Authors: Andreea NITA[1*], Stacey FINERAN[2], Athanasios GAVRILIDIS[1], Ramiro BERARDO[2]

Affiliations:

[1] Centre for Environmental Research and Impact Studies, University of Bucharest

[2] School of Environment and Natural Resources, College of Food, Agricultural and Environmental Sciences, The Ohio State University

Corresponding author*Andreea.nita@cc.unibuc.ro

Title: HIDDEN LINKS BETWEEN COVID19 GLOBAL PANDEMIC AND THE ENVIRONMENTAL IMPACTS

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Abstract:

At global level, people's lives have changed with the emergence of the Covid19 pandemic, leading to a change in the way people carry out their usual day-to-day activities. Very quickly, we have transitioned an astonishing number of activities from physical spaces to virtual ones. This has impacted many aspects of the society, including our efforts to achieve sustainability, or how we practice mandatory assessments such as: Environmental Impact Assessment (EIA). Other changes are less visible, such as diminishing public participation in decision making procedures critical to the success of EIA. Using keyword network analysis, our paper investigates the ways in which the Covid19 global pandemic has impacted sustainability as discussed in the scientific literature since the pandemic began. For our analysis, we have extracted over 146 scientific articles from Scopus database that have in their abstract, title or keywords the following: TITLE-ABS-KEY (environmental AND impact*) AND TITLE-ABS-KEY (covid*) OR TITLE-ABS-KEY (coronavirus*) OR TITLE-ABS-KEY (sars-cov*)) AND (LIMIT-TO (PUBYEAR , 2020)) AND (LIMIT-TO (SUBJAREA , "ENVI")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")"). As data investigation methodology, we investigate the journals and countries that are key players or initiators of this research topic. We further apply metrics for the keywords network resulted, like co-occurrence and density network. Our results show that most analyzed scientific articles envisage the favorable effect on the impact of air quality and water pollution during this pandemic period due to the decrease of traffic and low industry activities, especially in urban areas, but also means of transmission and impact on health. Of particular note is Covid-19's negative impact on the conduct of public meetings at which public participation of stakeholders is essential to inform decision making and to better achieve sustainability. Finally, the paper discusses the impact of the Coronavirus pandemic related to the impact

assessment procedures or importance of the health risk assessment, while also understanding the current role of stakeholders in the approval of EIA projects.

Introduction / Context

The modern human society projects complex impacts over environmental components through a wide variety of activities, which cumulated cause global environmental unbalances (Andonova and Mitchell 2010). Mitigating the effects of these impacts have become an important challenge, procedures concerning impact assessments being endorsed through legislation by worldwide governments (Glasson and Therivel 2013). Environmental Impact Assessment (EIA) procedure aims to anticipate the potential environmental burdens or impacts spawned by various local or transboundary projects. Though EIA's efficiency has been debated over the last couple of decades (Snell and Cowell 2006, Jay et al. 2007, Morgan 2012), there is no doubt that this tool helped prevent the occurrence of unfiltered impacts throughout the planet (Wathern 2013).

The emergence of EIA procedures since the late 1960's has encouraged worldwide businesses and governments to shift their traditional ways of action into more environmental friendly approaches, boosting scientists from all fields to focus on the development of less invasive technologies, with less impact over the environment (Weston 2004). The ongoing improvements towards EIA procedures, trying to tackle newly emerged environmental challenges led to the implementation of sustainability assessment systems (Devuyst 2000, Bond and Morrison-Saunders 2011), designed for evaluating the sustainability impacts of buildings and infrastructures. Morgan (2012) highlights that at international level, the institutionalization of EIA progressed over the years, gaining political recognition of problems associated with climate change, loss of biodiversity, threats to freshwater sources and water quality, damage to marine areas and other environmental issues is becoming more compelling.

