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# Exploring the evolving landscape of COVID-19 interfaced with livelihoods

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The aim of this study was to gain an understanding of the evolving landscape of research on the intricate relationship between COVID-19 and livelihoods, while also identifying research gaps and directions. To achieve this aim, a systematic review methodology was adopted, and metadata was developed using VOSviewer and R software. A total of 1988 relevant articles on COVID-19 and livelihoods were collected since the outbreak of the pandemic. However, after applying exclusion criteria and conducting thorough reviews, only 1503 articles were deemed suitable for analysis. The data was analyzed in relation to three phases of COVID-19 impacts: the early stage of COVID, the middle stages during the outbreak, and the post-recovery phase. We examined the distribution of research disciplines, regions, authors, institutions, and keywords across these phases. The findings revealed that coping strategies, food security, public health, mental health, social vulnerability, and regional differences were extensively researched areas in relation to COVID-19 and livelihoods. It was found that the United States had the highest volume of research on COVID-19 and livelihoods. Additionally, the top 1.28% of journals published 18.76% of the literature, with a predominantly focused on the environmental category. This study offers valuable perspectives into the vulnerability caused by the COVID-19 pandemic and its impacts on livelihoods. Furthermore, it provides lessons learned, outlines potential future research pathways to understand the dynamics between environmental factors (like COVID-19) and livelihood stress, and includes a comparison of traditional livelihoods research.

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**Introduction**

Livelihoods, as defined by Chambers (1995) and Scoones (2009), refer to the means of gaining a living through a combination of resources and activities. The dynamics of livelihood encompass the basic and enabling living environment, as well as related security and tools (Singh et al., 2022; Li et al., 2023a). While livelihoods are a global concern, the COVID-19 pandemic has significantly disrupted the global economy, human health, and daily life, placing immense stress on livelihoods (Rasul, 2021; Sifat et al., 2022). Since the outbreak of the epidemic, governments worldwide have made diligent efforts to manage and control the pandemic (Farrell et al., 2020). Researchers from diverse fields have also made significant contributions to the fight against COVID-19 (Cunningham et al., 2021). The severity of the virus has been regarded as one of the most fatal in history (Fotiadis et al., 2021), resulting in significant disruptions to global economic trade, tourism and employment (Chaplyuk et al., 2021). Simultaneously, mobility restrictions and border closures implemented to curb the spread of the virus have had serious consequences for global economic development, leading to increased poverty and negatively affecting the sustainable development of pre-existing livelihoods. These effects present challenges to achieving the Sustainable Development Goals (SDGs) by 2030, particularly SDG1 (zero poverty) (Marzouk et al. 2022; Jeyakumar et al., 2022).

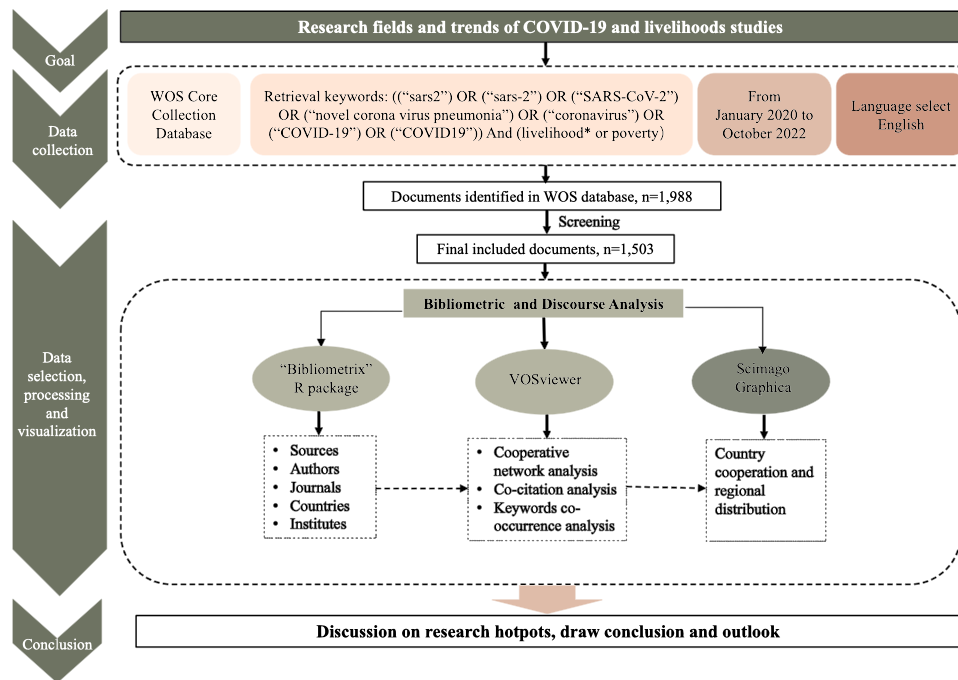
The outbreak of the COVID-19 pandemic has captured the attention of research scholars worldwide, resulting in numerous literature reviews utilizing scientometric or bibliometric analyses to investigate research topics and themes (Anholon et al., 2022; Su et al., 2022; Viana-Lora and Nel-lo-Andreu, 2022; Xi et al., 2023). These analytical approaches have been employed to provide an overview of current trends and evaluate the progress made in COVID-19 research. For instance, within the field of geosciences, a bibliometric analysis combined with machine learning was utilized to review 1171 articles, emphasizing the role of geography in COVID-19 research (Xi et al., 2023). Similarly, in the field of business and management research, a bibliometric study of 107 papers demonstrated that COVID-19 has prompted various policy changes (Verma and Gustafsson, 2020). Comparable studies have

been conducted in the field of social science (Nasir et al., 2020) and tourism research (Sigala, 2020; Viana-Lora and Nel-lo-Andreu, 2022) to investigate different measurement dimensions. However, despite these efforts, there remains a dearth of research on the intricate relationship between COVID-19 and livelihoods. Therefore, it is imperative to assess how research on livelihoods is being contextualized within the framework of COVID-19 and how this influences the developmental process.

Understanding livelihoods within the context of the ongoing COVID-19 pandemic and promoting socio-ecological system sustainability are crucial elements of human development. This study utilizes bibliometric analysis of metadata to investigate patterns and trends in research related to COVID-19 and livelihoods. With quantifying the relevant themes and topical dimensions, this research aims to provide valuable insights into expanding body of knowledge on livelihoods and its social impacts during the COVID-19 led pandemic. The findings have the potential to reveal the research frontiers and identify gaps in the field, offering guidance for future research. This research primarily addresses the following questions concerning livelihoods: (i) What is the current paradigm of global-scale research on livelihoods? (ii) Which themes have the most significant impact on people’s livelihoods during the pandemic? and (iii) What are the emerging trends in the impact of COVID-19 on livelihoods in the post-pandemic scenario?

**Research methodology and data analyses**

**Approach of data collection.** We conducted a bibliometric analysis to examine and quantify data on COVID-19 pandemic-related livelihood research. Bibliometric analysis, known as the “science of science” (Zeng et al., 2017; Fortunato et al., 2018), involves quantitative analyzing large datasets of literature. This approach enables us to evaluate the current state of research and identify potential avenues for future collaborative studies (Viana-Lora and Nel-lo-Andreu, 2022). We accessed data from the core collection of the Web of Science (WOS) and used the keywords “Covid-19 and livelihood” in our search (Fig. 1), which yielded a



**Fig. 1** Flowchart of paper selection and data processing process.

total of 1988 documents. To ensure alignment with the purpose of our study, we selected relevant literature based on three criteria: (i) *Relevance*: To evaluate relevance, we considered whether the literature directly addressed the research topic “Covid-19 and livelihoods”, ensuring alignment with the study purpose by employing keyword matching to ensure alignment manually, (ii) *Language*: The language of the literature was limited to English was considered to ensure that the research team could accurately understand and analyze the content of the literature, (iii) *Time frame*: The publication dates of the screened literature ranged from January 2020 to October 2022 to maintain a focus on the most recent research findings during the COVID-19 pandemic. By applying these criteria, our screening process aimed to include documents that met our research objectives while excluding irrelevant or non-English publications published outside the specified time frame. To mitigate bias and ensure consistency, we had another independent team randomly verified the screening process. We selected 30% of the total dataset for manual validation, striking a balance between the need for data accuracy and the practicality of manually checking a large dataset (D’Angelo and van Eck, 2020). The manual verification of this subset confirmed the reliability of our data and the effectiveness of our filtering criteria. As a result, we included a total of 1503 documents that matched the objectives of this study for further analysis.

