemic, and how this mapping out reveals issues of trust, agency, transparency and the rights and values of citizens. In this paper, I shall show that the use of geoinformation technologies reflects choices made that have ethical, social and political impact due to the way they change the relationships between individuals and the state, as well as between individuals themselves.

In Section 1 of this paper, I will be defining the concepts of risk, vulnerability and resilience, focusing specifically on the difference between biophysical and societal vulnerabilities (Bankoff, 2004; Birkmann, 2006; Cutter et al., 2003). This will be to point out how the COVID-19 pandemic tested the societal vulnerabilities of the countries which spread across. But I shall also address briefly how while geoinformation technologies are being relied on to map out the pandemic, it is necessary to emphasize that these technologies are not objective or neutral artefacts. As argued from critical geography scholars (Crampton, 2010; Wood et al., 2010), I will be pointing out how the process of mapping is embedded in relations of power that decide what is represented, how it is represented and who has the authority of making these representations.

And in Section 2, in the case of mapping COVID-19, what has become revealed is the utility of geoinformation technologies in efforts to promote capacity building and resilience. I shall be drawing attention to the work done in mapping deprived urban areas (i.e., known as 'slums' or informal settlements) in low-to-middle-income countries (LMICs). This study is essential in the management of cities in LMICs that face rapid urbanization without the proper resources and infrastructure to manage this influx, leading to increasing populations of communities in deprived urban areas (Brito et al., 2020; Kuffer et al., 2020; Thomson et al., 2020; Wilkinson, 2020). Management which became even more strained during the pandemic. The use of geoinformation technologies will, therefore, be shown to be instrumental in pinpointing the biophysical as well as societal vulnerabilities of those living in deprived urban areas.

In Section 3, I shall be turning from the biophysical and societal vulnerabilities revealed by geoinformation technologies, to what I consider the ethical vulnerabilities highlighted by surveillance studies scholarship (Bauman & Lyon, 2013; Datta et al., 2020; Haggerty & Ericson, 2000). I will be zooming in on the use of COVtech in India, emergency legislature in Ghana and other invasive uses of geoinformation technology that illustrate the emergence of pandemic biopolitics (Everts, 2020; Kitchin, 2020). What will become clear from these cases is that the race to contain the virus has created trade-offs between security, health and risk management, and the trust, agency, transparency and rights as well as values of individuals.

2 | THE TERRAIN OF CRISIS MANAGEMENT

In this section, I will be outlining the theoretical frame which I shall be using throughout the paper. Beginning with describing the notions of risk and vulnerability as defined in social studies and crisis management research, and the role of geoinformation in mapping vulnerability and risk from the perspective of critical geography.

The relationship between human wellbeing and risk is a very close one, as human beings have always had to overcome a variety of risks to preserve their individual and collective selves. These risks are related to the weather, diseases, animals and even other humans. In a review of the different uses of the term, Schneiderbauer and Ehrlich (2004) define risk as the 'probability of harmful consequences or expected losses resulting from a given hazard to a given element of danger or peril, over a specified time period' (Schneiderbauer & Ehrlich, 2004). Within this definition of risk, there is a clear consideration being given to who is at risk, what kind of impact (in terms of losses) this risk will lead to, the source of the risk along with its duration. It is also clear that risk is contingent rather than absolute since it is based upon a probability of causing harm. Similarly, a hazard as a source of risk can be defined as a 'potentially damaging physical event, phenomenon and/or human activity…[that] can be single, sequential or combined in their origin and effects' (Schneiderbauer & Ehrlich, 2004). The type of hazard and duration is closely related to the probability of risk imposed on individuals and groups of people. Someone driving a car has a higher risk of causing harm and becoming a hazard if they drive while intoxicated, just as a natural disaster such as an earthquake has a higher risk of causing harm based on its magnitude and whether it happens in a densely populated city. But the impacts of risks and hazards are affected by two interrelated concepts, vulnerability and resilience. Vulnerability refers to the 'characteristics of a person or a group in terms of their capacity to anticipate, cope with, resist and recover' from a given disaster, and this capacity is 'made up of many political-institutional, economic and socio-cultural factors' (Schneiderbauer & Ehrlich, 2004).