Despite the large amounts of benefits that the EIA procedure brought to the table, scholars have also focused on its effectiveness, highlighting its weaknesses (Cashmore et al. 2010) on different topics such as the questionable quality of EIA reports for example (Nita et al. 2015, Leung et al. 2016). Furthermore, Pölönen et al. (2011) emphasized that, in the case of the Finish EIA system, the key constrain is the inadequacy of the action-forcing mechanisms at the decision-making phase whilst Pope et al. (2013) claim that the plethora of specialist branches is generating a confusing picture and lack of clarity regarding how the pieces of the impact assessment jigsaw puzzle fit together. Cannaos and Onni (2019) indicated that an aspect which limits the effectiveness of EIA in Sardinia (Italy) is linked with the continuous normative evolution. However, the authors state that the normative continuously evolves as some aspects of EIA are ineffective.

As scholars all over the world have focused on catching EIA's technical and implementation, the outbreak of the SARS-COV2 pandemic displayed a multitude of vulnerabilities the procedure has when facing dramatic societal changes. The outbreak of the pandemic stretched the adaptation abilities of many sectors (George et al. 2020), especially those relying on physical interaction among various actors. Thus, the EIA procedural frameworks all over the world had to adapt to the new context. Thus, overnight, researchers and practitioners were obliged by the global circumstances to find a solution for the EIA procedure to be at least as effective as it has been so far without several vital features that were essential for the procedure, but implied physical interaction. Therefore, public participation within the EIA procedure, a fundamental pillar of the framework (Cuppen et al. 2012), though sometimes considered ineffective, time consuming or flaw prone (Glucker et al. 2013, Hasan et al. 2018), has been forced to be transferred online or halted. The new circumstances in which the EIA procedures had and still have to be applied are delicate as, despite living in a digitalized world for the past decade, the access towards digital means of communication is not as developed as we would have imagined (Hargittai et al. 2018). Thus, several groups of individuals are facing segregation in relation to participatory decision making within the EIA procedures, endorsing the concerns about digital inequalities (Morris and Morris 2013, Robinson et al. 2015, Van Deursen et al. 2017).

Besides public participation, several other steps within the EIA procedures involving human physical interaction had to adapt, thus since 2020 EIA procedure all over the world had to experience new approaches, some of which proved to be efficient while others failed to provide the desired outcomes. Within this paper, we aimed in reviewing the scientific literature published since the outbreak of the SARS-COV2 pandemic in relation with EIA procedure and direct environmental impacts in order to extract the challenges that have emerged due to this situation. It is important to extract and cluster these challenges for a better understanding of how the EIA procedure should change for becoming more resilient in times of global crisis.

Concepts and Methodology

In recent studies, network theory started to be a key instrument in identifying innovative ways to optimize environmental governance and management (Berardo et al. 2016, Bodin 2017, Manolache et al. 2020), to improve conservation practices (Bodin et al. 2019, Rozylowicz et al. 2019), to discover universal resilience patterns in complex networks (Gao et al. 2016), or better understand human wildlife interactions (Pătru-Stupariu et al. 2020).

Furthermore, network analysis proved to be extremely beneficial in analyzes elaborated in scientific research, whether we are talking about scientific production, the dynamics and impact of journals, the identification of the most important authors, the collaboration established between them and their

affiliations, but also from the perspective of word analysis. key of the articles that can lead to following the evolution of trends in the literature (Badiu et al. 2019, Modak et al. 2019, Taddeo et al. 2019).

For the bibliometric analysis envisaged, we extracted from SCOPUS database the articles published from 2020 to present the published papers that have in their Title, Abstract and Keywords, concepts such as: "environmental impact assessment" or "environmental impact statement" and "covid*"or "coronavirus" or "sar-cov*". The search code was the following: (TITLE-ABS-KEY (environmental AND impact*) AND TITLE-ABS-KEY (covid*) OR TITLE-ABS-KEY (coronavirus*) OR TITLE-ABS-KEY (sars-cov*)) AND (LIMIT-TO (PUBYEAR , 2020)) AND (LIMIT-TO (SUBJAREA , "ENVI")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")). After extracting the articles from the subject area: Environmental Science, Social Sciences, we obtained a database of 146 document results (See Supplementary Table 1). We have chosen Scopus database as it is easier to manipulate and includes data and metrics related with articles published in highly visible scientific journals (Burnham 2006).

