Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Science of the Total Environment 844 (2022) 157142

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Discussion

Climate change and COVID-19: Interdisciplinary perspectives from two global crises

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HIGHLIGHTS

- Far-reaching implications of the COVID-19 pandemic and climate change are discussed.
- Their interactions affected economy, energy, environment, health, and policy sectors.
- COVID-19 presented lessons for devising sustainable recovery plans for climate crisis.
- International collective actions are required to alleviate the co-created impacts.

GRAPHICAL ABSTRACT

ARTICLE INFO

Editor: Elena Paoletti

Keywords:
Collective action
Global pandemic
Public perception
Adaptation
Socio-economic impact
Renewable energy

ABSTRACT

The repercussions of the COVID-19 pandemic and climate change – two major current global crises – are far-reaching, the parallels between the two are striking, and their influence on one another are significant. Based on the wealth of evidence that has emerged from the scientific literature during the first two years of the pandemic, this study argues that these two global crises require holistic multisectoral mitigation strategies. Despite being different in nature, neither crisis can be effectively mitigated without considering their interdependencies. Herein, significant interactions between these two crises are highlighted and discussed. Major implications related to the economy, energy, technology, environment, food systems and agriculture sector, health systems, policy, management, and communities are detailed via a review of existing joint literature. Based on these outcomes, practical recommendations for future research and management are provided. While the joint timing of these crises has created a global conundrum, the COVID-19 pandemic has demonstrated opportunities and lessons for devising sustainable recovery plans in relation to the climate crisis. The findings indicated that governments should work collaboratively to develop durable and adjustable strategies in line with long-term, global decarbonisation targets, promote renewable energy resources, integrate climate change into environmental policies, prioritise climate-smart agriculture and local food systems, and ensure public and ecosystem health. Further, differences in geographic distributions of climate change and COVID-19 related death cases revealed that these crises pose different threats to different parts of the world. These learnings provide insights to address the climate emergency – and potential future global problems with similar characteristics – if international countries act urgently and collectively.

1. Introduction

Coronavirus disease 2019 (COVID-19) is a contagious disease that first emerged from China in December 2019 and was declared a global

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http://dx.doi.org/10.1016/j.scitotenv.2022.157142
Received 2 May 2022; Received in revised form 29 June 2022; Accepted 29 June 2022
Available online 5 July 2022

pandemic by the World Health Organisation shortly thereafter (Singhal, 2020; Zu et al., 2020). Climate change is a long-term shift in temperature and weather patterns primarily driven by human activities (e.g., greenhouse gas emissions) (Halpern et al., 2015; Howe et al., 2013). Climate change is projected to continue this century and beyond fuelling extreme events, including food, water, and energy insecurity, and environmental deterioration, leading to major socio-economic inequities and health issues worldwide (Carleton and Hsiang, 2016; Evans, 2019; Khojasteh et al., 2021; Khojasteh et al., 2022b; Malla et al., 2022). Together, these two crises have far-reaching global repercussions for society and the environment that are only beginning to be understood and documented.

Both climate change and the COVID-19 crises are transboundary threats, impacting different sectors of society, requiring international collaboration (Ebi et al., 2021). As climate change and COVID-19 are not geographic specific in nature, far-reaching sustainable and practical measures should be considered to help societies worldwide adapt to the current crisis and prepare for future crises. As these challenges unfold, a systematic review of the lessons learnt can provide insights into the interrelations between climate change and COVID-19. This includes potential effects to communities, the environment, and knowledge regarding the development of effective strategies that mitigate consequences and/or harness opportunities at a global scale.