And according to Cutter et al. (2003), there are three focal points in assessing the notion of vulnerability. These are identifying the conditions that make people and places vulnerable, the assumption that vulnerability is a 'measure of societal resistance or resilience to hazards', and the 'integration of potential exposures and societal resilience with a specific focus on particular places or regions' (Cutter et al., 2003, pp. 242–243). This is echoed by Birkmann (2006), pointing out that disasters are increasingly considered as a 'result of the complex interaction between a potentially damaging physical event… and the vulnerability of a society, its infrastructure, economy and environment, which are determined by human behaviour' (Birkmann, 2006, p. 10). The interaction between vulnerability and

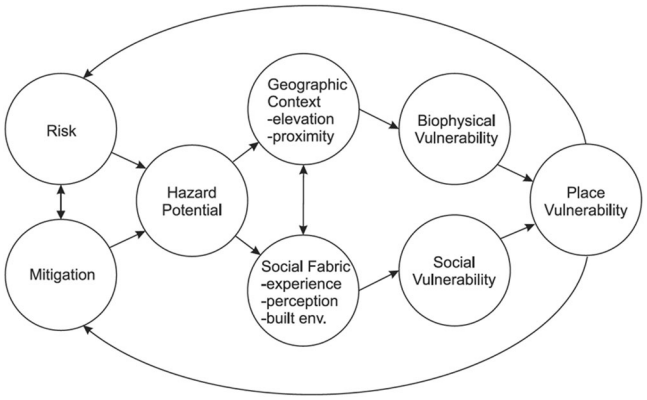

FIGURE 1 Conceptualizing risk and vulnerability (Cutter et al., 2003)

resilience (i.e., overcoming or mitigating risks), is, therefore, a result of responding to biophysical as well as societal factors, exemplified in Figure 1. Regarding the societal factors that contribute to vulnerability as well as resilience, these include access to resources (e.g., knowledge and technology), political power/representation, social capital, customs, physical and mental status of individuals, along with density and type of infrastructure (Birkmann, 2006, p. 245). And resilience or the mitigation of risk and vulnerability, though a contested term, can be considered as the factors allowing 'people, groups of people, animal populations, or whole ecosystems to cope with extreme dynamics in their biophysical environment, including, in the case of humans, social setting' (Hessen et al., 2014, p. 76). As will be discussed in Section 2, marginalized populations such as those living in deprived urban areas in LMICs have higher social vulnerabilities. Which is acutely referenced by Bankoff (2004), when stating that vulnerable populations "are those at risk not simply because they are exposed to a hazard but as a result of a marginality that makes their lives a 'permanent emergency'" (Bankoff, 2004, p. 25). This state of 'permanent emergency' being due to their insecurity regarding employment, housing, food, education and access to medical institutions—all of which was exacerbated in the wake of COVID-19.

And in the wake of the COVID-19 pandemic, the societal vulnerabilities of cities across the world have been tested. As countries have raced to respond to the spread of the pandemic, one of the methods that have become instrumental in understanding the spatial, as well as temporal dynamics of the pandemic's spread, has been the use of geographical information (geoinformation henceforth). This is because geoinformation presented in digital maps, dashboards and apps 'provide important insights into spatial dimensions and the relations of vulnerability and resilience' as well as 'enhance risk communication and support decision-making in all phases of disaster management' (Heesen et al., 2014, p. 74). Geoinformation is useful in capturing location-based information at micro scales (e.g., on individuals, households and neighbourhoods) and macro scales (e.g., on cities, nation-states and global phenomena such as climate change). In the context of crisis management, geoinformation is employed to understand the location, impact and duration of man-made and natural hazards. As a vital aspect of 'outbreak management is understanding infection transmission in time, place and person, and identifying risk factors for the disease to guide effective interventions' (Budd et al., 2020). Geoinformation gathered from epidemiologists, social scientists, geo-spatial databases, mobile apps, wearables and drones have become instrumental in representing the spatial as well as temporal dynamics of the spread of COVID-19, and useful in decision-making deliberations. Geoinformation has therefore become a key component of risk management, affording better understanding of those at higher risk and vulnerability, as well as helping decision-making processes that can improve the resilience of communities and cities.