After cleaning the data, we first observed the international journals promoting these new approaches that should be considered in the future. Furthermore, we investigated the scientific production focused on the link between COVID and EIA, investigating also the collaboration established between states for these issues. We considered this relevant to find out the countries or regional research centers (as called *brokers* in network analysis (Bellotti 2009, Everett and Valente 2016), which have begun to draw attention to the inevitable and already visible effects / impacts of the pandemic on the environmental factors, as well on the environmental procedures.

The next stage in our analysis was extracting the most relevant themes discussed in the literature after the COVID 19 pandemic began. For this, we standardized the keywords to consolidate and increase the consistency (Lozano et al. 2019) and used keyword co-occurrence analysis (Van Eck and Waltman 2010, Radhakrishnan et al. 2017), in order to illustrate the network of potential hidden links between the effects of COVID-19 pandemics and the direct environmental impacts. Furthermore, we investigated the keywords density to identify the hot spots and density clusters in the network, meaning the most discussed research topics (Van Eck and Waltman 2010) and from here, the direct effects on the environment and on the environmental procedures that are in the center of attention in this investigated period.

Hence, the basis of our analysis is the one mode network of collaboration between authors and one mode network of keywords. Analyzing this data will help to illustrate the level of involvement and interest in this field by calculating metrics to identify the intensities or strengths considering the VOS mapping technique, which uses the association strength normalization (van Eck and Waltman 2014), where the position of the

nodes in the collaboration network and especially in the keyword network analysis, puts strongly related nodes close together (Van Eck and Waltman 2010, van Eck and Waltman 2014).

For sure the articles database focus on the will grow over time, but in this paper, we want to capture the immediate environmental effects of the COVID-19 pandemic, discussed in the scientific research.

The analyses and visualizations were performed using the following programs: R, Vosviewer and Bibliometrix (Van Eck and Waltman 2010, Aria and Cuccurullo 2017).

Results

Preliminary statistics revealed that Science of the Total Environment Journal published the highest number of relevant papers for our study. From the total of 114 analyzed papers published in 39 journals, almost 27% were published in the Science of the Total Environment, followed by International Journal of Environmental research and public health (13%), Sustainability (11%) and Environmental Research (6%) (Figure 1).

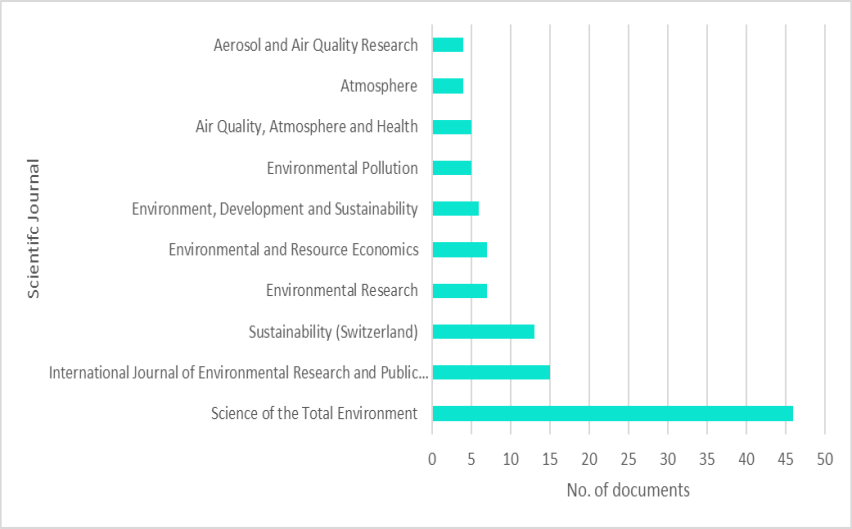

Figure 1 - Most relevant 10 sources in which the analyzed articles were published

The origin of the corresponding authors lays in India, China and USA for most of the cases (Figure 2). Furthermore, in the analyzed context, the most productive countries so far are: USA (58), CHINA (56), INDIA (32), ITALY (23), AUSTRALIA (22), BRAZIL (15), SPAIN (14), CANADA (12), MALAYSIA (10), UK (10), JAPAN (8) (Figure 2). In terms of most collaborative countries in this field, we mention the connections established between AUSTRALIA - USA, followed by CANADA - UNITED

KINGDOM, and USA with CHINA, with CANADA, with ITALY and with UNITED KINGDOM (see Figure 3).