Since the COVID-19 outbreak commenced, a growing body of literature has emerged across multiple disciplines that is aimed at exploring the association between climate change and the COVID-19 pandemic (Ahmadi et al., 2020; Ficetola and Rubolini, 2021). The majority of existing studies have focused on localised effects of climate change and COVID-19, including the influences on specific sectors such as agriculture, tourism, and energy (Gabriel-Campos et al., 2021; Norouzi et al., 2020; Rowan and Galanakis, 2020). This is despite the need for global solutions via international and interdisciplinary collaborations and the notion that modern global societies are interconnected across all sectors. To date, researchers have examined the specific interactions of climate change and COVID-19 on the economy (Chiappinelli et al., 2021; Mintz-Woo et al., 2021), energy (Bertram et al., 2021; Maniatis et al., 2021), agriculture (Rasul, 2021b; Zavaleta-Cortijo et al., 2020), the environment (Auler et al., 2020; Negev et al., 2021), and the health system (Coates et al., 2020; Di Ciaula et al., 2021). Further, research has also focused on particular geographic regions or countries, such as Spain (Martorell-Marugan et al., 2021), China (Bogdan, 2020; Fan et al., 2021; Yao et al., 2021), Iran (Ahmadi et al., 2020), India (Bherwani et al., 2020), Brazil (Auler et al., 2020), and the USA (Bashir et al., 2020). However, a holistic overview of these studies, which provides a broad picture of the interactions between COVID-19 and climate change across geographic regions and topics, is required.

To partly address this limitation, the present study aims to provide an overview of the existing literature on climate change and COVID-19 interactions in efforts to highlight the co-created challenges and opportunities. This is achieved through a review of recent research (see Section 2) that specifically explored the interactions and resultant effects of climate change and COVID-19 to different sectors of the community and environment. To highlight the global response to both crises, geographical patterns of death cases due to climate change and COVID-19 are provided. In addition to emphasizing the value of collaborative, multidisciplinary research initiatives at a global scale, the findings herein may be used to assist in developing green energy policies, supporting climate-smart agriculture, promoting economic recovery plans, encouraging carbon reduction initiatives, improving public and ecosystem health, and preparing for future global crises.

2. Climate change and COVID-19 interactions

The interplay between climate change and the COVID-19 pandemic is complex, hard to predict, and unprecedented (Ebi et al., 2021; Joshi et al., 2021). To date, understanding the interconnections between climate change and COVID-19 (and its challenges and opportunities) is primarily limited to studies that explored local or regional issues in isolation or on a specific sector (rather than cross-sectors). This is despite the fact that both crises have far-reaching national and international implications requiring multisectoral research and global actions. To highlight this limitation, this section explores over 110 recent studies that have investigated the interactions and compounding effects of the COVID-19 and climate change crises on different sectors of society and environment. To present an acceptable coverage of scholarly literature, joint climate and COVID-19 publications (written in English and peer-reviewed) were identified and retrieved from the Web of Science Core Collection, as illustrated in Fig. S1 in the Supplementary Information. These publications were then manually screened, reviewed, and classified based on their core focus. As summarised in Fig. 1, the findings from the sectoral analysis are then used to develop multidisciplinary international scientific recommendations that consider long-term feedback loops between all sectors.

Existing research on joint climate change and COVID-19 interactions can be categorised into 8 different themes (also see Fig. S1 in the Supplementary Information), including (i) food systems (food supply network and food security), (ii) the environment (air quality, climate indicators, and ecosystem response), (iii) policy (collective action, communication policy, and land use/change management), (iv) society (public perception, (in) justices, and education), (v) health system (public health and urban/rural health), (vi) economy (tourism, carbon pricing, recovery plans), (vii) energy and technology (renewable energy, energy supply/demand, and technological advancement), and (viii) global cooperation (managing global crises and new challenges/opportunities) (Fig. 1). The remainder of this section details the findings from existing COVID-19/climate change literature across these broad themes in efforts to improve global planning and management considerations.