**Characterization of data and their analyses.** Subsequently, relevant information was extracted from the research articles, encompassing the title, author names, institutional affiliations, country of research, abstracts, and keywords. Additionally, we collected data on the geographical distribution of COVID-19 concerning the livelihoods research field, along with the networks of keywords associated with this field and the top journals that published such research. In our research, we have captured the country and institutional affiliation data from each of the target papers. For papers resulting from international collaborations, we have recorded all participating countries and institutions in our database independently, counting each author once without considering their order in the author list. When an author is involved in more than one academic unit, each unit is counted, so the author will be included in each unit’s count. This multiple counts approach has allowed us to accurately portray and analyze the geographical distribution of these papers and provide deeper insights in our study. To facilitate further analysis and visualization, we exported the dataset as target files from the WOS. VOSviewer and R programming language were used for analyzing and visualizing this dataset, particularly “bibliometrix” package in R, an open-source program that is known for its language-based capabilities and statistical algorithms. Regarding the geographic area, data was analyzed using Scimago Graphica (Hassan-Montero et al., 2022). VOSviewer has been extensively employed as a key technique for constructing relationships in bibliometric data and providing visual representations of the current status and groupings within data (Van Eck and Waltman, 2010; Van Eck and Waltman, 2017; Li et al., 2021). The size of the circle in the visualizations represent the number of papers published in each area of research, while connections between distinct circles indicate different clustering modules. Moreover, to better demonstrate the co-authorship analysis network, we set the threshold to two, referring to a requirement that authors must have collaborated on at least two publications to be considered as connected or having a significant co-authorship relationship. Keyword occurrence analysis forms distinct clusters, aiding in the identification of various research themes within the text, thereby enhancing the understanding of research trends and preference,

which is applicable at different research stages. On the other hand, the R program provides a comprehensive set of tools for bibliometric analyses that feature high-quality statistical algorithms and integrated data visualization capabilities. These tools facilitate the efficient decomposition and parsing of raw data extracted from literature (Li et al., 2022b). Leveraging these tools, we identified and analyzed trends and patterns in livelihoods research within the context of the COVID-19 pandemic.

**Dynamic analysis of stages of development.** To capture the progression of the research on pandemic and livelihoods, we divided the developmental stages into three periods based on the nature of the COVID-19 outbreak. Early stage: Outbreak and initial response (January 2020 to July 2020); Middle stage: Widespread transmission and large-scale control measures (August 2020 to December 2021) and Post-recovery stage: Vaccine rollout and gradual return to normal life (January 2022 to the date of analysing the data).

The early stage was chosen because it marked the initial phase of the COVID-19 pandemic when the impact of the outbreak was just beginning to manifest, and research reflected society’s response to this new threat. The middle stage was selected because it represented a period of further evolution of the pandemic and evolving societal responses to control measures. The post-recovery stage was chosen as it signifies society’s gradual return to normalcy, allowing us to learn from experiences and prepare for potential future public health challenges.

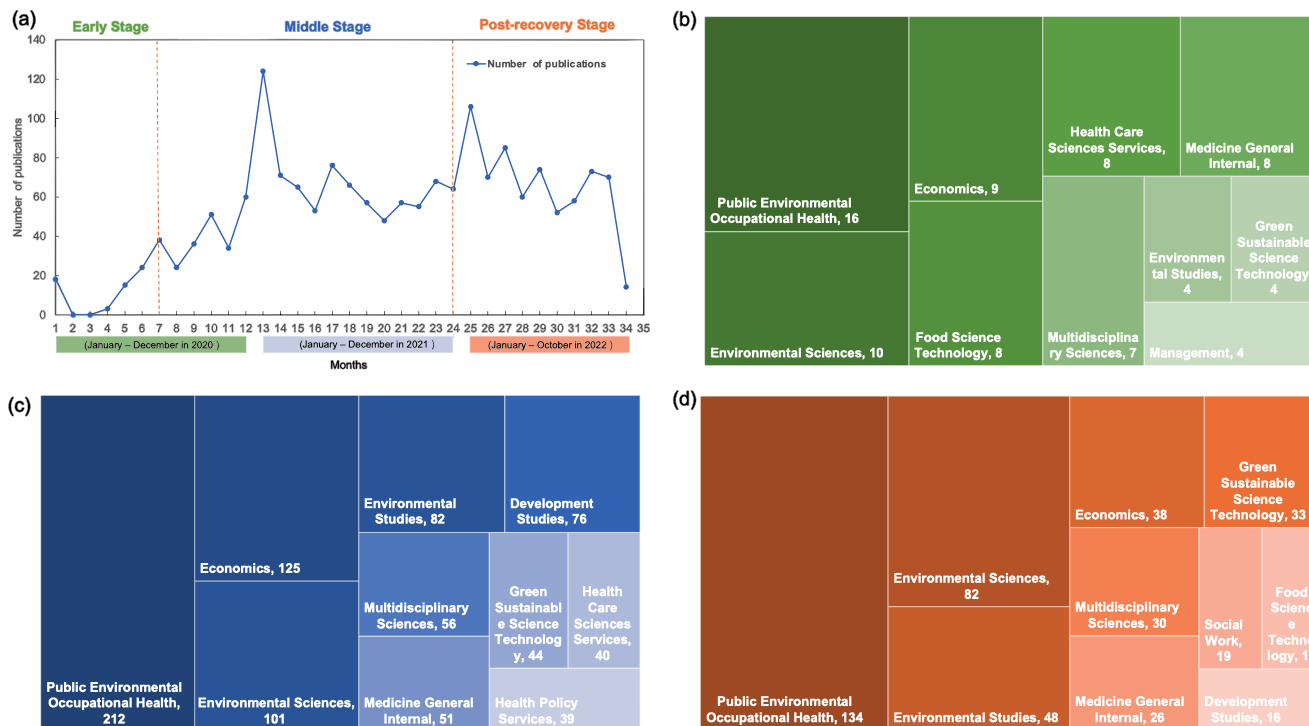
## Results

**Temporal evolution of COVID-19 and livelihood research.** Since the outbreak of COVID-19, a total of 1503 publications related to livelihoods research have been identified. Notably, these research papers have been published in 693 distinct journals, signifying a significant global growth rate of 541.5%. The study period into three phases (Fig. 2a). These phases are delineated as follows:

*Early stage.* During this phase, the volume of research on the intersection of COVID-19 and livelihoods exhibited a gradual increase. The number of publications rose from 18 in January to 60 by December. Despite the initial severe impacts on livelihoods, such as job losses and shifts in ways of living due to social distancing and lockdown measures, research on this theme was relatively scarce but grew steadily. The primary areas of research during this phase were public environmental occupational health, environmental sciences, and economics (Fig. 2b).

*Middle stage.* This phase experienced an exponential surge in research output, reaching its peak with 124 publications in the first month of 2021. This increase coincides with the widespread global transmission of COVID-19, leading to the implementation of large-scale control measures by governments worldwide. The pandemic necessitated adjustments in work and life patterns, making the impact on livelihoods during this stage more complex. While some people adapted to new earning methods, such as remote work, occupations that relied on face-to-face interactions faced significant disruptions. Research priorities shifted during this stage, with a greater emphasis on economics-related research and continued focusing on public environmental occupational health. Additionally, other fields like environmental sciences, environmental studies, and development studies gained prominence (Fig. 2c).

*Post-recovery stage.* Throughout this phase, research volume achieved stability, with fluctuations ranging from 52 to 106 publications per month. This stability coincides with a global



**Fig. 2 Temporal and research category evolution of COVID-19 and livelihood research.** **a** Represents overall trends in publications and their temporal evolution. **b** Represents the early phase, **c** represents the middle phase, and **d** represents the recovery phase of the top 10 categories in the Web of Science.

return to normalcy, which was made possible by widespread vaccine distribution and the implementation of effective control measures. The sector of livelihoods may experience uneven recovery, given that this stage is characterized by reflection and learning from past experiences in preparation for possible future public health crises. During the third stage, research continues to prioritize public environmental occupational health, with a growing focus on economic recovery and the disciplines of environmental sciences, environmental studies, green sustainable science, and technology (Fig. 2d).

Furthermore, the identification of number of publications the “January Peak” in both 2021 and 2022 may be attributed to various factors, including the commencement of the academic year, the continuation of pandemic-related research, international collaborative efforts, and the dynamic nature of global events.

