

CLIMATE CHANGE AND COVID-19 IN THE KRUGER TO CANYONS BIOSPHERE REGION, SOUTH AFRICA AND AMAZONAS, BRAZIL

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Introduction

Anthropogenically induced climate change and global warming is now endangering the sustainability of humankind's growth on earth as it jeopardizes the environmental support systems on which it relies, as well as human health and security – the ongoing enhancement of which ought to be the very objective of the growth progression itself (McMichael 2009; Harry and Morad 2005; Kagawa and Selby 2015). Chomsky and Pollin (2020) note that humankind is in deep trouble with regards to the climate crises, and that it is time to panic.

Emerging nations are especially susceptible – climate change effects will not be evenly distributed among nations. Their vulnerability is due to multiple factors, which can impede their means of preventing and responding to climate change (Martens 1998; dos Santos 2020). In short, King (1990) emphasizes that many emerging nations are demographically constricted, in that indigenous populations have exceeded – or are anticipated to exceed – the carrying ability of their local ecosystems, their ability to migrate, and the capability of markets to yield commodities and services in exchange for food and other supplies. These obstacles to sustainability are demonstrated by the health relationships related to contagious infections and famine. It is estimated that climate change will add extra stresses on already exploited ecosystems and burdened healthcare infrastructures (Adejuwon et al. 2008). Existing legislation and actions to aid the most vulnerable communities have

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been limited in terms of both range and reach (International Fund for Agricultural Development 2001).

The coronavirus SARS-CoV-2 (COVID-19) pandemic spread swiftly around the world during the duration of 2020 and continues into 2021 – with new variants most notably in South Africa, Brazil and the United Kingdom – on a magnitude and with a magnitude not witnessed since the devastating Spanish flu of 1918–1920². Humankind currently finds itself in an economic, ecological and social catastrophe (Michie and Sheehan 2021).

Everybody speculates about how the COVID-19 pandemic will alter our planet, our ethics, our predilections, in short, our lives – and if it will signify a stimulus to revolutionize existing models of sustainable development in broad, and in the healthcare sector specifically. However, the answers to these uncertainties depend on many factors, including the response of political powers to the ongoing crisis (Lucia and De Stasio 2020).

In spite of the worldwide economic recession as a consequence of the COVID-19 pandemic, deforestation in the Amazon in Brazil, for example, is intensifying exponentially, having increased for 13 successive months relative to year-earlier figures and reaching the peak level since monthly data started being released publicly in 2007, according to the nation's national space research institute, *Instituto Nacional de Pesquisas Espaciais* (INPE) (Earth.org n.d.). Nowadays, it is well recognized that many emerging communicable diseases, potentially including the novel COVID-19 virus, initiate from animals. The destruction of habitats, aggravated further by climate change and driven by economic advancement, is consequently furnishing the perfect circumstances for new disease emergence (Nonopen 2020; Rainforest Alliance 2020). At this point in time, however, climate has not yet surfaced as an identified driver of COVID-19, and the mechanistic understanding of the virus' climatic sensitivities remain limited. Nevertheless, there are phases in the zoonotic spillover progression at which climate forcing is to be expected. Zoonotic spillover refers to the multilevel process by which pathogens (for example: COVID-19, the Ebola virus, the human immunodeficiency virus (HIV) and avian influenza viruses) succeed in overcoming a sequence of naturally occurring barriers and infect other animal species. The zoonotic spillover theory, taking into account the complex adaptive systems processes, identifies the kinds of barriers that have to be surmounted in each situation.

2 The Spanish flu was an unusually deadly influenza pandemic caused by the H1N1 influenza virus, it infected approximately a third of the world's population – or an estimated 500 million people – in four successive waves. Its death toll is thought to be somewhere between 20-50 million people – though other estimates range from 17 million to as high as a potential 100 million (History.com 2020).

Identifying and grasping which of these barriers can be impacted by climate – by either being suppressed or heightened, thereby either facilitating or buffering spillover, respectively – is critical in predicting how climate change can affect cross-species pathogen transmissions. More directly, climate can act as a conduit to pathogen development, dissemination and survival. Indirectly, the effects of climate are far more complex and much wider. Generally, however, climate should be regarded as a necessary, though not sufficient factor, which interjects with disease emergence (Rodó et al. 2021).