2.1. Effects on the economy

COVID-19 and climate change are poised to exacerbate economic crises in many countries worldwide. These interactions are likely to alter the balance of supply and demand, result in ad-hoc support measures, and influence tourism and recovery plans (Jiricka-Purrer et al., 2020; Mintz-Woo et al., 2021; Stuart et al., 2021). Globally, governments are encouraged to design economic recovery plans for the COVID-19 pandemic that are aligned with long-term, global decarbonisation targets (Cazcarro et al., 2022; Chiappinelli et al., 2021; Masson-Delmotte et al., 2018). In this regard, carbon pricing may be a promising means to integrate climate change mitigation schemes into COVID-19 recovery plans, if implemented as carbon taxes or carbon trading schemes (Bogojevic, 2020; Mintz-Woo et al., 2021). In this way, COVID-19 stimulus packages have the potential to mitigate climate change and direct the world towards a low-carbon pathway (Mintz-Woo et al., 2021). However, climate change mitigation measures associated with COVID-19 recovery efforts may encounter short-term obstacles due to the absence of reliable international trading markets, as well as a lack of clear regulation frameworks and funding (Chiappinelli et al., 2021). To minimise and manage these issues, evidence-based policies are required to ensure concurrent economic growth and a major reduction in greenhouse gas emissions (Lahcen et al., 2020). Depending on a government's economic priorities, COVID-19 stimulus/recovery packages may also include investments in clean infrastructure, research and development, or education (Hepburn et al., 2020; Stern et al., 2021). Alternative measures are of particular significance for developing countries that may have a reduced capacity for adaptation and mitigation (Ingutia, 2021).

In addition to climate focused adaptation measures, economic effects within the global economy are particularly felt within the tourism sector and have been an important focus of the existing research. Climate change and COVID-19 impacts to national and international tourism spotlight a need to shift the pathway of tourism industry from high-resource consumption to an environmentally friendly model (Prideaux et al., 2020). Further, local communities that heavily depend on rural tourism should aim to improve their resilience to the challenges posed by climate change (Gabriel-Campos et al., 2021). This would then help communities develop strategic risk management plans to simultaneously offset climate change and enhance the tourism industry resilience to emerging threats.

Fig. 1. A hierarchical structure of research themes linking 111 joint climate change and COVID-19 publications to 22 sub-themes and 8 major themes, including food systems, environment, policy, society, health systems, economy, energy, and global cooperation.

2.2. Effects on energy and technology

Climate change and COVID-19 have further highlighted vulnerabilities of the existing energy network to global issues, emphasizing the need for reliable and efficient access to power supply for individuals and organisations (e.g., hospitals) (Samani et al., 2021). The COVID-19 pandemic has been the largest shock to the energy demand sector in the last 70 years (IEA, 2020; Samani et al., 2021), resulting in declines in global CO_2 emissions (Bertram et al., 2021). Conventional energy sources have struggled to maintain ongoing resilience with the global pandemic causing pressure on distribution systems (Norouzi et al., 2020). This has shifted international attention towards decentralised technological solutions that align with low-carbon, green energy (Chen et al., 2021; Jiao et al., 2020; Jin, 2020; Khojasteh et al., 2022a; Khojasteh et al., 2018a; Khojasteh et al., 2018b; Lancet Digital Health, 2021; Zhao and You, 2021), and renewable energy resources (Bertram et al., 2021; Maniatis et al., 2021). To this aim, policy makers and major producers/consumers of fossil fuels should work collaboratively to support stakeholders (e.g., workers, companies) in overcoming short-term socio-economic challenges of a low-carbon energy transition (Le Billon et al., 2021).