**Study area analysis.** Regarding the distribution of research regions, the three phases, as explained earlier, have experienced great changes. With only a few major countries, such as the United States, India, and China, were involved in this theme in the early stages, followed by a large number of scholars (as many as 112 countries and regions) being involved in the research on combating epidemics and sustaining livelihoods. Relatively a smooth development was found in the third phase in which 65 countries (regions) were involved (Fig. 3a–c). In total, the global geographic distribution of publications on this topic indicated that the United States (575 articles), the United Kingdom (288 articles), India (151 articles), China (134 articles), South Africa (122 articles), Canada (103 articles), and Australia (98 articles) had highly published the articles on COVID-19 and livelihoods (Fig. 3d). The growing interest to pursue research and publish them on this issues in these countries might be due to the increased vulnerability of livelihoods and the aggravating extent of COVID impact (Buheji et al., 2020). Additionally, according to the World Health Organization (WHO) data, these are also the countries those had the greater impacts on human health and

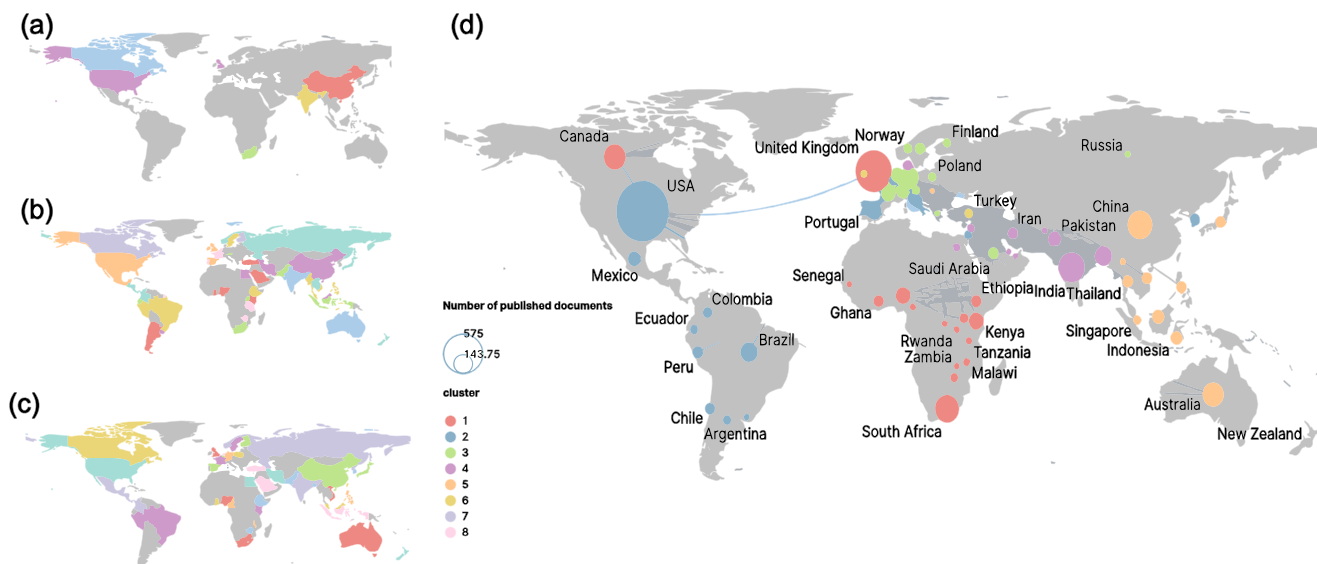
livelihoods at the beginning of the virus pandemic (Workie et al., 2020; Shang et al., 2021) (Fig. 3).

**Journal analysis.** Results indicated that the studies were published in a total of 683 journals. Notably, the top 10 journals accounted for 282 (18.76%) of research articles (Fig. 4). In contrast, 497 journals (63.35%) published only a single paper.

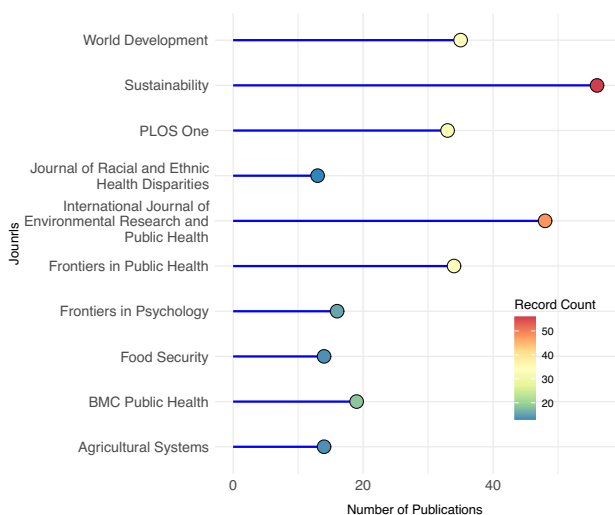
**Authorship analysis.** The results of authorship data from research studies on the COVID-19 pandemic and livelihoods indicated that 1503 publications involved a total of 8005 authors. The study authors also showed interesting changes, with only 4 main authors involved in the early phase of the epidemic and livelihoods research. It has been gradually increased as the epidemic continued to develop and expand. In the middle phrase of COVID-19, there were mainly 150 authors (only shown 9 in current network). Whereas in the third phase of COVID-19 pandemic, there were 36 authors (only shown 5 authors in the current network). In the phase third, a clear pattern of network patchiness was observed, which in turn illustrated the regional and localized nature of the research as a result of the impact of the epidemic (Fig. 5a–c). Notably, independent authors accounted for 11.5% of the total publications, indicating a significant amount of collaboration in the development of these studies. The rate of international collaboration was observed to be over 42%, at least 5 researchers per article, and an average number of authors per article were to a tune of 5.69. Results presented in Fig. 5d exhibited how the most relevant authors stand out, with Bodrud-Doza M. and Rahman M. M. publishing 6 articles receptively. Brookes VJ and Gupta A published 5 articles each. If we take at least 2 publications as a determining factor, we got 297 authors, whereas with at least 3 articles, 59 authors were mapped who led research on COVID-19 and livelihood perspectives.

In terms of author affiliation, 2954 research units were involved, with significant shifts those occurred across the three phases in leading the research on COVID-19. During the early





**Fig. 3 Global scale geographical distribution of COVID-19 and livelihoods research.** **a** Represents the early phase, **b** represents the middle phase, **c** represents the recovery phase, and **d** represents overall phase.



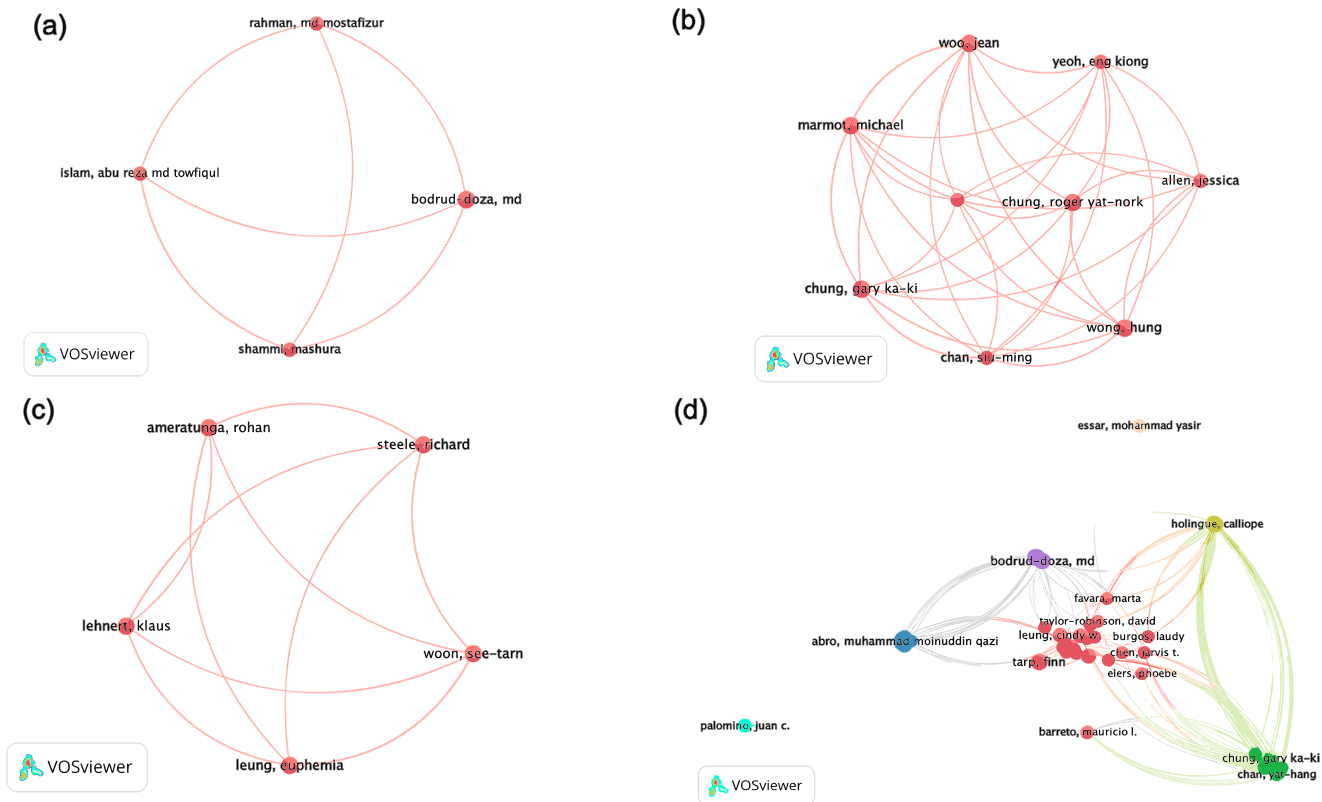
**Fig. 4 Top 10 most published journals in COVID-19 and livelihoods research field.**

stages, Oxford University, among the others, was the primary contributor. However, as the pandemic progressed into the middle and later phases, research powerhouses began to diversify. North American institutions such as Columbia University, Johns Hopkins University, and the University of Toronto took the helm, alongside European entities like Oxford University and the University of Edinburgh. Additionally, the involvement of institutions in South and East Asia and newcomers from countries like South Africa, including Cape Town University and the University of South Africa, added complexity to the collaborative network (Fig. 6a–c). It’s important to note that despite the substantial number of research institutions and overall publications from China and India, their research was learned to be somewhat fragmented. This fragmentation has led to a lack of a centralized body of researchers, even with multiple entities publishing more than ten papers and actively exploring this area. In conclusion, among the institutions with more than 30 publications, the University of Oxford had the highest number with 58 publications, followed by Cape Town University with 53 publications, the University of Toronto with 43 publications, the