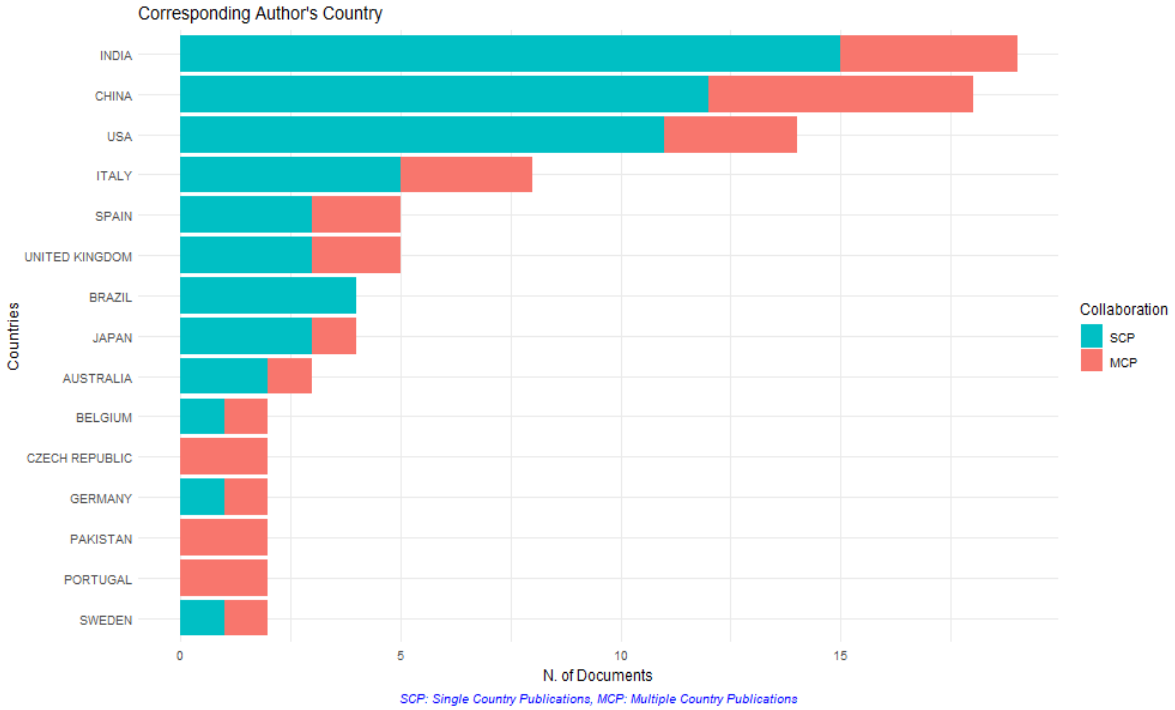

Figure 2 – TOP 15 Corresponding author's country

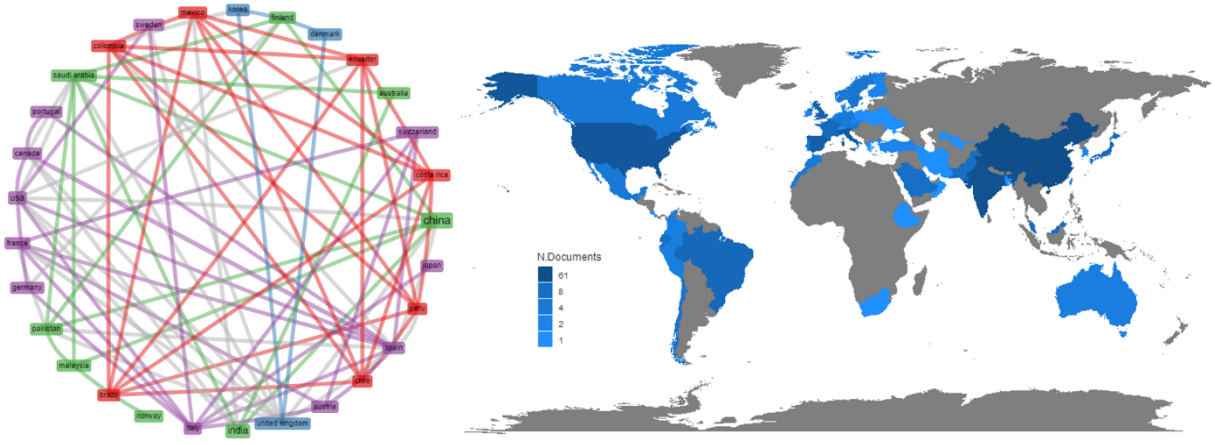

Figure 3 – Country Scientific Production & Collaboration Network

The keyword network co-occurrence emphasizes the key issues addressed by the analyzed publications. Most of the keywords are related with medical terms, but from the environmental perspective, the analyzed studies focused on topics such as: air pollution, environmental impact assessments, air quality, environmental monitoring, and so on. There were different research approaches since the outbreak, such as: the impact of the pandemic on air quality due to the halted industrial activities, the impact on household waste flows, diversion and reuse, the impact on the protected areas as a space for disease adaptation, the wastewater state of knowledge and research need or lack of proper public participation in planning. Figure 4 illustrates the clustered keywords co-occurrence visualizations from the beginning of the pandemic. The keywords are grouped into the following 8 clusters:

- Cluster 1 – adverse event, agriculture, climate change, circular economy, decision making, environmental consequences, environmental impact, environmental sustainability, environmental management, epidemic, food chain, food quality, food supply, GIS, government, migration, pollution control, vulnerability, waste management, urban resilience, resource management, planning, politics, life cycle analysis / life cycle assessment, etc.
- Cluster 2 – aerosol composition, assessment method, carbon emission, carbon footprint, coal industry, coal mining, disasters, economic conditions, economic growths, economic recovery, energy consumption, energy efficiency, environmental disasters, environmental economics, impact assessments, mitigation measures, preventive measures, remote sensing, scientific community, etc.