With the introduction of new generations of renewable energy resources, global policies that encourage investments on renewable and sustainable energy technologies are deemed promising to yield high returns and enhance socio-economic conditions post-pandemic (Hoang et al., 2021c; Hoang et al., 2021d; Khojasteh and Kamali, 2016). The costs of alleviating climate change impacts will likely increase if future technology costs follow current trajectories (Rosen and Guenther, 2015). As such, technological innovations and green finance governance should be promoted (Zhang et al., 2022), and short-term green renewable energy plans should be prioritised (Hoang et al., 2021d). Long-term policies should then focus on low-carbon energy and economy by supporting private companies and corporations, investing on renewables, producing tax credits, and offering lower interest rates to improve the price competitiveness of these sources against traditional energy resources (Hoang et al., 2021d). For instance, the shipping industry (currently producing 3 % of global greenhouse gas emissions) is presently capitalising on a policy framework to integrate green energy sources and technologies to move towards utilising low-carbon fuels such as electric propulsion, dual-fuel, solar, wind, liquefied natural gas (LNG), hydrogen fuel cell, and hybrid systems (Hoang et al., 2022; Nguyen et al., 2021a). Further, in smart city initiatives, renewable energy sources together with technological advancements could be integrated to optimise the benefits of the bioeconomy, transforming wastes into usable energy, lowering carbon emissions and toxic pollutants, and ensuring a sustainable future (Hoang et al., 2021e).

2.3. Effects on the environment

The unprecedented travel and work restrictions due to the COVID-19 pandemic have precipitated environmental improvements such as declines in greenhouse gas emissions, decreases in particulate matter and air pollution, and increases in ambient visibility (Laughner et al., 2021; Le et al., 2020; Martorell-Marugan et al., 2021; Mohsin et al., 2021; Nguyen et al., 2021c; Rugani and Caro, 2020; Usman et al., 2021; Venturi et al., 2021; Yao et al., 2021). For instance, a 20 % reduction in NO_2 emissions was observed worldwide in 2020 compared to 2019, which likely helped to decrease air pollution and the human mortality rate (currently 4.6 million death cases reported per annum due to NO_2 emissions) (Hoang et al., 2021b). However, this pandemic-driven relief may become insignificant in the short/mid-term, and emissions may even begin to rise (with a rebound already observed in many countries) without supporting green stimuli and economic incentives post-crisis as well as integrating climate change into environmental policies (Forster et al., 2020; Kumar et al., 2022; Le Quere et al., 2020; Li and Li, 2021; Ray et al., 2022). On the other hand, the effect of lockdown measures and the reduction in industrial and business activities during the first phase of the pandemic resulted in an increase in ozone (O_3) concentrations in several places (e.g., cities located in southern Europe or China) due to a significant decline in NO_X emissions and thereby lower O_3 titration rates (Chapman and Tsuji, 2020; Sicard et al., 2020). A high concentration of surface O_3 can bring about detrimental health effects including respiratory and cardiovascular diseases (Wang et al., 2020). As such, environmentally friendly strategies to sustainably reduce global (primary and secondary) emissions in the post-pandemic era are essential to ensure a global commitment to firm climate action (Camargo-Caicedo et al., 2021; Le Quere et al., 2021; Nguyen et al., 2021b; Shan et al., 2021).

Further, there is an ongoing scientific debate regarding the relationship between weather conditions (e.g., temperature) and the spread of COVID-19. Studies have hypothesised that warm weather may help stop (Fan et al., 2021; Mendez-Arriaga, 2020; Sarkodie and Owusu, 2021), transmit (Auler et al., 2020), or not be correlated to (Ahmadi et al., 2020; Zoran et al., 2020) the transmission of COVID-19. Also, variations in anthropogenic emissions owing to COVID-19 may alter the radiation levels on vegetation communities and lead to earlier or later spring seasons (Su et al., 2021). Therefore, future multidisciplinary research is required to assess the compounding environmental factors (e.g., relative humidity) and societal parameters (e.g., social distancing) to develop informed management decisions for different regions and environments worldwide (Bherwani et al., 2020; Paraskevis et al., 2021).