The Evandro Chagas Institute, a public health research institution in the city of Belém, Brazil, has classified approximately 220 distinct categories of viruses in the Amazon alone, 37 of which can cause infections in humans and 15 of which have the capacity to cause epidemics. They include a series of diverse encephalitis variations as well as West Nile fever and Rocio, a Brazilian virus from the same class which produces yellow fever and West Nile. Arboviruses, which can be transmitted by insects such as the mosquitoes that carry dengue fever and Zika, also present as a risk (Zucker 2020). Within the South African context most of the key challenges, such as – the upsurge of HIV/AIDS and COVID-19 cases, the impact of economic globalization, natural catastrophes such as droughts, economic and geopolitical stresses – converge with issues of climate change (McMichael 2009; Fields 2005).

Overall, climate change is multiplying many of the established sources of health inequalities, undercutting coping mechanisms that are customarily used to oversee extreme events such as pandemics, and disordering food systems and local diets. Dealing with primarily inequalities and reinforcing indigenous knowledge systems, which advocate more holistic approaches, advance prospects for fostering resilience to compound socioecological shocks, including climate effects and pandemics (Zavaleta-Cortijo et al. 2020).

Objective and approach

This paper interrogates, and is focused, on the Kruger to Canyons biosphere region in South Africa and the Amazonas state in Brazil as comparative geographic case studies in relation to the COVID-19 pandemic and aspects related to climate change. These two locations have been chosen for the following reasons: these two biomes are important because greenhouse gas (GHG) emissions are predicted to significantly increase in these two areas in the future, which will result in widespread environmental degradation (Nash et al. 2019). These two locations have also been chosen due to the respective colonial discriminatory historical similarities and legacies between the two

countries, to the international environmental and tourism significance of the two biomes, as well as to the ongoing sustainability-related issues in both areas relating to poverty and the overall vulnerability of the respective indigenous communities and their subsequent unequal access to healthcare. I have also personally spent time in both biomes and countries (in 2015, 2018 and 2021) and have subsequently become acquainted with their respective localized idiosyncrasies. The first part of the paper is focused on the Kruger to Canyons biosphere region in South Africa and discusses its historical, demographic, climate change, COVID-19 and healthcare infrastructural dynamics, this is followed similar discussion regarding the Amazonas state in Brazil in the second part of the paper. The discussion and conclusion that follows offers a critique and comparison between the regions, ending with a summative conclusion.

A PubMed literature search was conducted on the 22 March 2021 and again on the 9 June 2021, using the following MeSH codes: “Agincourt” [Mesh Terms] AND “COVID-19” [All Fields] OR “SARS-CoV-2” [All Fields] OR “health” [All Fields] AND “climate change” [Mesh Terms]; as well as: “Manaus” [Mesh Terms] AND “COVID-19” [All Fields] OR “SARS-CoV-2” [All Fields] OR “health” [All Fields] AND “climate change” [Mesh Terms], which resulted in no synthesized focal area outputs as yet in terms of modelling studies, narrative and systematic reviews, case studies, case series or qualitative research related to integrated outputs regarding climate change and COVID-19 in these two biomes specifically. While information is thus scattered and fragmented in terms of either climate change or COVID-19 in isolation, both across these two areas and countries, it has been possible to source and combined more localized information (both gray literature, technical reports and academic articles) regarding climate change, healthcare infrastructures and COVID-19 in the two biomes.

South Africa and the Kruger to Canyons biosphere region: history, demographics, climate change, COVID-19 and the healthcare infrastructure

Historical background, topography and demographics

In 2001, the United Nations Educational, Scientific and Cultural Organization (UNESCO)³ formed the Kruger to Canyons Biosphere Region as

³ UNESCO (2021) seeks to build peace and is a specialized agency of the United Nations, aimed at advancing world peace and security through international cooperation in education, the sciences and culture.

an International Man and Biosphere Reserve, providing an outline for investigating community solutions to difficulties by conventionalizing biodiversity conservation and sustainable development, synthesizing economic, social and environmental facets and acknowledging their critical roles within specified education settings next to the Protected Areas, it includes the Bushbuckridge municipality and Agincourt sub-district (Kruger to Canyons Biosphere Region 2021). The location in the north-eastern part of South Africa also contains the Kruger National Park and the Blyde River Canyon, two significant tourist attractions. The current demarcation expands north from the Letaba River to the Sabie River in the south, and west to the Blyde Escarpment, and then to the Mozambique border in the east. Extensive parts of the biosphere are protected areas. The savannah in the Great Escarpment Mountains (Drakensberg) and afro-montane jungles look out onto the grassland Bushveld of the Lowveld, while the water catchment collects higher rainfall in the Great Escarpment Mountains and links the three biomes by rivers flowing to the Indian Ocean (refer to Map 1 & 2 below).