- Cluster 3 – wastewater, water conservation, water quality, water supply, spatial analysis, wastewater treatment, wastewater management, prevention and control, stakeholders, river pollution, ecotoxicity, disinfectants, human resource management, incineration, public risks, etc.
- Cluster 4 – wildlife management, virus detection, viral contamination, viral contamination, conservation of natural resources, spread, nature-society relations, environment contamination, environmental risk, environmental education, practice guideline, risk assessment, occupational hazard, infection risk, tourism, etc.
- Cluster 5 – risks factors, sedentary lifestyle, socioeconomic factors, medical geography, public health, health impact, health impact assessment, disease association, follow up, health care planning, health promotion, etc.
- Cluster 6 – population exposure, human activity, spatio-temporal analysis, traffic, urban area, industrial area, industrial emissions, exhaust gas, particle matter, air quality, air pollutants, control strategies, emission inventory, pollution policy, policy making, etc.
- Cluster 7 – climate, climate effect, forecasting method, lockdown, mobility, population density, mortality, risk reduction, wind speed, social distancing, mathematical models, air temperature, prediction, temperature effect, wind speed, etc.

- Cluster 8 – capital, cities, ecosystem, environmental planning, pollution, pollution monitoring, geographic distribution, global health, human to human transmission, residential research, population research, etc.