But while the role of geoinformation in mapping the most vulnerable and most at risk, at the surface, has a clear utility—there are issues concerning the act of mapping that needs to be highlighted. An important point made regarding traditional maps and map-making, which is applicable to geoinformation produced in digital mediums, is that 'maps are systems of propositions, where a proposition is nothing more than a statement that affirms (or denies) the existence of something' meaning that 'maps are arguments about existence' (Wood et al., 2010, p. 34). What is displayed on a map is usually taken to be objective, as if the map has a 1:1 relation with the territory that is being mapped. And once the statements made by maps are repeated often enough, they solidify into facts (Wood et al., 2010, p. 34). The objectivity of maps has been shown to be a problematic assumption by critical geographers. Rather than positing reality or territory as it is, maps are embedded in relations of power as 'mapping is involved in *what* we choose to represent, *how* we choose to represent objects such as people and things, and *what* decisions are made with those representations' (Crampton, 2010, p. 41). What needs to be added here to the point being made by Crampton is *who* is doing the representing and mapping.

As maps make statements of reality, it is necessary to consider that these statements follow codes, standards and knowledge that are predominantly Western, dominated by nation-states, governments and elites (Crampton, 2010, p. 26). And so while mapping and maps may appear objective and neutral, by representing places, people and social processes, maps 'produce a cultural code, among other, competing cultural codes' (Hessen et al., 2015, p. 256). Even though over the last two decades, map making has moved out of the exclusive hands of professional cartographers and governments, and become digitized through the growth of collaborative tools, mapping applications and the geospatial web (Crampton, 2010, p. 40), the intelligibility and relations of power digital maps are embedded in still warrants attention. Especially as the 'subtleties of visual representation such as projection, generalization, and colour schemes' (Heesen et al., 2015, p. 254) which may appear clear to a certain audience may lead to misinterpretation by other audiences, as the map makers may assume universal intelligibility. And so even though the *who* that is involved in producing maps may have changed, the epistemic, as well as ontological choices in digitised maps, often remains invisible (Heesen et al., 2014, p. 75).

This is also relevant in the context of mapping risk and vulnerability, as the assertion that certain areas or peoples are more vulnerable or at risk than others can have positive as well as adverse effects. Given the agency that maps have in making statements about authority, "maps that are only seemingly descriptive are reducing reality's complexity and becoming prescriptive" (Heesen et al., 2015, p. 256). The prescriptive nature of maps may be taken for granted if it is assumed that they are objective and neutral. But as mentioned from the perspective of critical geography, this neutrality is questionable given that maps are embedded in relations of power.

Further, it is necessary to ask what are the sources of the data and the level of accuracy of the data, that mapmakers use. How areas are classified, bounded and represented on maps relies on aggregation and standardization that can be problematic, since by generalizing and reducing the complexity of social processes, maps can leave out certain variables and relationships between indicators of the demographics that are most vulnerable (Hessen et al, 2014, p. 78). This can lead to poorer understanding of these processes, hindering the success of risk management decision-making. Further, there is also a trade-off between protection of privacy and level of detail and precision (Hessen et al., 2014, p. 78). And as I will be arguing in Section 3, in the role of geoinformation in the surveillance and limiting of access of individuals to manage the spread of COVID-19, there are trade-offs between risk visualization, management and communication, and the agency, trust, values and rights of individuals and communities. This trade-off represents what I shall be calling the ethical vectors of vulnerability, which exist alongside the biophysical and societal vectors of vulnerability, that must be addressed in the use of geoinformation.

3 | GEOINFORMATION-DRIVEN GOVERNMENTALITY AND CAPACITY BUILDING

The measures taken by governments in the wake of the COVID-19 have run along two paths—one is the need to immediately contain the spread of the pandemic, the other is using the pandemic as an important sign for the need to deal with the vulnerability of populaces by improving the capacity building. I will be looking at the consequences of the first path in Section 3, and focus in this section on efforts of using geoinformation for capacity building. UN-Habitat defines capacity building as 'developing and strengthening the skills, instincts, abilities, processes and resources that organizations and communities need to survive, adapt, and thrive in a fast-changing world' (UN-Habitat, 2020). There is an implicit relationship, therefore, between capacity building and resilience, given that the skills, abilities and resources that are fostered can help improve the resilience of individuals and communities in the face of biophysical and societal vulnerabilities. The relationship between capacity building and geoinformation is not unique to the current pandemic. It is a long-running relationship that has been pronounced as far back as the United Nations (UN) World Summit of Sustainable Development in 2002, which called for countries to increase development in earth observation technologies and geoinfomation systems (UN, 2002). This call for greater geoinformation, specifically in developing countries, was echoed again in the UN's 2012 report, (United Nations, 2012) *The Future We Want* as well as in 2015, (United Nations, 2015) with the formulation of the 2030 *Agenda for Sustainable Development*.