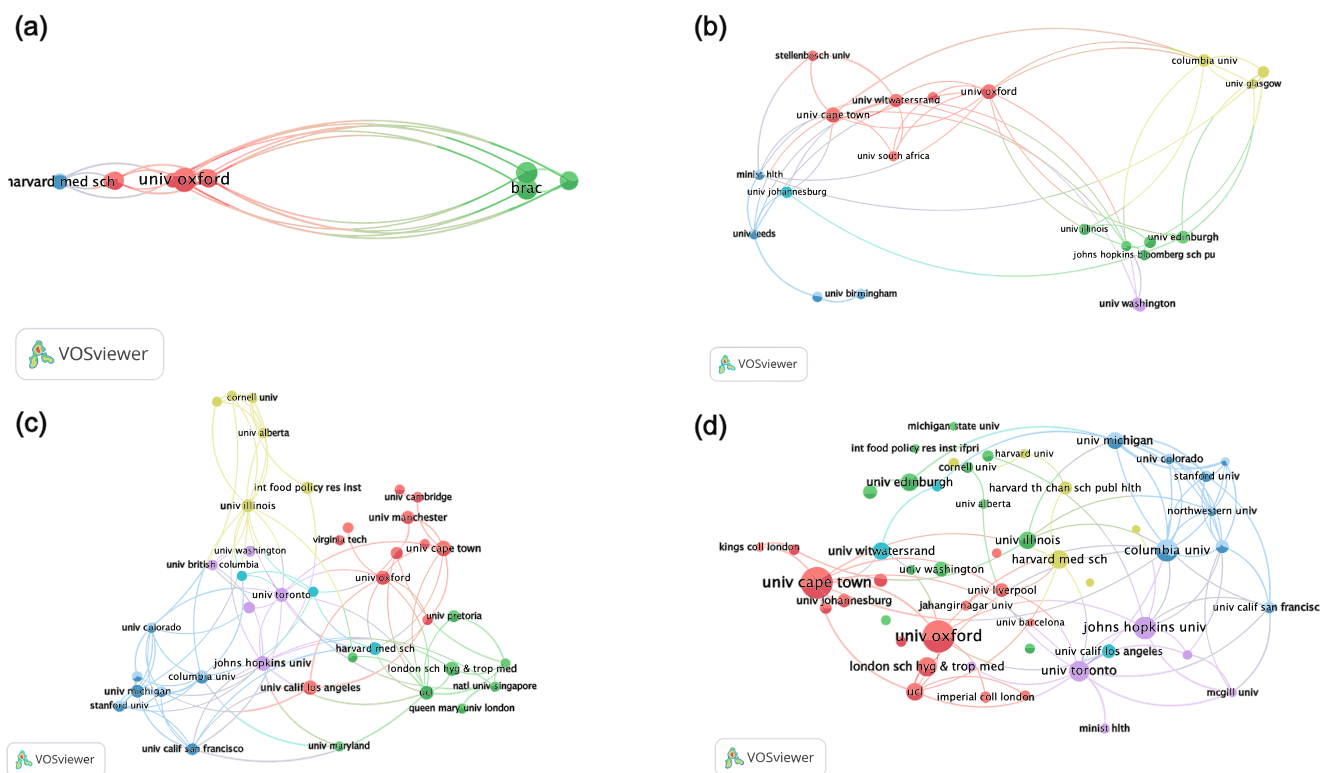
University of California, Los Angeles with 40 publications, Columbus University with 38 publications, Johns Hopkins University with 37 publications, and the London School of Hygiene and Tropical Medicine with 30 publications, as depicted in Fig. 6d.

In summary, our results of authorship revealed a collaborative effort involving 8005 authors across 1503 publications. International collaboration was prominent, with over 42% of articles involving researchers from multiple countries. Leading institutions evolved across pandemic phases, with Oxford University, Cape Town University, and the University of Toronto emerging as key contributors.

**Keywords analysis.** This section focuses on the most relevant keywords in the field of COVID-19 and livelihood research, highlighting hot topics and potential future research areas. A keyword co-occurrence analysis was conducted using VOSviewer, with a minimum threshold limit of 5 occurrences per word (Li et al., 2022a). A total of 3795 author keywords with an average of more than 12 citations per article. The resulting network of 194 keywords revealed COVID-19 was the most frequently occurring keyword, with 1072 occurrences. Notably, terms such as Sars-cov-2, Coronavirus, and COVID-19 pandemic were unified under the term COVID-19. By employing an automated algorithm, 8 clusters were formed based on the network relationships of these keywords. The analysis showed that keywords such as poverty (175 times), food security (56 times), public health (56 times), mental health (56 times) and resilience (46 times) were highly frequent (Fig. 7d). Furthermore, in addition to analyzing each stage’s keyword co-occurrence (Fig. 7a–c), we also paid attention to the evolution of high-frequency words. For example, along with related viral terms like ‘COVID-19’, the keyword ‘poverty’ emerged as a significant term during the early stage (Fig. 7b). While during the middle phase of COVID, the central themes noted to be revolved around ‘public health’, ‘policy’, and ‘housing’ (Fig. 7b). In contrast, the later stage witnessed a shift towards keywords such as ‘mental health’, ‘vulnerability’, ‘children’, and ‘food security’ (Fig. 7c). Moreover, to show more clearly the clusters at different stages of development and the related keywords, we have counted the clusters formed at each stage as well as the keywords and its frequency at each stage, as detailed in the online resources.

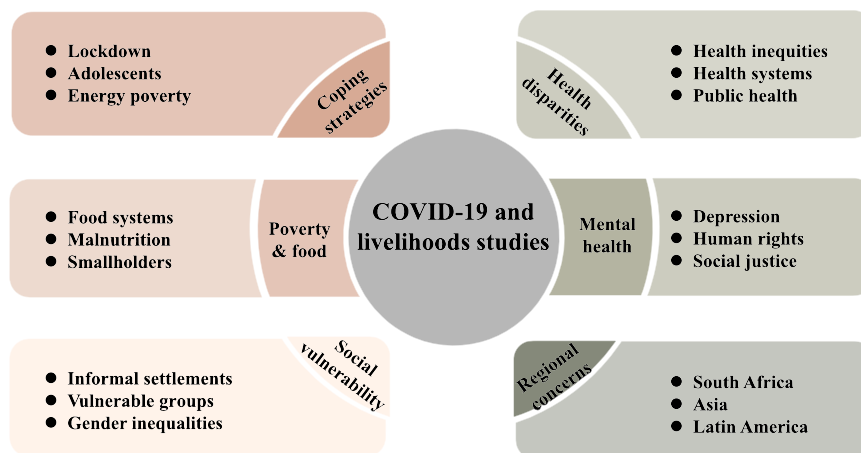


**Fig. 5** The most relevant authors non-weighted network based on co-authorship on COVID-19 and livelihoods research field. **a** Represents the early phase, **b** represents the middle phase; **c** represents the recovery phase. In (**b**, **c**), some of the 150/36 items in network are not connected to each other. The largest set of connected items consists of 9/5 items. In the figure, only this set of items is shown instead of all items. **d** Represents overall phase.



**Fig. 6** Author affiliation non-weighted network based on co-authorship on COVID-19 and livelihoods research field and three different phase non-weighted network visualization. **a** Represents the early phase, **b** represents the middle phase; **c** represents the recovery phase, and **d** represents overall phase.





**Fig. 8** Six main research themes on COVID-19 and livelihoods research studies.

facilities required for safe screening or isolation (Gaudron et al., 2022; Tunstall, 2022). Therefore, living in proximity without access to clean-living environments is ill-advised when combating a pandemic. The instability of income resulting from lockdown measures and other restrictions poses a significant risk to livelihoods.

