

A Bibliometric Study and Knowledge Mapping on the Assessment of Environmental Issues in Bangladesh between 1975 and 2021

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Abstract

In Bangladesh, environmental degradation and the depletion of natural resources are caused by poverty, overpopulation, inadequate or limited access to education, and ineffective communication about the causes and effects of environmental issues. These issues are caused by several different factors, including climate change, diverse pollution, land-use change, and ecological destruction. Intense economic activity and fast urbanization in Bangladesh are creating new environmental problems. The study explores bibliometric analysis and knowledge mapping on the top authors, countries, and organizations that contributed to the environmental challenges research in Bangladesh between 1975 to 2021 in the Scopus database. It also aimed at examining the top keywords to find the most and least valued areas/topics of this field. This study used the bibliometric analysis for 415 documents related to environmental challenges and Bangladesh retrieved from the Scopus database on August 25, 2021. Citations and the number of documents are the tools to find top contributors. This study considers the urge of much interdisciplinary and diverse research on the connectivity between government policies, industrial waste, plastic pollution, environmental sustainability, and combating ecological challenges for all the affected parts of the countries. This study is the first attempt at a bibliographic analysis of Bangladesh's environmental challenges that provide an extensive overview of published documents and scopes for more research to combat the challenges.

Keywords: Bibliometric analysis; Environmental pollution; Ecological imbalance; Climate change; Sustainability

1. Introduction

Bangladesh is severely vulnerable to the environmental issue facing severe environmental challenges over the decades. The leading ecological challenges for Bangladesh are climate change, environmental degradation, and pollution. Bangladesh is facing the severe impacts of climate change and paying high costs every year for the consequences of that cause. The geophysical and demographic characteristics made Bangladesh more vulnerable to climate change issues (Hasnat et al., 2018). Due to climate change, cyclones, monsoon floods, flash floods, droughts, storm surges, thunderstorms, salinity intrusion, soil erosion, and landslides are widespread phenomena in Bangladesh (Rana and Ilina, 2021). As a result, the impacts of climate change are visible in affecting human lives and resources such as water, agriculture, forests, ecosystems, biodiversity, and the environment (Hasnat et al., 2018).

In addition, human migration and displacement have increased direly in Bangladesh owing to the consequences of climate change impacts (Rana and Ilina, 2021). This scenario has been found mainly in the coastal belt, landslides, and flood-affected areas in Bangladesh. Climatic imbalance is also a common phenomenon, including the north-eastern part of Bangladesh; hence, this area confronts scanty rainfall, delayed rainfall, and heavy rains that adversely impact the yield of principal crops, especially tea cultivation (Islam et al., 2021). However, it is also projected that rice

production in Bangladesh will be reduced by an average of 7.4% every year from 2005 to 2050 due to adverse climatic consequences (Mehedi et al., 2020). The adversity of climate change has become the prime cause of loss of livestock, destroyed shelter, reduced productivity, and increased cost of production and living; as a result, the extreme burden for poor and marginal people is being created in Bangladesh (Hossain et al., 2012).

The population of Bangladesh is more than 169 million, and it is one of the most densely populated countries in the world (Hasan et al., 2019). Along with the impacts of climate change, demographic characteristics, i.e., increased population with small areas, have pushed threats on Bangladesh's environment and ecosystem. The vast number of people means more interactions between human activities and the environment, resulting in environmental changes. The increased consumption of natural resources generates deforestation, desertification, pollution, energy resource depletion, river and marine resources (Hasnat et al., 2018), and ecosystem imbalance. The magnitude of the increased population refers to the environmental exploitations and improper uses of resources that have brought ecological degradation. A study by Hossain and Moniruzzaman (2021) documented a significant environmental change during the period 2010-2020 in Bangladesh, and the recent massive Rohingya refugee camp settlements drive deforestation and ecological degradation.

Bangladesh is constantly maintaining a seven-plus G.D.P. growth rate; even during the covid-19, it demonstrates a positive growth rate (Trading Economics, 2021), with the blessing of rapid industrialization and urbanization. This economic progress has increased energy consumption, consequently the enhanced level of greenhouse emissions and air pollution that magnifies the urban heat island effect, the threat to aquatic systems, and human health (Kafy et al., 2021). The water resources are being polluted by anthropogenic sources such as untreated industrial effluents, improper disposal of industrial and domestic waste, and agriculture runoffs. Previous studies in this regard documented that health risk attributed to water-borne diseases is increasing day by day, and 8.5% of total death in Bangladesh has occurred because of water, sanitation, and hygiene-related issues (Hasan et al., 2019).