It is in this regard that geoinformation used for mapping deprived urban areas (such as so-called 'slums' and informal settlements) merits attention. A common issue concerning these areas is a lack of representation spatially and politically, whereby state censuses and maps fail to include them and many of those living in these areas are often not considered to be full members of the city they are in (Brito et al., 2020). This lack of inclusion and awareness of these areas is also coupled to the difficulty in defining them, as developing countries and cities have their own terms to describe them—such as bidonvilles in francophone countries, favelas in Brazil and townships in South Africa (Taubenbock & Kraff, 2014). Due to the negative connotation that historically surrounds the term 'slum', I will be borrowing the term deprived urban area from Kuffer et al. (2020) and Thomson et al. (2020) that looks at these areas according to their scale of deprivation in terms of infrastructure, social services and health factors that the people in these areas face.

Although deprived urban areas do not appear homogenously, operationally they are classified in relation to five indicators: lack of security of tenure, water and sanitation, overcrowding and inadequate structural quality of housing (UN-Habitat, 2018) and measured according to the criteria in Table 1. These indicators are compounded by the socio-political as well as epidemiological issues faced by these communities, relating to the existence of underlying health conditions, increased social mixing due to overcrowding, lacking availability of intensive care facilities and public health services, along with lacking social protection measures (Brito et al., 2020; Wilkinson, 2020).

These issues make it especially difficult for these communities to meet the WHO and government prescribed guidelines (i.e., social distancing, self-isolation, frequent hand washing, wearing of Personal Protective Equipment, and working from home) that were advised to be taken unilaterally in the Global North and Global South. Such guidelines show a lack of acknowledgement of the precarity that those in deprived urban areas live with, especially regarding having to choose between following lockdown orders and risking starvation or continuing to try to make a living and risk severe punishment from police authorities as in Nigeria (Iwuoha & Aniche, 2020). Which is also pointed out by Corburn et al. (2020), 'space constraints, violence and overcrowding in slums and tenements make physical distancing and self-quarantine impractical, and the rapid spread of an infection highly likely' (Corburn et al., 2020, p. 350). Worse still, the rate at which populations in deprived areas grow and lack of consistent accounting has also affected accurately measuring the rate of COVID-19 infections in deprived urban areas. As Saharasanaman and Jensen's (2020) study reveals, in Rio de Janeiro's favelas 'the number of people infected by COVID-19 in these slums could be 30 times official estimates' (Sahasranaman & Jensen, 2020, p. 4).

TABLE 1 Indicators used by UN-Habitat in categorizing 'slums' (UN-Habitat, 2018)

Indicator	Measurement
Security of tenure	• Proportion of households with formal title deeds or tenure arrangement to either land and/or residence
Adequate water	• Settlements are considered to have an inadequate water supply if less than 50% of households have a household connection, public stand pipe or less than 20 L/person/day available
Access to sanitation	• Settlements are considered to have inadequate sanitation if less than 50% of households have public sewers, septic tanks, pour-flush latrine or ventilated improved pit latrines
Structural quality of housing and location	• Settlements are considered lacking adequate location if they are located next to geological hazardous zones, around high-industrial pollution areas, or other unprotected high-risk zones (e.g., railroads and energy transmission lines) • Settlements are considered lacking in structural quality of housing based on the quality of construction materials and compliance with local building codes, standards and bylaws
Overcrowding	• Settlements are considered overcrowded if households have more than two persons allocated in a room

Given this need for making the invisible visible as well as supporting the growing number of people living in deprived urban areas in the wake of the COVID-19 pandemic, geoinformation on these areas is increasingly needed. Deprived urban areas are mapped using four main approaches, as presented in a review of the mapping of these areas presented by Kuffer et al. (2020). First, aggregated approaches use the UN-Habitat operative definition that defines households in an area as 'slums' if more than 50% fit the criteria of the definition. Second, field-based mapping approaches are usually led by nongovernmental organizations such as Slum Dwellers International (SDI) and Humanitarian OpenStreetMap Team (HOT), which provide low-cost devices, geovisualization software and training to those living in these areas in surveying and profiling households. Such initiatives enable members of the community to have an active role in creating digital representations of their living conditions, creating a greater sense of advocacy especially in the face of state censuses that may exclude them. Third, human imagery classification approaches use morphological criteria (e.g., building density and irregular layout patterns) identified by local community experts in (some freely accessible) very high resolution (VHR) images from satellites, Google Earth and drones with 3–30 cm image resolutions. Finally, semi-automatic imagery classification approaches utilize commercial VHR imagery, that are identified by machine-learning models that are trained in classifying smaller areas in cities.