**Health disparities (cluster 2).** As data from the pandemic accumulate, COVID-19 may affect some segments of society more than others. Evidence suggest that blacks, Hispanics, and Asians had much higher rates of infection, hospitalization and mortality compared to whites, while African Americans had a higher incidence of COVID-19 cases (2.6 times), hospitalizations (4.7 times) and deaths (2.1 times) compared to non-Hispanic whites (Selden and Berdahl, 2020). These have caused a dramatic change in the pattern of human capital, and thus livelihood sustainability (Lopez et al., 2021). The discrepancies in the level of development across countries and regions further amplify these differences, leading to significant disparities in the availability of medical supplies, life-saving treatments, and post-rehabilitation care, particularly in poorer regions. This exacerbates health resource inequalities, posing an even greater risk of infection.

Unfortunately, COVID-19 risk factors significantly overlap with pre-existing health disparities, such as hypertension, diabetes, heart disease, lung disease, and immune disorders (Poojitha and Narendra, 2020). One of the most troubling aspects of the COVID-19 pandemic is the disproportionate harm it causes to socio-politically marginalized groups (Hashim et al., 2020).

**Poverty and food (cluster 3).** The COVID-19 pandemic has affected food security worldwide (Sreenonchai and Arunrat, 2021). The pandemic, along with associated policy responses, triggered a massive economic downturn and major disruptions in the food value chain, especially for low- and middle-income countries, affecting their local food systems and other shocks and stressors for their actors in different ways, with a dramatic impact on the food and nutrition security of the poor (Béné, 2020). Some studies have shown that COVID-19 has a greater impact on food security and nutrition for the poor than for the rich (Swinnen and McDermott, 2020). The evidence suggested that even food grain production could loss up to 23% due to the labor shortage (human capital) during the COVID-19 pandemic. Additionally, the environmental pollution due to the agricultural operations (residue burning) was anticipated to compound the health risks

(across the human population) with COVID-19 resurgence (Singh et al., 2020).

The COVID-19 pandemic will have an impact on families who have lost family members to the virus, further exacerbating the play of human capital (Béné, 2020). The impact of the epidemic on the sustainable livelihoods of poor farm households might be large in terms of natural capital and financial capital, large in terms of social capital and human capital, and small in terms of physical capital (Chan et al., 2022). To reduce the impact of the COVID-19 epidemic on the sustainable livelihoods of material resource-poor farmers, the governments can introduce relevant policies to encourage farmers to actively participate in agricultural production and enhance the sustainability of the livelihoods of material resource-poor farmers. Although many food systems were severely damaged, others were more resilient and food supply was relatively unaffected (Swinnen and McDermott, 2020).

**Mental health (cluster 4).** In addition to the physical damage caused by the new pneumonia pandemic and the physical damage caused by the virus itself, there was also the psychological stress caused by people's fear of it (Usher et al., 2020). The mental stress caused by the blockade and restrictive measures could also incalculably damaged (Jiloha, 2020). Moreover, these psychological impairments can directly affect interest, engagement, and efficiency in future work, which can also affect livelihoods in the long run (Gaudron et al., 2022). In addition to the significant health burden of COVID, there is also the stigma and discrimination associated with the disease that could lead to the relationship breakdowns and problems at the work (Nostlinger et al., 2022). As a result this may cause the significant additional suffering, which in itself can impact treatment and affect a person's mental health (Saeed et al., 2020). The long-term research on the extended conditions by asthma, depression and AIDS like issues have shown that associated stigma has terrible consequences for public health (Turner-Musa et al., 2020). Fear of such stigma can also drive people away from the health services and other supports, which over time can have a negative impact on people's physical and mental health (Zheng, 2023). These interrelated processes of stresses have adverse implications on productive human capital that primarily shape the livelihood.

**Social vulnerability (cluster 5, 6 & 7).** The COVID-19 pandemic was widespread worldwide, but its impact was observed to vary across different social classes based on their adaptive capacity (Barton et al., 2021; Herbers et al., 2021). People with low income



were learned to be more susceptible contract the virus (Bauer et al., 2021), and faced increased health risks and financial burdens (Paul et al., 2021). There has been much media coverage of how the COVID-19 pandemic has exacerbated inequality (Bessell, 2022; Escalante and Maisonnave, 2022; Van Wyngaard, 2022). Many public opinion polls also showed that most people believed that the COVID-19 pandemic has had a negative impact on the poor (Ronkko et al., 2022). Moreover, it affected the people differently from gender to age group to varying degrees (Vakili et al., 2020). Key insights from the past suggest it is not only the elderly, children and women, but there were also racial differences in terms of impacts and vulnerability caused by this pandemic (Gaynor and Wilson, 2020). The social inequalities could further exacerbate in remote and resource-poor areas (Power et al., 2020), which may increase the pressure on family labor income. Scholars observed that the loss of learning from school closures during a pandemic may further exacerbate inequalities between the countries (Gambau et al., 2022), and result poor human resources development. Students acquired skills are particularly affected in countries with prolonged school closures and a lack of effective online educational infrastructure (Özdemir et al., 2022). Therefore, improving human capital will be crucial to enhancing social resilience for the stress like COVID-19 pandemic.

**Regional concerns (cluster 8).** From a global perspective, regions concentrated in South Asia (India and Bangladesh), Latin America region, and South Africa region (South Africa, Kenya, Nigeria, etc.) were the critical areas for sustainable livelihood research prior to the pandemic (Mbunge, 2020). The outbreak of the epidemic has severely disrupted the coordination of livelihood capital in these areas, resulting in substantial challenges for health and socio-economic systems. The elderly population is expected to face more difficulties in coping with the pandemic and may further experience difficulties in the later life, due to the much higher risk of death faced by the elderly (Heid et al., 2021). The urban/rural scale analysis is also important because remote rural areas are also areas of concentration of older adults (Kashnitsky and Aburto, 2020). Therefore, these areas are important elements that need to be prioritized for recovery and development in the next decade. They are also elements that will help make up for the shortcomings of the SDGs and should be given attention.

### **COVID-19's impact on livelihood studies: a comparative perspective**

The unprecedented pandemic of COVID-19 has dramatically reshaped various academic fields (You et al., 2020), including the sphere of livelihood studies. As global communities struggle to adapt to the new normal, understanding the shifts in the focus and methodology of livelihood studies is of utmost importance. Prior to the COVID-19 outbreak, livelihood studies largely concentrated on examining socio-economic factors, development policies, and environmental aspects influencing people's livelihoods (De and Zoomers, 2005; Ofori et al., 2020; Li et al., 2022a). The quantitative analysis (Blundo-Canto et al., 2018; Li et al., 2023b), field surveys (Li et al., 2022c), and case studies (Piggott-McKellar et al., 2020; Li et al., 2023c) were common research methodologies, revealing insights into diverse local contexts and the effects of global trends on communities. The advent of the COVID-19 pandemic, however, has compelled a pivot in these studies (Swinnen and Vos, 2021). New research questions have emerged, focusing on the pandemic's effects on livelihoods, food security (Swinnen and McDermott, 2020), employment (Chaplyuk et al., 2021), and health (Saeed et al., 2020; Turner-Musa et al., 2020), among others. The virus's differential impact on various socio-economic groups and regions has emphasized the

need for more inclusive and nuanced studies. The urgency of the situation has also necessitated rapid research techniques, including online surveys and remote data collection, altering the methodologies traditionally used in livelihood studies (Jeyakumar et al. 2022; Paul et al., 2021). Furthermore, the pandemic's disruptive effects on global economies and local livelihoods have brought new insights and perspectives to the fore (Swinnen and Vos, 2021; Piquer-Rodriguez et al., 2023). The centrality of health in maintaining sustainable livelihoods, the role of social protection schemes in crisis situations, and the need for resilient and adaptable livelihood strategies have become evident in the wake of the COVID led crisis.

Looking ahead, these changes herald new directions for livelihood studies. Future research will need to further explore the long-term effects of the pandemic, the efficacy of different coping strategies, and the lessons learned for improving resilience and adaptability of livelihoods. In addition, the crisis has highlighted the need for multidisciplinary approaches, incorporating health (Usher et al., 2020), economics (Gaudron et al., 2022; Tunstall, 2022), sociology (Barton et al., 2021; Herbers et al., 2021), and environmental sciences (Swinnen and McDermott, 2020; Zhu et al., 2023), among others. Therefore, the COVID-19 pandemic has significantly altered livelihood studies, shifting research questions, methodologies, and conclusions. It is crucial to recognize and understand these changes to effectively respond to the current crisis and to prepare for similar emergencies in the future.