A study conducted by Islam et al. (2018) on green supply chain practices in Bangladesh revealed that the leather industry in Bangladesh has enormous prospects in showing excel in earning foreign currencies. Still, government regulations stick the development of this sector on account of environmental pollution. Their study has raised questions on corporate environmental sustainability and suggested that corporations participate in the ISO 14001 environmental certification system and select suppliers who have adopted environment-friendly strategies and policies for sustainable operations. In addition, the plastic-driven product has severe impacts on environmental pollution. As the plastic is not disposable, it creates ecological hazards, the danger of marine life, soil fertility, and groundwater contamination, afterward low production in agriculture, and serious human health risks (Mourshed et al., 2017).

The impact of environmental degradation and pollution is enormous; therefore, sustainable resource mobilization and consumption are very urgent in Bangladesh. The World Bank (2018) reported that Bangladesh loses around \$6.5 billion in urban areas due to environmental degradation and diverse pollutions every year. Bangladesh's pollution scenery always appeals to governmental intervention to ensure citizens' accountability towards controlling environmental degradation and pollution. And management system of many industries in Bangladesh is not supportive of protecting the environment, biodiversity, and ecosystem (Mourshed et al., 2017). Recently, Bangladesh has brought remarkable regulatory, institutional, and policy reforms, but better enforcement are lacking in pressurizing individuals and organizations to integrate strategies and policies for sustainable consumption. Though the department of environment (DoE) Bangladesh imposes a penalty on the violations of the environment-friendly code of conduct, this is very minimal, which cannot enable industries to realize the adoption of effective measures to prevent pollution (Haque, 2017).

Many studies have been conducted on environmental challenges in Bangladesh, highlighting transboundary water resources management (Baten and Titumir, 2016), the implementation of the industry with safety and environmental protection (Moktadir et al., 2018), environmental variability, and temporary migration (Call et al., 2017), potentials of the blue economy for enhancing economic sustainability (Sarker et al., 2018), climate change migration and environmental sustainability (Chowdhury et al., 2021; Suhi et al., 2019). However, as far as knowledge goes, no study has attempted to explore environmental research in Bangladesh through bibliometric analysis. There is a growing gap of knowledge in this field, and the present study would fulfill this gap by outlining through the investigations conducted on environmental challenges researches in Bangladesh.

Environmental vulnerability and the obligations of achieving sustainable development goals (S.D.G.s) within 2030 of Bangladesh emphasize further rigorous research to reduce environmental degradation and pollution. Hence, this study would keep a significant value by providing a progressive view to future researchers and policy-makers regarding the literature of environmental challenges, the bundle of information about authors, and institutions. Moreover, this study would highlight the authors' contribution to the constructs with conceptualization, operationalization, and visualization of various aspects of environmental challenges research in Bangladesh. In addition, this study would also demonstrate the researchers' collaborations and relationships for building a research community to generate and share knowledge for better implications in society (Zainuddin and Lui, 2021; Issah and Rodrigues, 2021; Haque et al., 2019). Therefore, the present study objectives accentuate investigating intellectual progress, knowledge generation and share, the collaboration of authorship, and research trends on the environmental challenges research in Bangladesh through the bibliometric analysis using VOSviewer software.

The remainder of this research is designed as follows: The following section addresses the literature review, followed by a research method. The next section focuses on analysis, and the last area designates discussion and conclusion.

2. Literature Review

The environmental challenge is one of the most burning areas of research, which is evident by the dramatic escalation of research outputs in this field by the physical and social scientists (Ahmed et al., 2015). As an over-populated country, Bangladesh encounters diverse environmental challenges; consequently face climate change, natural disaster, biodiversity loss, ecosystem changes, river and marine environment imbalance, depletion of energy resources, water scarcity, soil erosion, and food security (Hasnat et al., 2018). Hence, researchers concentrate on various environmental challenges in Bangladesh, examine the source of problems, and suggest controlling environmental degradation and pollution. Air pollution is among one of the most leading environmental challenges in Bangladesh. Siddiqui et al. (2020) revealed that air pollution is caused by gaseous substances emitting from the household, road dust, textile, and dyeing businesses, tanneries, brick kilns, and chemical and cement factories that negatively impact human health like cardiovascular and respiratory diseases, and suppressed visual health.