These approaches are at times implemented in conjunction (as is done by organizations such as WorldPop), and the situation of revealing those at most risk from COVID-19 in these areas calls for integrating top-down (e.g., using VHR imagery and machine learning models with criteria defining these areas) as well as bottom-up (e.g., engaging with members of the community) mapping strategies. The work done by NGOs HOT and Geo-referenced Infrastructure and Demographic Data for Development (GRID3) showcases how geoinformation is a key part of informing capacity building to deprived urban area communities for policymaking and resource allocation (Geo-referenced Infrastructure and Demographic Data for Development, 2020; Humanitarian OpenStreetMap Team, 2020).

For instance, Yeboah et al. (2020) utilized OpenStreetMap data to account for the appropriate healthcare facilities for deprived urban areas in Nigeria. Using a combination of remote participatory mapping, local participatory mapping and identifying which dwellings had adequate structure (Yeboah et al., 2020). Another example is in Brazil, where Brito et al. (2020) point out the utility of VHR imagery, census data, community-based mapping and drone imagery in providing a better understanding of the morphology, facilities and environmental situatedness (as shown in Figure 2). In responding to COVID-19, these three aspects (urban morphology, facilities and environment) help in determining how likely individuals can actually be socially distant (e.g., overcrowding in rooms as well as narrow pathways between buildings lower this likelihood), or access to water and sanitation (an issue in many deprived urban areas) and the effect of needing to continue working despite quarantine orders. All of which are vital for helping municipal authorities in understanding where services and resources are needed most.

The initiatives of representing deprived urban areas through the four approaches outlined, therefore, inform mapping out the societal and biophysical vectors of vulnerability that are related to socio-political as well as environmental factors that affect the resilience of communities in responding to the COVID-19 pandemic. These vectors are related to demographic, comorbidities, social security, urban morphology and environmental situatedness. And they affect the vulnerability of individuals and communities especially in their exposure to risks not only from hazards such as COVID-19, but also from the environmental, socio-political and economic problems they face.

4 | THE MORAL WEIGHT OF GEOINFORMATION DURING COVID-19

But as countries increasingly rely on and use geoinformation technologies to render the pandemic visible, it becomes necessary to also assess what is ethically at stake. In the race to make sense of the

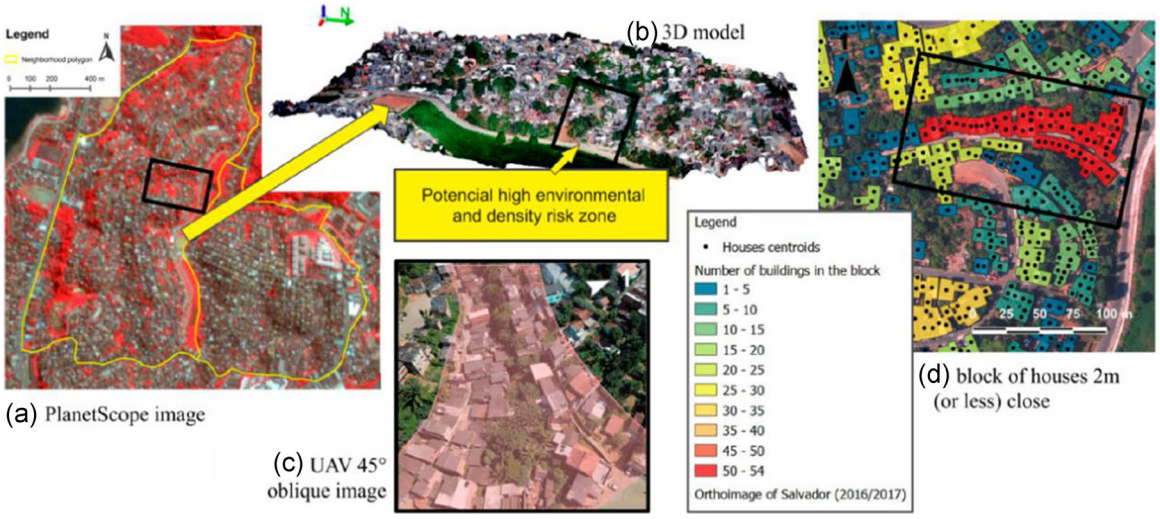

FIGURE 2 Urban density and environmental factors affecting COVID-19 vulnerabilities in Salvador, Brazil (Brito et al., 2020)