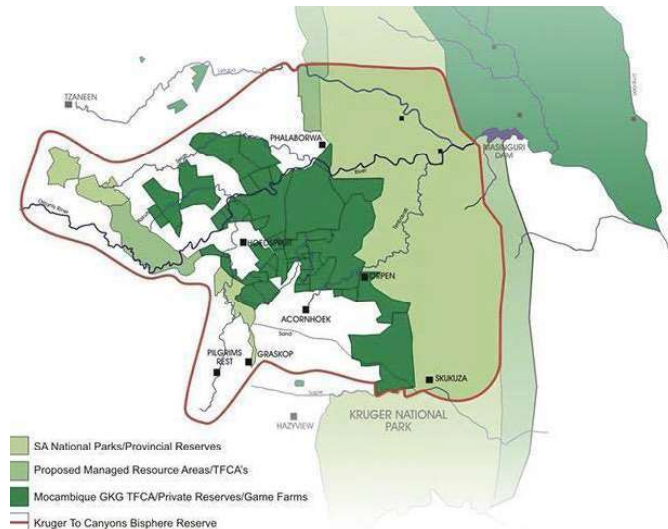
Map 1: The Kruger to Canyons Biosphere location in South Africa



Source: Google Maps (2021)*

*<https://www.google.co.za/maps/search/kruger+to+canyons+biosphere/@-25.7054565,17.9526543,5.11z>.

Map 2: Kruger to Canyons Biosphere



Source: Mpumalanga (2013)*

*<http://www.mpumalanga-info.co.za/provinces/article/181/kruger-national-park-biosphere-reserve>.

There are more than 420 documented archaeological locations in the Kruger National Park, attesting to its habitation prior to modern times. Most locations, however, had comparatively brief occupation phases, as the incidence of predators and the tsetse fly inhibit cattle farming. At Masorini hill, alongside the H9 road in the Kruger Park, iron casting was traditionally exercised up until the Mfecane period. The restored Thulamela on a hilltop south of the Levuvhu River was inhabited from the 13th to 16th centuries and had associations with merchants from the African east coast. Numerous kraals⁴ along the Sabie River and further north beyond the Letaba River could be observed, however, the north was sparingly inhabited in comparison compared to the south. Prior to the Second Anglo-Boer War⁵, what is now the Kruger National Park was first an isolated division of the eastern South African Republic's final wild frontier. President Paul Kruger of the South African Republic declared the area, which was then occupied by the indigenous Tsonga people, a reserve for the guarding of its wildlife at the time (Carruthers 1995). Jacob Dlamini's (2020) book entitled *Safari Nation*:

4 A 'kraal' is a traditional African village of huts.

5 The Second-Anglo Boer War, which took place from 1899-1901, was fought between the British Empire and the two independent Boer states, the Republic of the Transvaal, and the Orange Free State, over the Empire's influence in South Africa (Britanica 2021).

A Social History of the Kruger National Park traces the early history of the Kruger National Park, including its contentious land-grabbing policies and bureaucratic dehumanization of Africans. Even though black rangers were employed early on, they were not allowed to carry weapons to fight poachers, for example, and were frequently not even accorded the dignity of their full names. In 1930, the National Parks Board also protested, unsuccessfully, the Native Affairs Department acquiring land near the town of Acornhoek, adjacent to the southwestern section of the park, for black African settlement. The National Parks Board did not want black Africans near the park, believing that they were responsible for depredations against game. In the same year, John S Allison, who was the secretary for native affairs pointed out the board's hypocrisy in trying to use its power as a government agency to undermine a law that was, from the point of view of Africans and their legal guardians in the Native Affairs Department, already bad enough. This was neither the first nor the last time that the Native Affairs Department would clash with the National Parks Board over land for Africans.