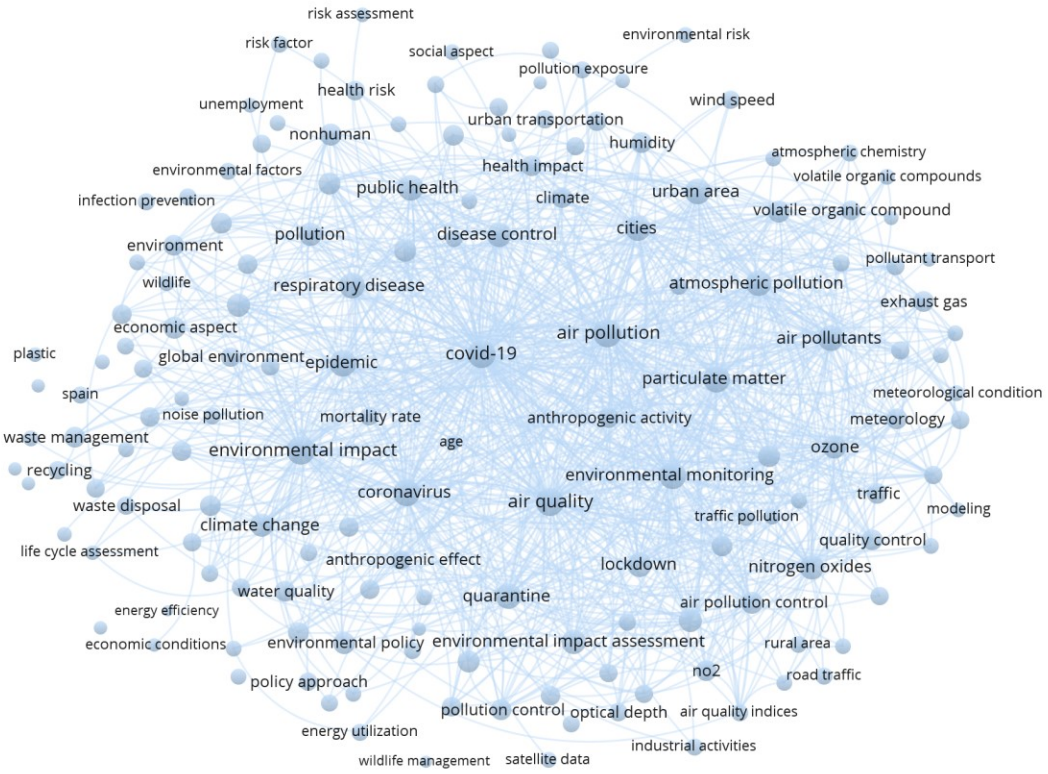

Figure 4 – Keywords co-occurrence grouped by clusters (scale given by total link strength)

Figure 5 illustrates the hotspots cluster density analysis, respectively the key issues or points to be improved when discussing the effects generated by COVID 19 related to environmental aspects. Considering the occurrence of keywords, in the top of the analysed articles, there are words related to the medical names of the virus, the disease, such as: pandemic, covid-19, coronavirus, disease, virus, and so on, sars-cov-2, respiratory disease, severe acute respiratory syndrome, quarantine etc., followed by specific environmental terms, such as: human, air pollution, environmental impact assessment, environmental impacts. public health, air quality, environmental monitoring, health risk, urban area, china, health impact assessment. As figure 4 shows, there are different hot research topics, like: the impact of the pandemic on air quality due to the stopped industrial activities, the impact on household waste flows, diversion and reuse, the impact on the protected areas as a space for disease adaptation, the wastewater state of knowledge and research

need, lack of proper public participation in planning, impact assessments and the role of health risk assessment, life cycle assessment. Besides the direct environmental impacts, in the analyzed articles special emphasis is placed also on the socio-economic impacts of the pandemic.