COVID-19 virus and control the movement of citizens, different geoinformation technologies have been used such as drones that monitor the temperature of individuals in public places in Italy (Url, 2020), as well as wristbands that ensure home quarantine orders are followed in Hong Kong (Stanley & Granick, 2020). More so, the outbreak management of COVID-19 has involved citizens becoming aware that their actions should be treated as a civic duty that could be the difference between reducing the transmission of the virus and saving or endangering lives. An illustrative example of this is how the adoption of the contact tracing app 'Smittestopp' in Norway was framed (Sandvik, 2020). But at the same time, this civic duty has led to citizens reporting on each other for not remaining in quarantine, as is evident in Hong Kong (Liu & Bennet, 2020) as well as Uganda (African Declaration on Internet Rights and Freedoms Coalition, 2020). As managing the COVID-19 pandemic (e.g., enforcing of self-isolation) is not only in the purview of distant experts and government authorities, but is also affected by the relations between individuals and technologies used to trace the virus, in this section I will be addressing the ethical concerns following the use of geoinformation technologies during the COVID-19 pandemic.

Digital maps and charts comparing the rate of infections in countries are transforming bodies, cities and countries into points of exposure in the fight against the virus. This transformation became effected (in part) by the dashboards displayed on mobile apps, desktops and control rooms. As Everts points out, the 'dashboard view of the pandemic—with its heat maps and aggregated numbers—is a biopolitical technology of anxiety that visualizes the unfolding disaster, suggesting strong responses by national and regional governments (or else accepting the descent towards disaster and death)' (Everts, 2020, p. 260). Where these technologies have become most embedded, the daily lives of individuals are becoming increasingly scripted (Aouragh et al., 2020) as they are technologically directed to what is permitted, what buildings and services can be accessed, and informing authorities of when mandates are not followed. This reveals that these dashboards and apps produced to contain the pandemic are not entirely neutral, and instead are embedded in relations of power that impact the behaviour of individuals and groups. Such a situation calls for inquiring what the ethical costs are, of having such geo-data driven decisions. And other than the potential loss of lives, the costs include exchanging values and rights such as individual and collective privacy, freedom of movement (stricter depending on technologies and government mandate issued), freedom for religious expression (as religious spaces are closed) and freedom of speech (those who question the measures can face punitive treatment) for the sake of upholding public health. This scripting effect, as well as overarching surveillance of individual and collective bodies, informs emerging pandemic biopolitics (Kitchin, 2020) that is fuelled by pandemic anxiety (Everts, 2020, p. 260).

An illustrative example of the positive as well as the negative reality of this pandemic biopolitics is the situation in Indian cities documented by Datta et al. (2020). The pandemic led to the integration of 'CCTV and drone surveillance, google map tracking, as well as AI, facial recognition and predictive analytics', the zoning of cities 'into red, orange and green areas based on infection rates' and repurposing of Integrated Command and Control Centres (ICCC) into war rooms monitoring the virus (Datta et al., 2020, p. 1). The resulting 'COVtech' utilized maps and apps to render the virus visible, while at the same time dissolving the boundaries between home, work and leisure (Datta et al., 2020, p. 1) as surveillance and control of the virus became embedded further and further into the lives of Indian citizens. Looking at the development of COVtech follows the logic of what Bauman and Lyon (2013) refer to as liquid surveillance. This logic is based on the fact that surveillance has penetrated the consumer realm, 'jolted by "security" demands and tipped by technology companies' insistent marketing, surveillance spills out all over' (Bauman & Lyon, 2013, p. 9). This spilling over works on two premises: first, surveillance operates split from moral or ethical

considerations, second, surveillance 'streamlines the process of doing things at a distance' (Bauman & Lyon, 2013, p. 13).

The surveillance operating under COVtech is focused on containing the virus even though the cost of this containment is the disruption of lives through increased scrutiny in the behaviour of individuals. And the war rooms become the site of 'doing things at a distance' as the decisions made to contain the virus are done from a remote distance without the effects having to be experienced by those making the decisions. The design of India's COVtech actualizes what Haggerty and Ericson (2000) two decades earlier had alluded to:

'The analysis of surveillance tends to focus on the capabilities of a number of discrete technologies or social practices. Analysts typically highlight the proliferation of such phenomena and emphasize how they cumulatively pose a threat to civil liberties. We are only now beginning to appreciate that surveillance is driven by the desire to bring systems together, to combine practices and technologies and integrate them into a larger whole' (Haggerty & Ericson, 2000, p. 610).