2.4. Effects on food system

Globally, agriculture and food security are increasingly threatened by climate change and COVID-19. For instance, farmers currently face a twin challenge where climate change has intensified extreme weather and the COVID-19 pandemic has caused disruptions in supply chain logistics (Rasul, 2021a; Rasul, 2021b). In this regard, those with existing food insecurity and/or indigenous populations are likely the most vulnerable demographics (Belsey-Priebe et al., 2021; Zavaleta-Cortijo et al., 2020). For instance, in Australia, COVID-19 exacerbated economic susceptibility for pre-pandemic food insecure people who had income losses, and low-income individuals had to purchase cheaper and less nutritious products (Louie et al., 2022). To address this issue, governments have recommended the establishment of local/regional food systems to shorten supply chains, support innovative solutions, and develop adaptation strategies that educate people and prioritise climate-smart agriculture (Aldaco et al., 2020; Haniotis, 2020; Hickey and Unwin, 2020; Kluczkovski et al., 2021; Rasul, 2021a; Rasul, 2021b). With respect to innovative solutions, the establishment and restoration of peatlands that integrate agri-food and science advances are recommended (Rowan and Galanakis, 2020).

2.5. Effects on the health system

There is scientific consensus that interactions between climate change and the COVID-19 pandemic can provoke detrimental effects on the public's physical and mental health (Cuschieri et al., 2021; Marazziti et al., 2021; Pascal et al., 2021; Patruno et al., 2020; Srivastava et al., 2021). Compounding impacts are likely to aggravate obesity (Cuschieri et al., 2021), skin diseases (Patruno et al., 2020), anxiety, depression, and stress (Marazziti et al., 2021), with children, women, elderly, and people with pre-existing conditions highlighted as the most susceptible groups (Boos, 2021; Gorji and Gorji, 2021). As such, governments and private sectors are urged to commit to public health measures, in addition to fiscal stimulus, that consider green medical approaches such as working in a healthy facility (Coates et al., 2020).

Further, the simultaneous crises of climate change and COVID-19 have wide-reaching implications for urban and rural environments (Schwartz, 2020), requiring a multi-sectoral approach that supports decarbonisation schemes and post-COVID-19 recovery measures (Duns, 2020; Milner et al., 2021). As human health directly or indirectly depends on natural ecosystems, the health of natural environments should be incorporated into management decisions, with the recent pandemic further illustrating the consequences of this ignorance (Armstrong, 2020). In this regard, policy makers are recommended to facilitate different modes of working (e.g., remotely), improve local green infrastructures, and promote active transport modes (e.g., cycling) (Milner et al., 2021; Schenk et al., 2021; Senay et al., 2021), and develop policy decisions that conserve biodiversity, ensure health and integrity of ecosystems, and stabilise the climate. This is of significance as changing environmental conditions can increase the transmission of water/air/food/vector-borne pathogens, undermine public health, and give rise to more epidemics or pandemics (Romanello et al., 2021).

2.6. Effects on policy and management

Despite nationalistic initiatives, climate change and COVID-19 are global crises that require collective action at a global scale (Jamieson and Jacquet, 2020). However, international collaborations to manage these crises have been limited (Cole and Dodds, 2021; Klenert et al., 2020). To this end, inclusive regulations and policies should be adopted that foster environmental communication campaigns and sustainable strategies (Meijers et al., 2022; Rahman et al., 2021). These policies should be durable, easy to adjust, contain a broad range of global efforts (e.g., targeted policy reforms and facilitated international coordination) (Auld et al., 2021; Di Ciaula et al., 2021; Mai, 2021), and be based on evidence and expert advice globally (Baldwin and English, 2020; Obergassel et al., 2021; Phillips et al., 2020). The post-crisis recovery plans should associate public policies and climate objectives to assist corporations in better managing liquidity issues (e.g., renewable energy sector), investing in low-carbon projects and infrastructures, funding innovative environmentally friendly technologies, and incentivising low-carbon consumptions (Dechezlepretre et al., 2020).