In addition, household air pollution (H.A.P.) and ambient air pollution (A.A.P.) are the two types of air pollution that cause severe health hazards in Bangladesh. The poorest households in Bangladesh rely on traditional solid fuels, including biomass fuels (wood, agricultural residues, and animal dung), kerosene, and candles that intensify household air pollution that is correlated with children health in Bangladesh, substantial fuels is associated with respiratory illness among girls (Kurata et al., 2019). A similar line of study by Naz (2015) documented that H.A.P. is one of the leading causes of respiratory illness and deaths of young children under five years old in Bangladesh. Khan (2017) stated that solid fuel uses in the household increase the risk of mortality of neonatal, infant, pregnancy complexity, and acute respiratory infection (A.R.I.). The use of clean fuels and structural development of household design like stove ventilation might be the way to decline adverse health effects from household air pollution.

On the other hand, Begum (2018) indicated that heavy-duty vehicles especially diesel fuel-run vehicles, road and soil dust, fuel from brick kilns industry and other manufacturing industries, unplanned construction of highways, flyover and building, and monsoon dust are the major causes for the ambient air pollution. Due to ambient or outdoor air pollution, people of Dhaka city face serious health problems like cardiovascular disease, asthma, chronic obstructive pulmonary disease, stroke, severe lower respiratory infections in children, and lung cancer (Rahman et al., 2019). In contrast, Sultana et al. (2020) conducted a study on noise pollution. They revealed that a higher noise level than the recommended threshold of acceptable noise level for the rise of heavy and medium vehicles, hydraulic horns, construction work, and microphones, which is detrimental

to human health like hearing loss, speech interference, sleep disturbance, reduction in productivity, and health disorders.

Citizens of Bangladesh also suffer from different water-borne diseases due to water pollution. A study by Hasan et al. (2019) mentioned that water in both surface and ground sources is contaminated with various contaminants like toxic trace metals, coliforms, and other organic and inorganic pollutants. Overpopulation growth, urbanization, industrial effluents, disposal of domestic waste, chemicals from agricultural land, power generation, and bacteriological contributor are the major contributor to surface water pollution, while arsenic is the main contributor to groundwater pollution. Arsenic originates in subsurface water and penetrates the food chain through flora and fauna, responsible for lung and skin cancers and detrimental to unborn children's metabolic system (Huq et al., 2020).

Faroque and South (2021) identified water pollution problems and documented that Bangladesh faces a scarcity of clean water despite having an abundance of water sources due to inefficient water management and poor law enforcement. Whereas Arifuzzaman (2019) stated that Bangladesh Water Act, 2013 provides a comprehensive legal framework for sustainable water resources, management, and water safety, compliance and enforcement or implementation of the environmental legal framework for water pollution is not satisfactory. In addition, Bangladesh also faces marine and coastal pollution challenges due to the wastage of textile and dyeing ship breaking yards, sewage, marine litter, and solid waste, oil spillage, unplanned tourism and marine transportation, and heavy metal (Alam and Xiangmin, 2018) while metal contamination is the main reason for soil pollution in Bangladesh. In the vicinity of brick kiln, hazardous elements originate through different industrial activities like fuel and coal combustion, wood burning, tires, and furnace oil that create soil toxicity and a potential risk to the environment (Proshad et al., 2017).

A study by Hossain et al. (2020) examined the toxic effects of plastic on Bangladesh's human health and the environment and found that it creates different physical problems for humans like irritation of the eye, vision failure, respiratory failure problems, breathing difficulties, liver dysfunctions, skin diseases, cancer, lungs problems, and birth effect. Besides, it pollutes soil, water, and air, creating an imbalance in the environment due to its non-biodegradability. Whereas Hasan et al. (2021) investigated a new type of micro plastics pollution, emerges from facemask disposal. The use of a facemask is widespread to protect the COVID-19 viral transmission, but its imprudent discharge creates environmental pollution and threats to the aquatic ecosystem in the country.

Along with environmental degradation and pollution, a natural disaster is a common phenomenon in Bangladesh due to its flat topography and low land above sea level; moreover, climate change is one of the significant environmental stresses and catalysts of natural disasters, causes calamities to citizen's life and livelihood. Floods, cyclones, storms, excessive rainfall, drought, salinity intrusion, desertification, heat stress, landslide, and other weather extremes threaten are very common in Bangladesh that keeps significant negative impacts on human lives and the

economy. Environmental challenges are among the significant barriers to achieving sustainable development goals in Bangladesh. The Bangladesh government has already taken multi-dimensional initiatives to face challenges to achieve environmental sustainability (Zafar et al. 2019).

3. Research Method

The Scopus database has several options ranging from open access, gold open, hybrid gold bronze and green (Table 1). Gold open documents are those that are published in publications that solely provide open access content. Hybrid Gold Journals that produce hybrid gold documents provide writers the option of publishing open access. Bronze options are the version of record that has been published or a manuscript that has been accepted for publication. The publisher has decided whether to give free access for a limited time or the long term. Green options are the versions that have been published, or manuscripts that have been accepted for publication are accessible in the repository (Pourret et al., 2020).