An example of this threat to civil liberties in containing COVID-19, is the 'Aarogya Setu' app which exemplifies the trade-off between security and the rights of citizens. The app was reported to be tracking 'home-quarantine citizens and their movement on a real time basis using GPS tracking', and in Delhi 'the authorities handed over 25, 429 private mobile phone numbers to the Police to monitor quarantine and isolation' (Datta et al., 2020, p. 3). This dissolution of the boundaries between home, security and travel is not unique to India alone as I will show below, but what is worth noting is the duality of COVtech.

On the one hand, the ICCs turned war rooms further deepen the social inequalities and vulnerabilities in India as they affect "who owns a smartphone, who can download the apps, who can therefore be traced and tracked on the mapping platforms, and who is subsequently displaced by the restraints of the apps and maps" (Datta et al., 2020, p. 4). Inequalities that are affected not only by the technologies used but also by the mandated lockdowns. One segment of the population that was heavily affected were migrant workers that were denied access to public spaces, and more disturbingly, they 'were often violently disciplined by the police' in response to their breaking of lockdown rules (Datta et al., 2020, p. 6). And because there was no central database with information on migrants, they were left invisible in the analytics of COVtech. At the same time, however, efforts in certain states in India such as Kerala's war room was a crucial node in managing the logistics of delivering goods to the stranded migrant workers, and in Karnataka where food relief was also directed using heat maps and hotspots (p. 7). These instances of COVtech being used in reducing the social vulnerabilities of the migrant workers in India show that these technologies are not entirely negative and only to be viewed through the lens of potential function creep.

The duality of India's COVtech highlights the double-edged nature of increased embedding of geoinformation in the governance of cities, showing the need to assess the morality and legality of the measures taken to contain the virus. As the leak of private numbers in Delhi shows, in the context of containing the pandemic state actors can engage in actions that go against the rights and values of citizens. One example is the Epidemic Act that was announced in Denmark on March 12, 2020, which gave the Danish government 'a power tool of a legal apparatus, with limited judicial and parliamentary oversight, and running for a full year' (Lauta, 2020). Even though an evaluation report found that this legal apparatus was not completely abused, over the past year there have been initiatives to call back this act and retain this power tool from the government to avoid 'an eternal emergency' (Lauta, 2020).

Another example is the Executive Instrument (EI) 63, the Establishment of Emergency Communications System Instrument in Ghana as of March 2020 (Oduro-Marfo, 2020). EI 63 enhances the Ghanaian government's control over telecommunication systems in times of public emergencies, with two potential eventualities: the tracking of citizen communication in real time that endangers citizens given that security agencies operate at the disposal of government actors, and its more long-term operationalization that justifies intrusive surveillance structures without clearly defining when the warrant for these structures will end (Oduro-Marfo, 2020). Bodies of citizens along with cities and countries have become transvalued into points of exposure that need greater monitoring and control, reflecting how the pandemic quickly turned into an opportunity for widening the surveillance systems at the disposal of governments (Daly, 2020; Ugarte, 2020).

What this analysis reveals, is the exposure of vectors of vulnerability involving trust and solidarity, transparency, agency and the rights as well as values of individuals and groups. Trust and solidarity are key in times of crisis, as whether or not individuals and communities can follow guidelines depends on their willingness to believe the guidelines are valid as well as sound. Along with the understanding that following guidelines are interpreted as a sign of believing in collective responsibility and the interests of the state over one's own individual interests (Kaurin, 2020; Wang, 2020; Yeung, 2020). Trust and solidarity rely on transparency, which geovisualizations on dashboards, contact tracing apps and wearables may obscure depending on who is designing them. As these technologies can provide epistemic insight through magnifying patterns of behaviour of citizens, they also enable greater control over setting the limits of access to where citizens can go and also what information they can access. The concern here is that as these technologies 'do not require active citizen cooperation, they entail important design choices about the extent to which their data-gathering and decision-making capacities provide citizens with the possibility to opt out' (Yeung, 2020). This further emphasizes the point that any kind of mapping process or map produced, is not an objective or neutral artefact that should be taken for granted as highlighted by critical geographers. Especially when the maps operation can have disadvantageous impacts on the lives of individuals as a result of limited transparency on how the map's representation and sources of the data are used.