The Kruger to Canyons biosphere region has a present-day population of approximately 541,248, of which 99.35% are black African. Most of the people live in poverty, with inadequate housing and no access to private medical care (Kruger to Canyons Biosphere Region 2021). The primary municipality in the area is Bushbuckridge, situated in the Mpumalanga province of South Africa, and it is a good example of a socioecological system. It is distinguished by a cultural setting where the symbiosis of community and the biophysical habitat is apparent. The forced relocation of black Africans from the 1950s to the 1980s under the apartheid administration, which implied separate development and a framework of social and economic inequality and deprivation, coupled with the appearance of Mozambican migrants during the 1990s fleeing the armed conflict in their homeland, has sustained a growing population concentration in the vicinity. It was only in 2000 that the South African government granted these Mozambican refugees residence permits (Brites and Padilha 2019). Bushbuckridge faces many of the same trials which are rampant throughout South Africa, such as a high HIV/AIDS rate, destitution, and poor organizational governance capacity (Erasmus et al. 2011; Brites and Padilha 2019). Only 5.7% of the Bushbuckridge community aged 20 years and older holds a higher education, while a low 6.2% of the community has access to flush toilets linked to a sewerage system. Most households, 96.6%, have electricity for lighting, though electricity percentage use for heating remains unknown (Bushbuckridge Local Municipality 2016).

Political milieu, climate change, COVID-19 and the healthcare infrastructure

From the start of the COVID-19 epidemic in South Africa in March 2020, all South African national parks, including Kruger National Park, were locked down to new guests. International visitors in the national parks from high-risk countries were placed into isolation within the parks. Conservation continued as normal, with distancing and isolation practices used to reduce risk. A gradual and phased reopening of the parks was declared in August 2020, with Skukuza and Lower Sabie gates entrances to the Kruger National Park functioning at a lower capacity and the Biyamiti, Maroela and Orpen gates remaining closed. Additional reopening was announced and took place between October and December 2020 (Latest Sightings 2020).

In a previous explorative study undertaken by the author relating to climate change and healthcare sustainability in the Agincourt sub-district of the Kruger to Canyons biosphere, the public and community healthcare facility and workforce assessment outcomes of eight (out of the 10) healthcare facilities in Agincourt indicated that the greatest need across the healthcare facilities related to adequate access to medical doctors and pharmacists, for example, three facilities had no access to a medical doctor, and seven of the facilities had no access to qualified pharmacy staff. Furthermore, only three of the facilities were accessible via a good road infrastructure and none had planned patient transport in place, patient had to rely on the informal taxi sector (dos Santos et al. 2019). ‘Transport poverty’ remains a very real under-acknowledged reality for many of the poor in South Africa, who generally remain geospatially segregated as a result of apartheid’s past political discriminations (dos Santos 2020). One facility also had no running water (or operating toilets) at the time of the study, which posed a serious health risk (dos Santos et al. 2019).

The Agincourt health and sociodemographic surveillance system (HDSS), comprising an expanse of 420km² in Bushbuckridge, was founded in 1992, in order to bolster the development of district health systems as instructed by the post-apartheid health ministry, and furnishes verbal autopsy data. Verbal autopsy can be defined as a systematic means for determining mortality causes in communities where no routine medical death certification exists (World Health Organization 2016). The HDSS is the single accessible source of historical district mortality data in South Africa, it forms the foundation for the University of the Witwatersrand (Wits), South Africa and Rural Public Health and Health Transitions Research Unit of the Medical Research Council (MRC) (the MRC/Wits-Agincourt Unit). The HDSS (which samples

over 90 000 individuals) focuses on an annual appraisal of occupant status and other significant events, backing earlier investigations into the source and result of complex health, population and community progressions (Kahn et al. 2012).

Due to the COVID-19 pandemic and subsequent lockdown in terms of the declared National State of Disaster in South Africa on 15 March 2020, Wits Agincourt was obligated to reinvent the manner in which primary-data directed research is conducted, particularly where data is primarily sourced by means of face-to-face consultations and interviews. To circumvent the likely gap in data as a result of the COVID-19 pandemic and lockdown, the MRC/Wits-Agincourt Research Unit effected telephonic data collection by making use of the newly instituted call center at the main office in Agincourt. As an outcome, there are currently three synthesized projects currently in progress in South Africa, namely the South African Population Research Infrastructure Network (SAPRIN) census (Agincourt being one of the rural nodes of SAPRIN), COVID-19 Intensive Surveillance (Agincourt is one of the 3 rural-based surveillance locations), and the Telephonic Verbal Autopsy (teleVA) (MRC/Wits-Agincourt Unit: Rural Public Health and Health Transitions Unit 2021).