Management policies should also include communication strategies that can influence behavioral changes, avoid delays, address psychological biases, and overcome inequalities (Klenert et al., 2020). Substantial evidence suggests that communication failures can impede the timely and effective response to global crises (Botzen et al., 2021; Janko, 2020; Leal et al., 2021; Ruiu et al., 2020). Further, policy makers should consider effective land-use planning and controls to reduce risks and improve resilience (Mitchell et al., 2021). For instance, governments may allocate equitable funding across areas and nominate centres of adaptation, mitigation, and action based on their share of population and land area (Teicher et al., 2021).

2.7. Effects on society and community

The co-occurring COVID-19 and climate change crises have highlighted the value of community leadership, with significant local efforts observed

to organise healthcare, environmental action, and education (Geiger et al., 2021; Sacks et al., 2021). However, there is a difference between the level of community/society support for climate change and COVID-19 as the latter is often recognised as a more direct threat (Kallbekken and Saelen, 2021). This is despite the fact that public support is also necessary for the successful implementation of climate-oriented policies worldwide (Engler et al., 2021), and climate change exceeded concerns related to the COVID-19 pandemic within several communities, such as in the UK (Evensen et al., 2021) and Australia (Patrick et al., 2021). As an example, news coverage of climate change significantly declined in early 2020 during the intense phase of the COVID-19 emergency (Lyytimaki et al., 2020; Rauchfleischet al, n.d.; Stoddart et al., 2021). This could be of significance for countries where climate action is urgently required, as COVID-19 is likely to impact or interrupt short-term planning of climate change adaptation-mitigation strategies (Loureiro and Allo, 2021). In this regard, community-based strategies could be effective in addressing priority issues if they are well incorporated into broader national and international policy decisions (Sacks et al., 2021). For instance, in Bhutan, as a carbon-neutral nation, the government has set up support systems in local communities by training and identifying local champions who are responsible for controlling pandemics, and delivering crucial items to vulnerable populations (Sacks et al., 2021).

Furthermore, climate change and COVID-19 are overlapping crises that co-create new forms of stresses and injustices, such as intense economic recessions and water shortages (Boretti, 2022; Nyahunda et al., 2021; Sultana, 2021; Watson et al., 2020). To this aim, it is suggested that COVID-19 preventive measures should simultaneously encourage climate change mitigation (Atanasova, 2021). In this context, many international conferences have switched to virtual platforms to help stop COVID-19 transmission, which may continue in the post-pandemic era in order to further raise climate change awareness and reduce emissions (Goebel et al., 2020; Huish, 2021; Shankar et al., 2020).

2.8. The way forward

The cumulative impacts of climate change and COVID-19 will ultimately (if not already) be felt by all citizens worldwide. As such, effective and rapid actions are required to address socio-economic, political, health, and environmental effects of both climate change and COVID-19 (Heyd, 2021). As evidenced during the COVID-19 pandemic, global challenges necessitate global cooperation and solutions that are achievable via international breakthroughs in science and leadership (Joshi et al., 2021; The Lancet Editorial, 2021; Zang et al., 2021). The COVID-19 pandemic has also provided insights into how we may address climate problems such as the short-term demand for fossil fuels and electricity, underpinning an urgent shift towards renewable energy resources (Chen and Shen, 2021), as well as prioritising future green investments (Das Sarma, 2020; Fuentes et al., 2020; Manzanedo and Manning, 2020).

It should be noted that COVID-19 and climate change are not similar in all aspects as the latter requires measures beyond individual borders. Whereas closing down borders of a country may help slow down the spread of COVID-19 (Gemenne and Depoux, 2020; van der Ven and Sun, 2021), such localised policies may not be appropriate to combat the climate crisis. In contrast, communities and governments are encouraged to 'flatten the curve' of climate change by embracing collective responsibility (Perkins et al., 2021), and blending environmental education into public and university training curricula (Hoang et al., 2021a). Improved climate change knowledge, communication, and awareness will likely increase public engagement with climate policy and may lead to positive behavioral changes (Khatibi et al., 2021). In this regard, joint challenges and opportunities of climate change and COVID-19 are difficult to predict and long-term management decisions should be made with caution. Indeed, this highlights the need for further interdisciplinary studies that link the compounding impacts and interactions of these events to different sectors, concurrently encouraging decarbonisation targets, renewable energies, local food systems, public health, and effective global action. A visual demonstration of these dimensions, together with a set of recommendations for future research and management, is depicted in Fig. 2.