This opacity as well as greater technological oversight diminishes the agency of citizens who are no longer trusted to be self-determined

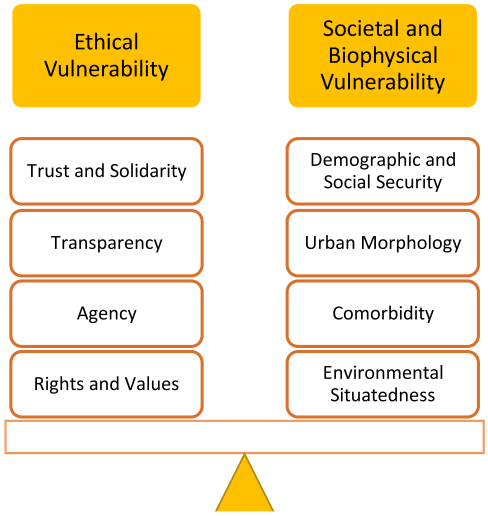

FIGURE 3 Vectors of vulnerability in the management of risks during COVID-19

or self-disciplined. Compliance becomes determined and guaranteed by data-driven systems (Kitchin, 2020) that utilize geoinformation to track and confirm whether individuals are where they are supposed to be. It is with this increase of geoinformation used in data-driven governmentality, that the rights and freedoms of citizens are a vector that becomes endangered. As such it is worth noting that not only geoinformation technologies are being introduced and embedded in daily life without resorting to social acceptance or ethical acceptability. Legislation that may be justified during the pandemic and impact the rights and values of individuals, may remain in force even after the pandemic. This legislation might be effective in helping to mitigate the spread of COVID-19, but whether or not the policies may be rolled back is somewhat uncertain.

Consequently, analysing the use of geoinformation technologies to contain the COVID-19 pandemic has revealed the ability of these technologies to map the societal and biophysical vectors of vulnerability outlined in Section 2, while also exposing the ethical vectors of vulnerability outlined in this section. What is becoming clear as the pandemic still lingers, with debates surrounding the use of contact tracing apps, drones, online dashboards, digital maps and the implementation of quarantines and lockdown legislation continuing, is that these two kinds of vectors of vulnerability need to be balanced (as shown in Figure 3). This balance is an ideal situation, that may not be the case in all countries given differences in democratic or authoritarian regimes, the trust citizens have in governments given long-standing inequalities that the COVID-19 pandemic has only worsened, as well as different urban morphologies and demographics that impact how well quarantine and self-isolation mandates can be followed. But it is a balance that will depend on what kinds of technologies are left in place (e.g., the COVtech war rooms in India), what legislature has been used and remains in use to justify the further embedding of surveillance (e.g., the Epidemic Act in Denmark or El 63 in Ghana).

5 | CONCLUSION

While it may not be clear yet when the COVID-19 pandemic will be over, it is clear that there are many social, political and ethical considerations that will need to be reflected upon. The race to lower the risk of viral transmission, has reshaped the way individuals interact and the way they are treated and seen. A vital instrument in the tracking and containing of the virus has been the use of geoinformation technologies, which have presented two sides to the impact of these technologies. On the one hand, as I explore in Section 2, geoinformation technologies are important in efforts for capacity building and improving resilience, especially in relation to individuals and communities that are often left invisible. These technologies are useful in mapping out the biophysical and societal vulnerabilities of communities such as in the mapping of deprived urban areas in cities in LMICs. On the other hand, as I show in Section 3, taking the perspective of critical geography and surveillance studies, the examples of COVtech and other invasive uses of these technologies present ethical problems that warrant attention. These problems are rooted in the fact that as fears of the pandemic increased and biopolitical measures were taken to respond to these fears, it became clear that trade-offs (e.g., between public health and privacy of personal data in the Delhi leak) were made as governments strategized how best to contain the virus. The trade-offs revealed what in this paper I refer to as the ethical vectors of vulnerability, namely trust and solidarity, transparency, agency and the rights and values of individuals and groups. Consequently, the use of geoinformation in revealing the biophysical and societal vulnerabilities of individuals and groups in cities during crises highlights the importance of geoinformation in improving the resilience of these populations by identifying their vulnerabilities. But at the same time, attention needs to be given to the ethical vulnerabilities that may become exposed as the supply as well as the demand of geoinformation increasingly accumulates and becomes more and more invasive. With this increased accumulation and invasiveness, it is necessary to question what is at risk of being lost and what ethical trade-offs are worth being made.

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