The 2020 SAPRIN census is novel in comparison to previous years in two manners: it is now completely telephonically operated, and it also now includes a COVID-19 Screening Module. This screening module includes all people presently living in the study location and documents the household socioeconomic effects of COVID-19, as well as COVID-19's impacts on the mental health of participants as well as their overall psychological well being. Furthermore, the module also incorporates a screening tool for potential COVID-19 symptoms. The COVID-19 Intensive Surveillance, which commenced with 1159 participating households, chose households regarded to be more at-risk to COVID-19, taking into consideration projections of potential widespread diffusion of the virus nationally, threat of substantial morbidity and mortality in at-risk communities, and estimated strain on both the healthcare system and economy. The project collects data from the sampled households and individuals at 10-14-day intervals. Furthermore, the individual-level screening part pinpoints study participants who present with potential COVID-19 related symptoms, who are then referred by dedicated project medical staff for further screening and testing. The Telephonic Verbal Autopsy (teleVA) is a subdivision of the yearly population surveillance and strives to gather comprehensive evidence concerning the sociodemographic and disease profile of the deaths gathered from the census. From 2020 the instrument includes a COVID-19 section which is directed at establishing

potential COVID-19 effects on mortality, which has shown to be significant in recognizing mortality cases ascribed to COVID-19 (MRC/Wits-Agincourt Unit: Rural Public Health and Health Transitions Unit 2021).

Brazil and the Amazonas: history, topography, demographics, climate change, COVID-19 and the healthcare infrastructure

Historical background, topography and demographics

Very little is known about the history of Brazil before 1500, when Europeans first travelled there. Archaeological remains, which consist mainly of pottery, suggest a number of complex societies that were in existence long before the colonialists arrived. After more than 300 years of Portuguese colonization, Brazil became a republic in 1889. Long periods of totalitarian rule finally led to the return of democracy in 1989. Democracy, however, has always been hard to maintain, and Brazil's history has been pervaded by *coups d'état* and dictatorships (Ghose 2018).

Amazonas, named after the Amazon river, is a federal state of Brazil situated in the north-western section of the nation (see Map 3). It is the biggest Brazilian state by region and the 9th greatest national subdivision on the planet. The state is mostly tropical rainforest with cities clustered beside traversable waterways which are reachable only by boat or airplane (Governo do Estado do Amazonas 2021). The state remained relatively undisturbed until the rubber boom in the 19th century. An estimated 240 indigenous groups live in the Amazonas, most are semi-nomadic, and subsist by means of hunting, gathering, fishing and migratory farming. These indigenous communities reside in intimate harmony with the rhythms of the rainforest, and conservation and sustainability are regarded as integral to their existence. Contact with and exposure to Western civilization fluctuates significantly amongst the indigenous tribes, for example the Maku tribe are extremely isolated, with others, such as the literate Ticuna are extremely dependent on modern Brazilian society (Ghose 2018).

Map 3: Amazonas state location.



Source: Encyclopedia Britannica (2021).*

*<https://www.britannica.com/place/Amazonas-state-Brazil>

Political milieu, climate change, COVID-19 and the healthcare infrastructure

From the time of his appointment as Brazilian president in 2019, Jair Bolsonaro has been lobbying for an increased industrial development in the Amazon rainforest, which captures two billion tons of atmospheric carbon dioxide (CO₂) every year⁶. Since Bolsonaro took office, immeasurable expanses of the rainforest have been annihilated and indigenous peoples' livelihoods endangered. Deforestation in the Amazon has escalated by nearly 50% within a 2-year period, reaching its highest level since 2008. The infiltration of indigenous regions escalated by 135% in 2019, and at least 18 people were killed in territory disputes last year. In spite of this, penalties for ecological violations fell

⁶ The Amazon rainforest is regarded to be the world's largest carbon dioxide sink, capturing 25% of global carbon dioxide emissions. The Amazon rainforest thus plays a very significant role in mitigating global climate change (Pannett 2021).

by 42% in the Amazon basin in 2019, and the federal administration slashed cut the budget for law enforcement by 27.4% this year (Werneck et al. 2021).

Experts have cautioned that Bolsonaro's detrimental regulations has the ability to drive the Amazon rainforest to an irreversible juncture, transforming strips of the rainforest into grassland, and thus making it impossible to control, halt or reverse global climate change. Indigenous heads and human rights lobbyists denounce Bolsonaro for crimes against humanity and the environment, and the Brazilian president is facing charges in the International Criminal Court (ICC) for ecocide and genocide, terms defined as instigating severe and lasting harm to the environment and people (Al Jazeera 2021; Milhorance 2021).