3. Global challenge – global action

The co-occurring climate change and COVID-19 crises are pervasive threats, impacting populations regardless of socio-economic class, ethnicity, gender, etc. Actions taken at the national or local government levels may not be sufficient to overcome challenges at a global scale and, in this context, it is important to identify parallels and linkages between these crises (e.g., does climate change directly affect the spread of COVID-19?). One measure to assess local impacts of mitigation strategies on an international scale is to analyse the geographic distribution of climate change and COVID-19 related deaths between regions. While data for climate (e.g., non-optimal temperature) and COVID-19 related mortality exists at a global scale (e.g., Johns Hopkins University, 2022; Zhao et al., 2021), limited studies have linked these datasets to explore potential linkages between crises.

Fig. 2. Recommendations for future strategies on climate change and the COVID-19 pandemic, with considerations of sectoral feedback loops that require interdisciplinary international approaches and collective action.

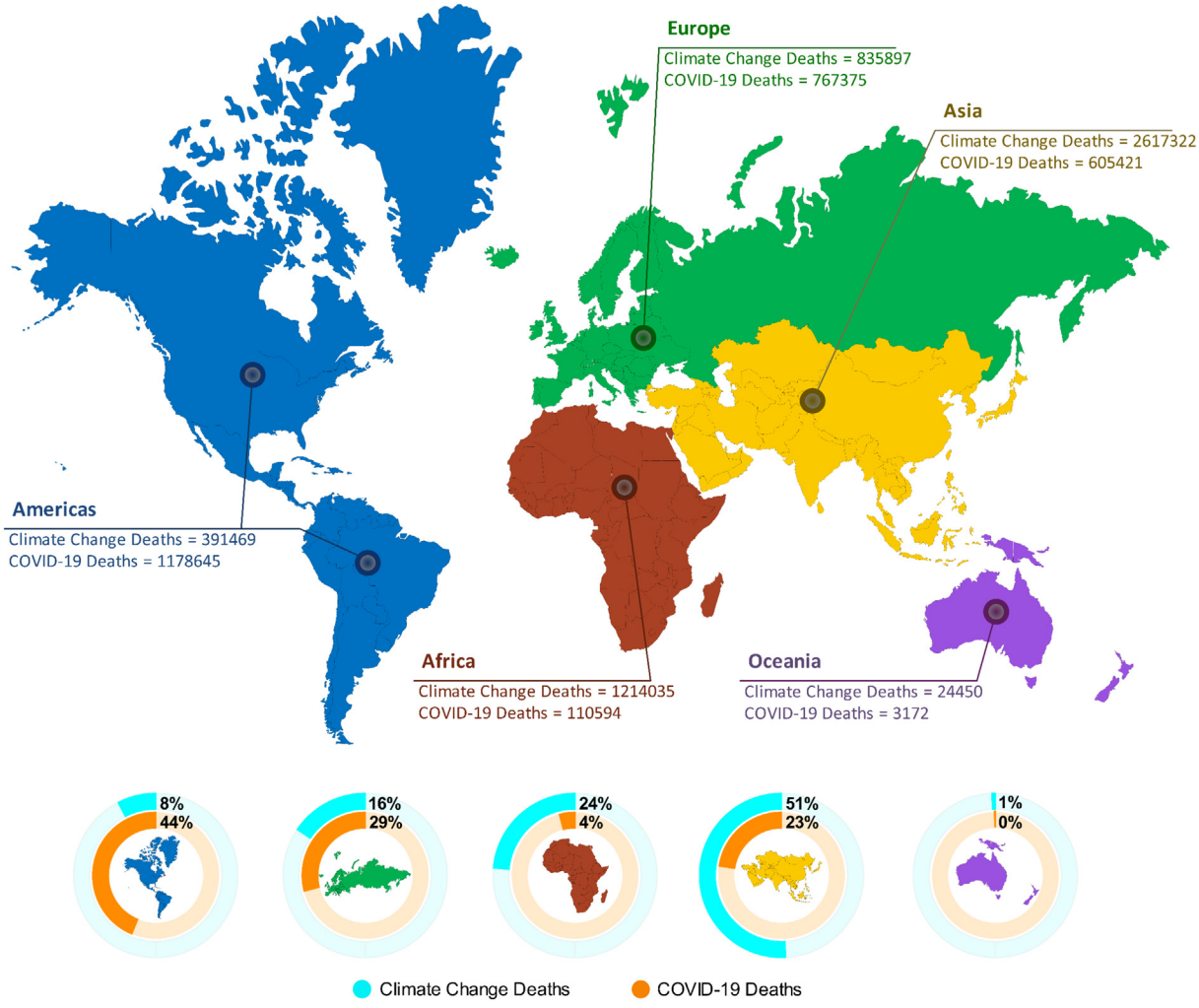

Fig. 3. Annual average death cases (and overall percentages) due to climate change (non-optimal temperatures) and COVID-19 across different continents. Data of non-optimal temperature related death is taken from Zhao et al. (2021) and data of COVID-19 related deaths is taken from Johns Hopkins University (2022).

Fig. 3 illustrates the geographical distribution of climate change (non-optimal temperature) versus COVID-19 related deaths. As per Fig. 3, of all COVID-19 death cases, 44 % occurred in Americas, 29 % occurred in Europe, 23 % occurred in Asia, 4 % occurred in Africa, and ~0 % occurred in Oceania (Johns Hopkins University, 2022). Conversely, these percentages are 8 %, 16 %, 51 %, 24 %, and 1 %, respectively, for climate related deaths (Zhao et al., 2021). The geographic differences in death distributions reveal that climate change and the COVID-19 pandemic pose different threats to different parts of the world and nations may need to learn from each other on how to better cope with different crises. For instance, most death cases associated with COVID-19 occurred in the Americas and Europe (73 % in total), whereas climate change related deaths primarily