### **Conclusion and policy insights**

The primary objective of this study was to conduct a quantitative bibliometric analysis of scientific outcomes in the field of COVID-19 and livelihoods. This study provides valuable insights on the intersection of COVID-19 pandemic and livelihood perspectives under different scenarios. Specifically, we identified the main geographical distribution of studies, significant journals and subject areas, research institutions, notable authors, and co-occurrence clustering analysis of the keywords related to COVID-19 and livelihood in three distinct phases of pandemic occurrence. This study demonstrated that pandemics and the consequent human control measures brought about significant shifts in livelihoods and COVID-19 research, both at granular regional levels and on a broader global scale. There was a rapid escalation in research output during the early phase, peaking in the mid-term. This body of work has spanned from local to global scales, with the primary emphasis on North America, Europe, East Asia, South Asia, and South Africa. The network analysis illustrates that, regardless of the authors' affiliations, institutional relationship networks, or keyword networks, the fragmentation within the network significantly increased during the middle and later studies, leading to a more complex network.

The authorship analysis revealed the involvement of 8005 authors across 1503 publications in COVID-19 and livelihoods research. Notably, over 42% of these articles showcased international collaboration, indicating a significant level of cooperation among researchers from various countries. However, despite the presence of numerous research institutions, we observed an increasing dispersion in institutional collaboration. This dispersion has impacted the comprehensive representation of the network, suggesting that regional collaboration tends to outweigh global cooperation in these studies. Moreover, the leading institutions contributing to this research evolved as the pandemic progressed through its phases. In the early stages, Oxford University played a significant role. Still, as the pandemic continued, research powerhouses such as Cape Town University and the University of Toronto emerged as key contributors to this

evolving landscape. These findings contribute to a deeper understanding of the current focus and future trends in livelihoods research, offering important data support and theoretical foundations towards achieving the SDGs by 2030. Given the increasing number of publications on this topic, it is crucial to assess the quality of the papers presented in order to obtain the most relevant information.

Our study identified six major directions for livelihoods research, providing targeted response strategies and recommendations for achieving sustainable livelihoods. An important insight from our research highlights the need for effective data sharing and collaborative research mechanisms among scholars to address the physical and mental stress on livelihoods caused by the pandemic. By conducting paradigm studies, such efforts can enhance the global sustainability of human livelihoods, improve human well-being, and work towards eradicating poverty. This study is probably the first of its kind to examine the intricate relations between COVID-19 and livelihoods, offering valuable lessons and future pathways regarding the vulnerability caused by the pandemic and its impacts on livelihoods. The key insights derived from this research also contribute to enhancing the transfer of knowledge from livelihoods theory research to livelihoods improvement research, helping mitigate the consequences of the pandemic. The COVID-19 pandemic presents significant challenges to the livelihoods of the global population, particularly those on the verge of poverty. Consequently, exploring effective approaches to address these challenges at different levels of government, scientist, and society—including policy mechanisms, research priorities, and exploration of key regions—will be an important focus of the future research.

### Limitation of the study

One of the limitations of the current study is its exclusive focus on English-language publications. This approach may have led to the omission of valuable research available in other languages. Recognizing the potential benefits of exploring research conducted in diverse languages, it is important to acknowledge that doing so could provide new insights and perspectives on COVID-19 and sustainable livelihoods. Despite this limitation, the key results and findings of our study can function as a significant starting point for other scholars to pursue similar research in other languages. Replicating these studies in various languages would contribute to a more comprehensive understanding of the dynamics of COVID-19 and sustainable livelihoods, thereby enhancing the existing theory of sustainable livelihoods.

### Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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### References

- Anholon R, Rampasso IS, Dibbern T, Serafim MP, Filho WL, Quelhas OLG (2022) COVID-19 and decent work: A bibliometric analysis. *Work* 71(4):833–841. <https://doi.org/10.3233/WOR-210966>
- Atalan A (2020) Is the lockdown important to prevent the COVID-19 pandemic? Effects on psychology, environment and economy-perspective. *Ann Med Surg* 56:38–42. <https://doi.org/10.1016/j.amsu.2020.06.010>
- Barton JR, Gutierrez-Antinopai F, Ulloa ME (2021) Adaptive capacity as local sustainable development: Contextualizing and comparing risks and resilience

- in two Chilean regions. *Sustainability* 13(9):32. <https://doi.org/10.3390/su13094660>
- Bauer A, Garman E, McDavid D, Avendano M, Hessel P, Diaz Y, Araya R, Lund C, Malvasi P, Matijasevich A, Park AL, Paula CS, Ziebold C, Zimmerman A, Evans-Lacko S (2021) Integrating youth mental health into cash transfer programmes in response to the COVID-19 crisis in low-income and middle-income countries. *Lancet Psychiatry* 8(4):340–346. [https://doi.org/10.1016/S2215-0366\(20\)30382-5](https://doi.org/10.1016/S2215-0366(20)30382-5)
- Béné C (2020) Resilience of local food systems and links to food security—a review of some important concepts in the context of COVID-19 and other shocks. *Food Security* 12(4):805–822. <https://doi.org/10.1007/s12571-020-01076-1>
- Berkowitz RL, Gao X, Michaels EK, Mujahid MS (2021) Structurally vulnerable neighbourhood environments and racial/ethnic COVID-19 inequities. *Cities Health* 5(sup1):S59–S62. <https://doi.org/10.1080/23748834.2020.1792069>
- Bessell S (2022) The impacts of COVID-19 on children in Australia: deepening poverty and inequality. *Child Geogr* 20(4):448–458. <https://doi.org/10.1080/14733285.2021.1902943>
- Buheji M, da Costa Cunha K, Beka G, Mavric B, De Souza Y, da Costa Silva SS, Hanafi M, Yein TC (2020) The extent of covid-19 pandemic socio-economic impact on global poverty: a global integrative multidisciplinary review. *Am J Econ Sociol* 10(4):213–224. <https://doi.org/10.5923/j.economics.20201004.02>
- Blundo-Canto G, Bax V, Quintero M, Cruz-García GS, Groeneveld RA, Perez-Marulanda L (2018) The different dimensions of livelihood impacts of payments for environmental services (PES) schemes: A systematic review. *Ecol Econ* 149:160–183
- Chambers R (1995) Poverty and livelihoods: whose reality counts? *Environ Urban* 7(1):173–204. <https://doi.org/10.1177/0956247895007001006>
- Chan SM, Chung GKK, Chan YH, Chung RYN, Wong H, Yeoh EK, Woo J (2022) Resilience and coping strategies of older adults in Hong Kong during COVID-19 pandemic: a mixed methods study. *BMC Geriatr* 22(1):10. <https://doi.org/10.1186/s12877-022-03009-3>
- Chaplyuk VZ, Alam RMK, Abueva MM-S, Hossain MN, Humssi ASA (2021). “COVID-19 and its impacts on global economic spheres”, in: *Modern Global Economic System: Evolutional Development vs. Revolutionary Leap* 11: Springer), 824–833
- Cunningham E, Smyth B, Greene D (2021) Collaboration in the time of COVID: a scientometric analysis of multidisciplinary SARS-CoV-2 research. *Humanity and Soc Sciences Commun* 8(1):240. <https://doi.org/10.1057/s41599-021-00922-7>
- D’Angelo CA, van Eck NJ (2020) Collecting large-scale publication data at the level of individual researchers: A practical proposal for author name disambiguation. *Scientometrics* 123:883–907. <https://doi.org/10.1007/s11192-020-03410-y>
- Dunn CG, Kenney E, Fleischhacker SE, Bleich SN (2020) Feeding low-income children during the Covid-19 pandemic. *N Engl J Med* 382(18):e40. <https://doi.org/10.1056/NEJMp2005638>
- Escalante LE, Maisonnave H (2022) Gender and Covid-19: Are women bearing the brunt? A case study for Bolivia. *J Int Dev* 34(4):754–770. <https://doi.org/10.1002/jid.3603>
- Farrell P, Thow AM, Wate JT, Nonga N, Vatucawaqa P, Brewer T, Sharp MK, Farmery A, Trevena H, Reeve E, Eriksson H, Gonzalez I, Mulcahy G, Eurich JG, Andrew NL (2020) COVID-19 and Pacific food system resilience: opportunities to build a robust response. *Food Secur* 12(4):783–791. <https://doi.org/10.1007/s12571-020-01087-y>
- Fotiadis A, Polyzos S, Huan T-CTC (2021) The good, the bad and the ugly on COVID-19 tourism recovery. *Ann Tour* 87:103117. <https://doi.org/10.1016/j.annals.2020.103117>
- Fortunato S, Bergstrom CT, Börner K, Evans JA, Helbing D, Milojević S, Petersen AM, Radicchi F, Sinatra R, Uzzi B, Vespignani A, Waltman V, Wang DS, Barabási AL (2018) Science of science. *Science* 359(6379):eaao0185. <https://doi.org/10.1126/science.aao0185>
- Gambau B, Palomino JC, Rodriguez JG, Sebastian R (2022) COVID-19 restrictions in the US: wage vulnerability by education, race and gender. *Appl Econ* 54(25):2900–2915. <https://doi.org/10.1080/00036846.2021.1999899>
- Gaudron CZ, Boulaghaf L, Moscaritolo A, Pinel-Jacquemin S, Basson JC, Bouilhac C, Claudet I, Collomb N, Delpierre C, Dupuy A, Gaborit E, Glorieux I, Katkoff V, Kelly-Irving M, Larrosa V, Marchand P, Mennesson C, Ratinaud P, Renard J, Willig TN (2022) Situations of family vulnerability and the COVID-19 pandemic. *Prat Psychol* 28(2):93–121. <https://doi.org/10.1016/j.prps.2022.01.003>
- Gaynor TS, Wilson ME (2020) Social vulnerability and equity: The disproportionate impact of COVID-19. *Public Adm Rev* 80(5):832–838. <https://doi.org/10.1111/puar.13264>
- Hashim MJ, Alsuwaidi AR, Khan G (2020) Population risk factors for COVID-19 mortality in 93 countries. *J Epidemiol Glob Health* 10(3):204–208. <https://doi.org/10.2991/jegh.k.200721.001>
- Hassan-Montero Y, De-Moya-Anegón F, & Guerrero-Bote VP (2022) SCLImago Graphica: a new tool for exploring and visually communicating data. *Profesional de la información*, 31(5). <https://doi.org/10.3145/epi.2022.sep.02>