Now, as Brazil – which was hit by COVID-19 as well as its P.1 variant though the death rate is finally easing due to the intensifying of vaccination – concentrated on containing the virus, illicit loggers and mineworkers are gaining from the state of affairs by cutting down extensive sections of the Amazon. From January and April 2021, 464 square miles of the rainforest was razed to the round, that is 55% more of what was destroyed in the same period in 2019. The apparent intention is that the cleared land will be burned rendering it fit for cattle grazing, this in turn substantially increases the likelihood of wildfires; in 2019 wildfires burnt out of control and destroyed an estimated 3,500 square miles of rainforest, blinding large cities such as São Paulo with smoke (Japanese Times 2020; Tedesco 2020; Beck, Mestre, and Wanzeller 2021).

The capital and largest city in the state of Amazonas, Manaus (refer to Map 4), is located in the center of the Amazon forest. The city is regarded to be the gateway to the Amazon rainforest, and its primary link to the remainder of the world is by airplane or boat. The town is situated sits at the confluence of the Solimões and the Rio Negro rivers (which are the names of the Amazon river in the respective sections). Manaus was one of the centers of the globe hardest hit COVID-19 outbreaks in April and May 2020. COVID-19 hospitalizations in Manaus remained stable and fairly low for 7 months from May to November 2020, despite the relaxation of COVID-19 control measures during the period. When the healthcare system collapsed in Manaus, photographs and videos of thousands of freshly dug graves became illustrative of Brazil's coronavirus calamity, its mortality counts second only to that of the United States. Scientists and epidemiologists have established that a new coronavirus variant, called P.1 (and first identified in Manaus), is most likely propelling the new round of devastation that's befallen Manaus as it is more infectious and more lethal. However, it seems as though the current COVID-19 vaccines

can still offer protection against the pattern of mutations observed in the new variant – though more research is needed (Rivers 2021).

Map 4: Manaus' locality in Amazonas state



Source: Amazonas Brazil Travel (2021).*

*<https://www.v-brazil.com/tourism/amazonas/map-amazonas.html>.

As a consequence of COVID-19, for frontline medical staff, it resulted in frenzied 36-hour hospital shifts. Cemeteries in Manaus are increasingly overcrowded. Manaus has approximately 30 public and private hospitals, offering services to a number of secluded indigenous and small communities in the vicinity. However, the logistics of getting there and equipping those clinics and hospitals – can be difficult as road connections are few, thus most approaches to the town have to be via the river or by air.

COVID-19 first ripped through Manaus like a blaze in April 2020, resulting in such an extensive increase in cases that scientists hypothesized that it might result in herd immunity. Legislators and politicians took hold of this notion, hoping that they would be able to circumvent future economically damaging lockdowns. However, in September 2020, the Oswaldo

Cruz Foundation (Fiocruz), an esteemed Brazilian research institute for public health, advised Manaus to impose lockdown restrictions once again as the city started to experience a second wave of the virus. Notwithstanding, both the local and national government used the theory of herd immunity to justify their continued relaxed measures. After months, towards the end of December 2020, an undeniable surge in documented COVID-19 cases was evident in Amazonas. State governor, Wilson Lima, eventually consented to expert counsel, declaring new lockdown regulations. However, these measures were aggressively decried by protesters who aligned with Bolsonaro's stance on keeping the country's economy going. By early January 2021, it became evident that Manaus was close to running out of the required amount of oxygen needed for severe COVID-19 patients. Lack of preparedness and political unrest have been cited for the situation in Manaus. A distinct disengagement between the local and state administration has also resulted in chaos since the start of the pandemic last year. The Amazonas state government, in turn, has cited the logistical barriers to quickly resupplying this hard to reach town (Gallón and Reverdosa 2021).

Discussion

As opposed to other pandemics and famines, COVID-19 has hit all nations, irrespective of economic, political and social leanings, making it in many instances a 'leveler', but also at the same time highlighting the disparities and inequalities across these systems, which can clearly be seen in these two biomes, as well as within the borders of South Africa and Brazil in general. It is evident that parallels exist between the external relationships established by historical colonial powers over colonized peoples and the relationship of economic, educational, social, and racial groups within some Latin American societies, such as Brazil, and within South Africa, resulting in 'internal colonialism' in these societies, despite post- and decolonization initiatives (Wolpe 1975; Crush 2012; Ribeiro 2011). On a global scale, government reactions to the pandemic also exemplify broadening and intensifying worldwide political polarization (Michie and Sheehan 2021).

Furthermore, It is evident that climate change can both facilitate zoonotic spillovers and have an effect on transmission change. It is also clear that these effects, together with human behavior and awareness, need to be integrated into pandemic forecasting models (Rodó et al. 2021). The COVID-19 pandemic has deepened many of the economic and social difficulties that Brazil and South Africa are already facing.