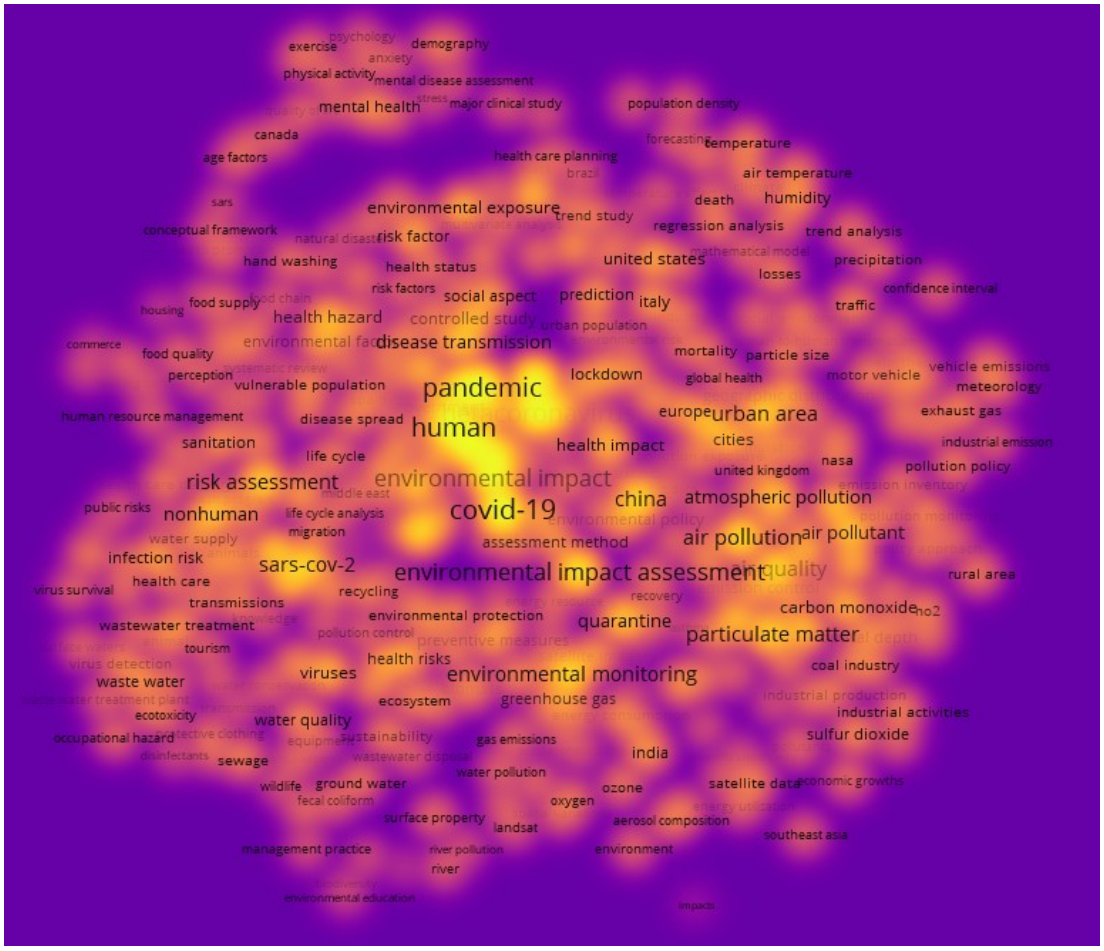

Figure 5 - Hot spots and density clusters in the network by density considering a kernel width of 0.50

Research Findings and Discussion

Our results have highlighted how research communities from the most affected countries by the SARS-COV2 pandemics (Salgotra et al. 2020) have been the most active in terms of publishing issues in relation with EIA procedure and environmental topics in many top scientific journals in this field (Figures 1-2). At the same time most of these countries are in top ten when it comes to scientific production according to SCImago (2020) rankings. Thus, the amount of scientific concerns coming from the countries revealed by our findings is natural. In terms of collaboration on the analyzed topic, the results showed the US being pivotal, as it is the country with the biggest scientific production and it also has been highly affected by the outbreak. Besides that, the pandemic occurred during one of the most mediatized US presidency election

in history, as well as during election times in other countries (Landman and Splendore 2020). This timing may have influenced the way the pandemic was dealt within those countries by central authorities, triggering scholars to publish at higher pace and fueling their research with topics and case studies. Collaboration in this scientific field of impact assessment is still a priority in order to promote best practices and determine the future of EIA (Nita 2019). An interesting fact is that without adding a title under the map (Figure 3), it could easily been confused with the worldwide number of covid cases at the peak of the outbreak, but at the same time, the highlighted countries are world leaders when it comes to scientific production, regardless. In terms of collaboration on the analyzed topic, the results showed the US being pivotal, as it is the country with the biggest scientific production on this theme, and it also has been highly affected by the outbreak. Besides that, the pandemic occurred during one of the most mediatized US presidency election in history, as well as during election times in other countries. This timing may have influenced the way the pandemic was dealt within those countries by central authorities, triggering scholars to publish at higher pace and fueling their research with topics and case studies.