occurred in Asia and Africa (75 % in total). This raises several ethical questions related to the global response to crises and whether wealthier nations may be more likely to respond to the climate crisis if they experienced similar death rates from climate change as poorer countries? Raising awareness of these inequities may help improve public awareness, encourage international multidisciplinary collaborations, promote effective multinational health plans, and develop adaptive management strategies.

4. Conclusions

Historically, global crises have largely been driven by world wars or pandemics that occur independently in time and space. However, the joint occurrence of the COVID-19 and climate change crises provides valuable lessons for policy, economics, and social responses. This is particularly important as the climate change crises are likely to continue for the foreseeable future and other crises will invariably arise.

The outcomes from this article highlight the value of cross-sectoral decision-making and how mitigation measures can be developed that are beneficial for both crises. At the same time, this study emphasised the importance of global decision-making and collective action. Indeed, throughout the 20th century, global decision-making entities, including the League of Nations, the United Nations, and the World Health Organisation, were developed in response to worldwide crises. However, during times of greatest need, these organisations have lacked the political power to overcome nationalistic viewpoints. To this aim, hopefully the lessons learnt from the COVID-19 crises will help drive global collective action in the future, especially for developing countries that have been shown to suffer the largest impact.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2022.157142.

CRediT authorship contribution statement

Danial Khojasteh: Conceptualization, Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration.

Ehsan Davani: Formal analysis, Investigation, Writing - Original Draft.

Abbas Shamsipour: Formal analysis, Investigation, Visualization.

Milad Haghani: Conceptualization, Methodology, Formal analysis, Writing - Review & Editing.

William Glamore: Conceptualization, Writing - Review & Editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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