The scale of the climate and COVID-19 crisis necessitates very atypical and unique types of government strategies in comparison to the *laissez faire* outlooks endorsed since the 1980s. Michie and Sheenan (2021) comment on the 2007–2008 global financial crisis and the subsequent international recession of 2009, bequeathing mostly an unreformed system of global financial speculation, underlying inequalities as a result of colonialism (and apartheid in the case of South Africa), and industrial or state level tax fraud and corruption. From that time, in many nations a decade of austerity and inequality has left critical public institutions under-funded and insufficiently or not optimally prepared to deal with the COVID-19 crisis due to healthcare capacity shortfalls, this was clearly witnessed in Manaus, and to a lesser extent in the Kruger to Canyons biosphere, during the COVID-19 pandemic. Furthermore, the indigenous communities of both South Africa and Brazil suffer from economic ‘unfreedom’, in the form of extreme poverty, which has overall been intensified by the COVID-19 pandemic (dos Santos 2019).

According to the World Bank, South Africa remains the world’s most unequal country, with 1% of the country owning 70.9% of the wealth and has had to also deal with more recent corruption and state capture⁷ ramifications which occurred under the presidency of Jacob Zuma (The World Bank 2021; Sulla and Zikhali 2018; Shubin 2019; Greenwood 2018). Some of the challenges that South Africa faces can be traced back to the country’s apartheid legacy, which significantly contribute to racial disparities in terms of access-related aspects such as living far away from a clinic, and lack of private medical cover. Two thirds of the country’s 3 300 ventilators, for example, can only be found in private hospitals in South Africa. Challenges in delivering health services before the pandemic, which are now out in the open as a result of the pandemic, provides an opportunity to move forward. By strengthening the National Health Insurance (NHI) introduced by the government, and thus achieve universal access to quality healthcare services (Devermont and Mukulu 2020).

Within the Brazilian context, economic recession coupled with sharp social tensions and biased politics during the COVID-19 pandemic has stalled

⁷ State capture is a type of systemic political corruption in which private interests significantly influence a state’s decision-making process to their own advantage. Reports compiled by the South African Council of Churches and South African academics and researchers in 2017 estimates approximately R40 billion (equivalent to US\$3 billion) was illegally smuggled out of South Africa to Dubai by the Gupta family, in collusion with President Jacob Zuma, and their associates between 2011–2017 (Mpumlwana 2017, Centre for Complex Systems in Transition, Public Affairs Research Institute, Development Policy Research Institute, SAR-CHi Chair African Diplomacy and Foreign Policy, University of Johannesburg, University of Stellenbosch, 2017).

attempts at cooperating with science-based directives for the greater benefit of Brazil (da Silva Bastos 2020; Lopes 2021). President Bolsonaro has essentially downplayed the severity of the epidemic, and eschewed public health containment actions. Instead, he has endorsed pharmacological treatments which hold no scientific credibility, leaving Brazil's committed medical staff to cope the most ill for in intensive care units and forced to improvise solutions when hospital beds are unavailable – this has led to the near collapse of Brazil's health system, and virtual complete collapse in Manaus (Kmietowicz 2021). Furthermore, the Brazilian government has disrupted environmental protection agencies, permitting the upsurge of illicit deforestation – which in turn accelerates climate change and the emergence of new zoonotic diseases. Indigenous populations in the Amazon have the highest risk of poor health and social outcomes (Lopes 2021). Together with his supporters, Bolsonaro has essentially defended the government's response to resist containment measures as a means of protecting the economy. Despite, for example, Médecins Sans Frontières (MSF) calling on Brazilian authorities to admit to the intensity and severity of the crisis, after more than 12 months into the COVID emergency, Brazil still has no, or at least a limited, effective, coordinated or centralized public health response or intervention program (Kmietowicz 2021).

In comparison to Brazil, South Africa's overall response to the pandemic can be regarded as a standout in the region and in the world. President Cyril Ramaphosa and the government borrowed best practices from prior public health responses to health emergencies, such as the tuberculosis and HIV/AIDS crises and thus have the infrastructure and knowledge base of how to conduct mass testing, particularly with key populations. Unlike Brazil, the South African government also moved quickly to close borders and restrict movement, and reopening occurred and is still occurring, in a phased approach based on scientific guidance (Devermont and Topaz 2020). The South African government also promoted a science-based approach to the pandemic, and a greater compliance to public health campaigns was ensured by working together with religious and non-traditional leaders and unifying the political class.