The keyword network analysis, along with the density cluster analysis (Figures 3 and 4) revealed that one of the hottest research topics among the analyzed publications was related with air quality during the outbreak and lockdowns. This topic was mostly related with the halt of major industries for a while during 2020. Recent studies highlighted how the restrictions have had a positive impact over air quality, especially in major urbanized areas (Nakada and Urban 2020, Shakoor et al. 2020). Thus, the pandemic context may be considered the perfect opportunity to redesign and rethink how major industries must mitigate their air pollution impact. This experience could encourage government to rethink the existing legal pollutants concentration thresholds. Therefore, if air quality during the pandemic would be considered as a standard by governments around the world, then we might look at harsher EIA implementation and requirements asked for industrial projects.

Another hot topic reveled by our analysis, which may be relevant for the future paradigms of the EIA procedure is related with the impact on household waste flows. Researchers have indicated that when the flow of goods is restricted the public's concerns on reusing and recycling increases, the results of this behavior meaning less overall waste (Ikiz et al. 2021). However, while the air quality issue has the potential to set a new bar within EIA implementation as constraining project developers to use newer, non-polluting technologies will boost other emerging industries, the waste reduction is more delicate, and requires more legal input rather than change in consumption patterns. The outbreak exposed the flaws and inefficiency of the consumerist society (Maboloc 2020, Bhat et al. 2021a), but at the same time the global economy relies on this type of society and a sudden shift may determine a global recession with critical social impacts. This

issue brings into the spotlight the discussion about merging the environmental and social impact assessments (Barrow 1997, Iron and Mining 2013).

Lack of proper public participation in planning was yet another being another consequence of the Covid pandemic, the institution and stakeholders being for the first time in front of such a situation regarding the stage of EIA public consultation. While the pandemic is still far from being over, and the post pandemic years will be marked by a high reluctancy towards public gatherings due to public health safety, public participation in the decision-making process will be at risk, along with a number of conflicts that may arise (Gavrilidis et al. 2020). Thus, EIA processes taking place during and after the pandemic must consider proper solutions to innovate and improve the stage of public participation issues along the process. Best practices from different countries ensuring public participation within the process, without any form of segregation should be introduced as standard approaches for the future, which will raise the quality of impact assessments (Bond et al. 2018). Otherwise, neglecting the public's input within the EIA procedures would lead to a lack of transparency, making the procedure only bureaucratic and only on paper, without having direct utility in order to minimize the impact of projects on the environment, which will have serious consequences if projects with significant negative impact are not stopped in time.

Conclusion and Future Work

The hot-spot and keyword co-occurrence analysis revealed that one of the hottest research topics among the analyzed publications was related with air quality during the outbreak and lockdowns. Recent studies highlighted how the restrictions have had a positive impact over air quality, especially in major urbanized areas. Researchers have indicated that when the flow of goods is restricted, the public's concerns on reusing and recycling increases, the results of this behavior meaning less overall waste. However, the air quality issue has the potential to set a new bar within EIA procedures by constraining project developers to use newer, non-polluting technologies, the waste reduction issue is more delicate, and requires more legal input rather than changes of the consumption patterns. The outbreak exposed the flaws and inefficiency of the consumerist society but at the same time the global economy relies on this type of society and a sudden shift may determine a global recession with critical social impacts (George et al. 2020, Bhat et al. 2021b). This issue brings into the spotlight the discussion about merging the environmental and social impact assessments. While the pandemic is still far from being over, and the post pandemic years will be marked by a high reluctancy towards public gatherings due to health safety issues, public participation in the decision-making process will be at risk.

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