- Heid AR, Cartwright F, Wilson-Genderson M, Pruchno R (2021) Challenges experienced by older people during the initial months of the COVID-19 pandemic. *Gerontologist* 61(1):48–58. <https://doi.org/10.1093/geront/gnaa138>
- Herbers JE, Hayes KR, Cutuli JJ (2021) Adaptive systems for student resilience in the context of COVID-19. *School Psychol* 36(5):422–426. <https://doi.org/10.1037/spq0000471>
- Jeyakumar A, Dunna D, Aneesh M (2022) Loss of livelihood, wages, and employment during the COVID-19 pandemic in selected districts of chhattisgarh in India, and its impact on food insecurity and hunger. *Front Public Health* 10:9. <https://doi.org/10.3389/fpubh.2022.810772>
- Jiloha R (2020) COVID-19 and mental health. *Epidemiol Int* 5(1):7–9. 0000-0001-5518-6090
- Joshi N, Lopus S, Hannah C, Ernst KC, Kilungo AP, Opiyo R, Ngayu M, Davies J, Evans T (2022) COVID-19 lockdowns: Employment and business disruptions, water access and hygiene practices in Nairobi's informal settlements. *Soc Sci Med* 308:11. <https://doi.org/10.1016/j.socscimed.2022.115191>
- Kashnitsky I, Aburto JM (2020) COVID-19 in unequally ageing European regions. *World Dev* 136:105170. <https://doi.org/10.1016/j.worlddev.2020.105170>
- Li T, Singh RK, Cui L, Xu Z, Liu H, Fava F, Kumar S, Song X, Tang L, Wang Y, Hao Y, Cui X (2023a) Navigating the landscape of global sustainable livelihood research: past insights and future trajectory. *Environ Sci Pollut Res* 30:103291–103312. <https://doi.org/10.1007/s11356-023-29567-6>
- Li T, Singh RK, Cui L, Xu Z, Pandey R, Liu Y, Cui X, Liu Y, Fava F, Yang Y, Wang Y (2023b) Managing multiple stressors for sustainable livelihoods in dryland ecosystems: Insights and entry points for resource management. *Land Degrad Dev* 1–17. <https://doi.org/10.1002/ldr.4964>
- Li T, Singh RK, Pandey R, Liu H, Cui L, Xu Z, Xia A, Wang F, Tang L, Wu W, Du J, Cui X, Wang Y (2023c) Enhancing sustainable livelihoods in the Three Rivers Headwater Region: A geospatial and obstacles context. *Ecol Indic* 156:111134. <https://doi.org/10.1016/j.ecolind.2023.111134>
- Li T, Cui L, Lv W, Song X, Cui X, Tang L (2022a) Exploring the frontiers of sustainable livelihoods research within grassland ecosystem: A scientometric analysis. *Heliyon* 8(10):e10704. <https://doi.org/10.1016/j.heliyon.2022.e10704>
- Li T, Cui L, Scotton M, Dong J, Xu Z, Che R, Tang L, Cai S, Wu W, Andreatta D (2022b) Characteristics and trends of grassland degradation research. *J Soils Sediments* 22(7):1901–1912. <https://doi.org/10.1007/s11368-022-03209-9>
- Li T, Cai S, Singh RK, Cui L, Fava F, Tang L, Xu ZH, Li CJ, Cui XY, Du JQ, Hao YB, Liu YX, Wang Y (2022c) Livelihood resilience in pastoral communities: Methodological and field insights from Qinghai-Tibetan Plateau. *Sci Total Environ* 838:155960. <https://doi.org/10.1016/j.scitotenv.2022.155960>
- Li T, Cui L, Xu Z, Hu R, Joshi PK, Song X, Tang L, Xia A, Wang Y, Guo D (2021) Quantitative analysis of the research trends and areas in grassland remote sensing: A scientometrics analysis of web of science from 1980 to 2020. *Remote Sens* 13(7):1279. <https://doi.org/10.3390/rs13071279>
- Lopez L, Hart LH, Katz MH (2021) Racial and ethnic health disparities related to COVID-19. *Jama* 325(8):719–720. <https://doi.org/10.1001/jama.2020.26443>
- Marzouk M, Azab S, Elshaboury N, Megahed A, Metawie M, El Hawary M, Ghaith D, Bayoumi A (2022) Modeling COVID-19 effects on SDGs using system dynamics in Egypt. *Environ Sci Pollut Res*:12. <https://doi.org/10.1007/s11356-022-20019-1>
- Mbunge E (2020) Integrating emerging technologies into COVID-19 contact tracing: Opportunities, challenges and pitfalls. *Diabetes Metab Syndr* 14(6):1631–1636. <https://doi.org/10.1016/j.dsx.2020.08.029>
- Nasir A, Shaikat K, Hameed IA, Luo S, Alam TM, Iqbal F (2020) A bibliometric analysis of corona pandemic in social sciences: A review of influential aspects and conceptual structure. *IEEE Access* 8:133377–133402. <https://doi.org/10.1109/ACCESS.2020.3008733>
- Nostlinger C, Van Landeghem E, Vanhamel J, Rotsaert A, Manirankunda L, Ddungu C, Reyniers T, Katsuva D, Vercruyssen J, Dielen S, Meudec M (2022) COVID-19 as a social disease: Qualitative analysis of COVID-19 prevention needs, impact of control measures and community responses among racialized/ethnic minorities in Antwerp, Belgium. *Int J Equity Health* 21(1):13. <https://doi.org/10.1186/s12939-022-01672-x>
- Ofosu G, Dittmann A, Sarpong D, Botchie D (2020) Socio-economic and environmental implications of Artisanal and Small-scale Mining (ASM) on agriculture and livelihoods. *Environ Sci Policy* 106:210–220. <https://doi.org/10.1016/j.envsci.2020.02.005>
- Özdemir C, Reiter C, Yildiz D, Goujon A (2022) Projections of adult skills and the effect of COVID-19. *Plos One* 17(11):e0277113. <https://doi.org/10.1371/journal.pone.0277113>
- Paul A, Nath TK, Mahanta J, Sultana NN, Kayes A, Noon SJ, Javed MA, Podder S, Paul S (2021) Psychological and livelihood impacts of COVID-19 on bangladeshi lower income people. *Asia-Pac J Public Health* 33(1):100–108. <https://doi.org/10.1177/1010539520977304>
- Piquer-Rodríguez M, Friis C, Andriatsitohaina RNN, Boillat S, Roig-Boixeda P, Cortinovis C, Geneletti D, Ibarrola-Rivas MJ, Kelley LC, Liopis J, Mack EA, Nani AS, Zae bringer JG, Henebry GM (2023) Global shocks, cascading disruptions, and (re-) connections: viewing the COVID-19 pandemic as concurrent natural experiments to understand land system dynamics. *Landsc Ecol* 38(5):1147–1161. <https://doi.org/10.1007/s10980-023-01604-2>
- Piggott-McKellar AE, Pearson J, McNamara KE, Nunn PD (2020) A livelihood analysis of resettlement outcomes: Lessons for climate-induced relocations. *Ambio* 49:1474–1489. <https://doi.org/10.1007/s13280-019-01289-5>
- Poojitha D, Narendra JB (2020) Prevalence of comorbidities associated with COVID19 in andhra pradesh, India. *Int J Pharm Drug Anal* 8(10):1–4
- Power T, Wilson D, Best O, Brockie T, Bearskin LB, Millender E, Lowe J (2020) COVID-19 and indigenous peoples: An imperative for action. *J Clin Nurs*. <https://doi.org/10.1111/jocn.15320>
- Rasul G (2021) Twin challenges of COVID-19 pandemic and climate change for agriculture and food security in South Asia. *Environ Challenges* 2:100027. <https://doi.org/10.1016/j.envc.2021.100027>
- Ronkko R, Rutherford S, Sen K (2022) The impact of the COVID-19 pandemic on the poor: Insights from the Hrishipara diaries. *World Dev* 149:14. <https://doi.org/10.1016/j.worlddev.2021.105689>
- Saeed F, Mihan R, Mousavi SZ, Reniers RL, Bateni FS, Alikhani R, Mousavi SB (2020) A narrative review of stigma related to infectious disease outbreaks: What can be learned in the face of the Covid-19 pandemic? *Front Psychiatry* 11:565919. <https://doi.org/10.3389/fpsy.2020.565919>
- Scoones I (2009) Livelihoods perspectives and rural development. *J Peasant Stud* 36(1):171–196. <https://doi.org/10.1080/03066150902820503>
- Selden TM, Berdahl TA (2020) COVID-19 and racial/ethnic disparities in health risk, employment, and household composition: Study examines potential explanations for racial-ethnic disparities in COVID-19 hospitalizations and mortality. *Health Aff* 39(9):1624–1632. <https://doi.org/10.1377/hlthaff.2020.00897>
- Sereenonchai S, Arunrat N (2021) Understanding food security behaviors during the COVID-19 pandemic in Thailand: A review. *Agronomy* 11(3):497. <https://doi.org/10.3390/agronomy11030497>
- Shang Y, Li H, Zhang R (2021) Effects of pandemic outbreak on economies: evidence from business history context. *Public Health Front* 9:632043. <https://doi.org/10.3389/fpubh.2021.632043>
- Sifat RI, Ahmed F, Miah MRA, Khisa M (2022) Effects of COVID-19 on livelihood, health, and psychology of hijra population: Insights from Dhaka, Bangladesh. *J Homosex*:17. <https://doi.org/10.1080/00918369.2022.2048162>
- Sigala M (2020) Tourism and COVID-19: Impacts and implications for advancing and resetting industry and research. *J Bus Res* 117:312–321. <https://doi.org/10.1016/j.jbusres.2020.06.015>
- Singh RK, Bhardwaj R, Sureja AK, Kumar A, Singh A, Hazarika B, Hussain S, Singh A, Legu Y, Rallen O (2022) Livelihood resilience in the face of multiple stressors: biocultural resource-based adaptive strategies among the vulnerable communities. *Sustain Sci*:1-19. <https://doi.org/10.1007/s11625-021-01057-z>
- Singh B, Shirsath PB, Jat ML et al. (2020) Agricultural labor, COVID-19, and potential implications for food security and air quality in the breadbasket of India. *Agric Syst* 185:102954. <https://doi.org/10.1016/j.agsy.2020.102954>
- Singu S, Acharya A, Challagundla K, Byraredy SN (2020) Impact of social determinants of health on the emerging COVID-19 pandemic in the United States. *Front Public Health* 8:406. <https://doi.org/10.3389/fpubh.2020.00406>
- Smood B, Spratt JR, Mehaffey JH, Luc JG, Vinck EE, Lehtinen ML, Wallen TJ, Jenkinson CG, Kim W, Kesieme EB (2021) COVID-19 and cardiothoracic surgery: Effects on training and workforce utilization in a global pandemic. *J Cardiothorac Surg* 36(9):3296–3305. <https://doi.org/10.1111/jocs.15773>
- Stockwell S, Trott M, Tully M, Shin J, Barnett Y, Butler L, McDermott D, Schuch F, Smith L (2021) Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: A systematic review. *BMJ Open Sport Exerc Med* 7(1):e000960. <https://doi.org/10.3390/jerph18105251>
- Su RX, Obrenovic B, Du JG, Godinic D, Khudaykulov A (2022) COVID-19 pandemic implications for corporate sustainability and society: A literature review. *Int J Environ Res Public Health* 19(3):23. <https://doi.org/10.3390/jerph19031592>
- Swinnen J, Vos R (2021) COVID-19 and impacts on global food systems and household welfare: Introduction to a special issue. *Agric Econ* 52(3):365–374. <https://doi.org/10.1111/agec.12623>
- Swinnen J, McDermott J (2020) COVID-19 and global food security. *EuroChoices* 19(3):26–33. <https://doi.org/10.1111/1746-692X.12288>
- Tunstall B (2022). *Being vulnerable or ill at home in the pandemic*. Policy Press, pp. 101-135
- Turner-Musa J, Ajayi O, Kemp L (2020). “Examining social determinants of health, stigma, and COVID-19 disparities”, in: *Healthcare: MDPI*, 168
- Usher K, Durkin J, Bhullar N (2020) The COVID-19 pandemic and mental health impacts. *Int J Ment Health Nurs* 29(3):315. <https://doi.org/10.1111/inm.12726>
- Vakili S, Savardashtaki A, Jamalnia S, Tabrizi R, Nematollahi MH, Jafarinaia M, Akbari H (2020) Laboratory findings of COVID-19 infection are conflicting