Notwithstanding these positive aspects, South Africa's resilience has been tested once again, the COVID-19 pandemic has proven to be another challenge in South Africa's complex history, which is characterized by apartheid and its long-term ramifications, the AIDS pandemic, and ongoing social trauma. South Africa was fortunate in that the virus arrived here later than in the other parts of the world, offering some respite to an already burdened health systems. The pandemic has, however, exacerbated social and economic

challenges and increased mental health risks (Naidu 2020). The Agincourt HDSS in the Kruger to Canyons Biosphere Region is demonstrating its adaptability to respond to Covid-19 emergency. In March 2020, South Africa had no data on the potential rural impacts of the pandemic. The MRC/Wits-Agincourt Research Unit answered to this concerning void by collaborating with the state-run Human Sciences Research Council (HSRC) and SAPRIN. Benefiting from its existing infrastructure and knowledge of telephonic surveillance, an investigation was finalized with more than 1300 respondents randomly selected from the existing HDSS database; the study investigated respondent cognizance of COVID-19 symptoms and preventive measures, as well as the impact of the national lockdown in South Africa (MRC/Wits-Agincourt Unit: Rural Public Health and Health Transitions Unit 2021).

Conclusion

It is widely agreed amongst researchers and scholars that the annihilation of biodiversity sets the scene for the emergence of new diseases and virus as a result of animals losing their natural habitats, and as a consequence, crowding together and thus increasing the chance of them interacting with humans. It is also equally important to take cognizance of climate change, as it can modify the distribution of diseases. Unfortunately, worldwide resources for ecological conservation has been diluted as a result of governmental endorsement of activities which are detrimental to the environment, this in particular, is relevant to the Amazon rainforest in Brazil, which has experienced rapid rainforest depletion, intensifying considerably at an alarming rate each year, and experiences high social inequalities (Lorenz, Oliveira Lage, and Chiaravallotti-Neto 2021).

Pandemics have been anticipated and predicted by scientists for a long time, particularly since, for example, the 2003 SARS pandemics, which was also caused by a similar type of coronavirus as to that of COVID-19. It is also predicted that there will be further and likely worse pandemics in the future. If it is hoped to prevent any further ones, it will be necessary to ask on a global scale how this happened and change what went wrong (Polychroniou 2020). Both South Africa and Brazil, to greater and lesser extent, experience 'thin equality' and 'emancipated democracies', resulting from the historical brutal exploitation of indigenous communities (dos Santos 2019). Furthermore, extractive systems, and extensive land use on a large scale, have resulted in deforestation, loss of biodiversity, carbon emission and water

contamination, heightened temperatures, indigenous land dispossession, violence, discrimination and cross border and rural-urban migration.

The COVID-19 pandemic has evidenced how viruses and pathogens move quicker and further than before, which implies that countries also need to respond quickly, displaying political will, financing and, more overtly, changes in human behavioral patterns (Lorenz, Oliveira Lage, and Chiaravalotti-Neto 2021). Collective action offers a means of moving forward, both Brazil and South Africa will need to find ways of building back better; politically, socially, economically and from an infrastructural standpoint, which all needs to lead to the transformation toward the sustainable use of the available resources.

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ABSTRACT

Climate change is predicted to exert further stress on already exploited ecologies and healthcare systems, added to this, the coronavirus SARS-CoV-2 (COVID-19) has signified a stimulus to revolutionize existing models of sustainable development in broad, and sustainable supply chains in the healthcare sector in particular. The Kruger to Canyons biosphere region in South Africa and the Amazonas state in Brazil serve as geographic case studies for this paper. The impact of economic globalization, natural catastrophes such as droughts, economic and geopolitical stresses, deforestation, economic and healthcare access inequalities in these two biomes converge with issues of climate change, and undercut coping mechanisms that are customarily used to oversee extreme events such as pandemics. The COVID-19 pandemic has deepened many of the economic and social difficulties which South Africa and Brazil are already facing. In comparison to Brazil, South Africa's overall response to the pandemic can be regarded as a standout. By borrowing from best practices from prior public health responses to health emergencies in South Africa, such as the tuberculosis and the HIV/AIDS crisis, South Africa has demonstrated its comparatively successful means of dealing with COVID-19.

KEYWORDS

Climate Change. COVID-19. Kruger to Canyons Biosphere Region. Amazonas. Healthcare Systems. Human Resources In Health. Ecocide. Genocide. Inequality. Brazil. South Africa.

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