- in different age groups and pregnant women: A literature review. *Arch Med Res* 51(7):603–607. <https://doi.org/10.1016/j.arcmed.2020.06.007>
- Van Eck N, Waltman L (2010) Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 84(2):523–538. <https://doi.org/10.1007/s11192-009-0146-3>
- Van Eck NJ, Waltman L (2017) Citation-based clustering of publications using CitNetExplorer and VOSviewer. *Scientometrics* 111:1053–1070. <https://doi.org/10.1007/s11192-017-2300-7>
- Van Wyngaard A (2022) A pandemic of inequality: reflections on AIDS and COVID-19 in the southern African context. *AJAR-Afr J Aids Res* 21(2):152–161. <https://doi.org/10.2989/16085906.2022.2078730>
- Verma S, Gustafsson A (2020) Investigating the emerging COVID-19 research trends in the field of business and management: A bibliometric analysis approach. *J Bus Res* 118:253–261. <https://doi.org/10.1016/j.jbusres.2020.06.057>
- Viana-Lora A, Nel-lo-Andreu MG (2022) Bibliometric analysis of trends in COVID-19 and tourism. *Humanit Soc Sci Commun* 9(1). <https://doi.org/10.1057/s41599-022-01194-5>
- Workie E, Mackolil J, Nyika J, Ramadas S (2020) Deciphering the impact of COVID-19 pandemic on food security, agriculture, and livelihoods: A review of the evidence from developing countries. *Curr Opin Environ Sustain* 2:100014. <https://doi.org/10.1016/j.crsust.2020.100014>
- Xi J, Liu X, Wang J, Yao L, Zhou C (2023) A systematic review of COVID-19 geographical research: Machine learning and bibliometric approach. *Ann Am Assoc Geogr* 113(3):581–598. <https://doi.org/10.1080/24694452.2022.2130143>
- You S, Wang H, Zhang M, Song H, Xu X, Lai Y (2020) Assessment of monthly economic losses in Wuhan under the lockdown against COVID-19. *Humanit Soc Sci Commun* 7:52. <https://doi.org/10.1057/s41599-020-00545-4>
- Zheng M (2023) Fighting stigma and discrimination against COVID-19 in China. *Clin Microbiol Infect* 29(2):135–137. <https://doi.org/10.1016/j.cmi.2022.10.032>
- Zeng A, Shen Z, Zhou J, Wu J, Fan Y, Wang Y, Stanley HE (2017) The science of science: From the perspective of complex systems. *Phys Rep* 714:1–73. <https://doi.org/10.1016/j.physrep.2017.10.001>
- Zhu J, Yang Y, Liu Y, Cui X, Li T, Jia Y, Ning Y, Du J, Wang Y (2023) Progress and water stress of sustainable development in Chinese northern drylands. *J Clean Prod* 399:136611. <https://doi.org/10.1016/j.jclepro.2023.136611>

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## Author contributions

Credit authorship contribution statement Conceptualization, TL, ZX, YW; Data collection, TL, HL, LC; Funding acquisition, XC, TL, YW; Methodology, TL, RKS, ZX, XS, XC; Resources, ZX, YW; Software, TL; Supervision, ZX and XC; Visualization, LC, TL, Writing—original draft, TL, LC, ZX; Writing—review and editing, TL, RKS, LC, HL, XC, XS, ZX. Language editing, ZX, RKS, LC, HL; Academic editing, RKS, XC, YW. All authors have read and agreed to the published version of the manuscript.

## Competing interests

The authors declare no competing interests.

## Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

## Informed consent

This article does not contain any studies with human participants performed by any of the authors.

## Additional information

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