Table 1: Types of access for environmental challenges research in Bangladesh.

| S.L. | Types of Access | Number |
|------|-----------------|--------|
| 1 | All open access | 135 |
| 2 | Gold | 59 |
| 3 | Hybrid Gold | 20 |
| 4 | Bronze | 28 |
| 5 | Green | 80 |

In this bibliometric study, 415 documents related to environmental challenges and Bangladesh were retrieved from the Scopus database through Title-Abs-key (environmental AND challenges AND Bangladesh). The search was initiated on August 25, 2021. For exploring the documents, title, abstract and keyword, were considered. All publications were taken into account irrespective of articles, reviews, conference papers, book chapters, and notes (Table 2). Source type was Journal, book, conference proceeding, book series, and trade journal (Table 3).

Table 02: Types of documents

| SL. | Type | Number | Percentage |
|-----|---------|--------|------------|
| 1 | Article | 278 | 66.99% |
| 2 | Review | 41 | 9.88% |

| | | | |
|-------|-------------------|-----|-------|
| 3 | Conference Paper | 35 | 8.43% |
| 4 | Book Chapter | 33 | 7.95% |
| 5 | Book | 18 | 4.34% |
| 6 | Editorial | 4 | 0.96% |
| 7 | Erratum | 2 | 0.48% |
| 8 | Note | 2 | 0.48% |
| 9 | Conference Review | 1 | 0.24% |
| 10 | Short Survey | 1 | 0.24% |
| Total | | 415 | 100% |

Table 03: Type of Source

| SL. | Type | Number | Percentage |
|-------|-----------------------|--------|------------|
| 1 | Journal | 323 | 77.83% |
| 2 | Book | 49 | 11.81% |
| 3 | Conference Proceeding | 33 | 7.95% |
| 4 | Book Series | 8 | 1.93% |
| 5 | Trade Journal | 2 | 0.48% |
| Total | | 415 | 100% |

A comparison was made among South Asian countries and found that India is in the top rank with 2,235 documents for environmental challenges research while Bangladesh is in the 2nd rank with 415 papers, followed by Pakistan (370), Nepal (204), Sri Lanka (134), Afghanistan (95), Bhutan (47) and Maldives (31) (Table 4).

Table 04: Document published in South Asian countries on environmental challenges in Scopus.

| Rank | Countries | Document |
|------|------------|----------|
| 1 | India | 2,235 |
| 2 | Bangladesh | 415 |

| | | |
|---|-------------|-----|
| 3 | Pakistan | 370 |
| 4 | Nepal | 204 |
| 5 | Sri Lanka | 134 |
| 6 | Afghanistan | 95 |
| 7 | Bhutan | 47 |

Collecting 415 documents related to environmental challenges and Bangladesh was investigated through the bibliometric analysis, including document type, top-cited documents, document distribution worldwide, the most productive countries, institutions, and journals. A .csv format file was extracted from the Scopus database, which contained 415 documents. After filtering, the researchers further found a workable file to study. VOSviewer and Microsoft Excel were used to calculate the retrieved documents to present and visualize the results (Haque & Zhang, 2021; Hajduk, 2017). VOSviewer is more popular and widely used software for conducting bibliometric analysis. It helps to create maps based on network data, as well as simulates and explores them. VOSviewer may create networks of scientific articles, journals, academics, research organizations, countries, keywords, and concepts. Co-authorship, co-occurrence, citation, bibliographic coupling, and co-citation connections can all be used to bind items in these networks (Pan et al., 2018).

In addition, this software can use Web of Science, Scopus, PubMed, R.I.S., and Crossref JSON files. Network visualization, overlay visualization, and density visualization are all examples of visualization techniques. The zooming and scrolling interface enables a map to be viewed in great detail (Van Eck & Waltman, 2013). The study exported all data into Microsoft Excel after finishing data extraction for statistical analysis and rating various bibliometric indicators, such as top authors, cited papers, top countries, organizations, and journals. To visualize the relationship between names, keywords, countries, and so on, the study used the VOSviewer software.

4. Results

Top authors in terms of document publication

The bibliometric analysis identifies the top five authors in terms of document publication (figure 1). The results discovered that Ahmed N. has ten articles with 303 citations and thus ranks first, while Ahmed S. has six publications with 12 citations and thus ranks second. Allan A., with four documents and 103 citations; Huq S., with four papers and 115 citations; and Nicholls R.J., with four documents and 114 citations.

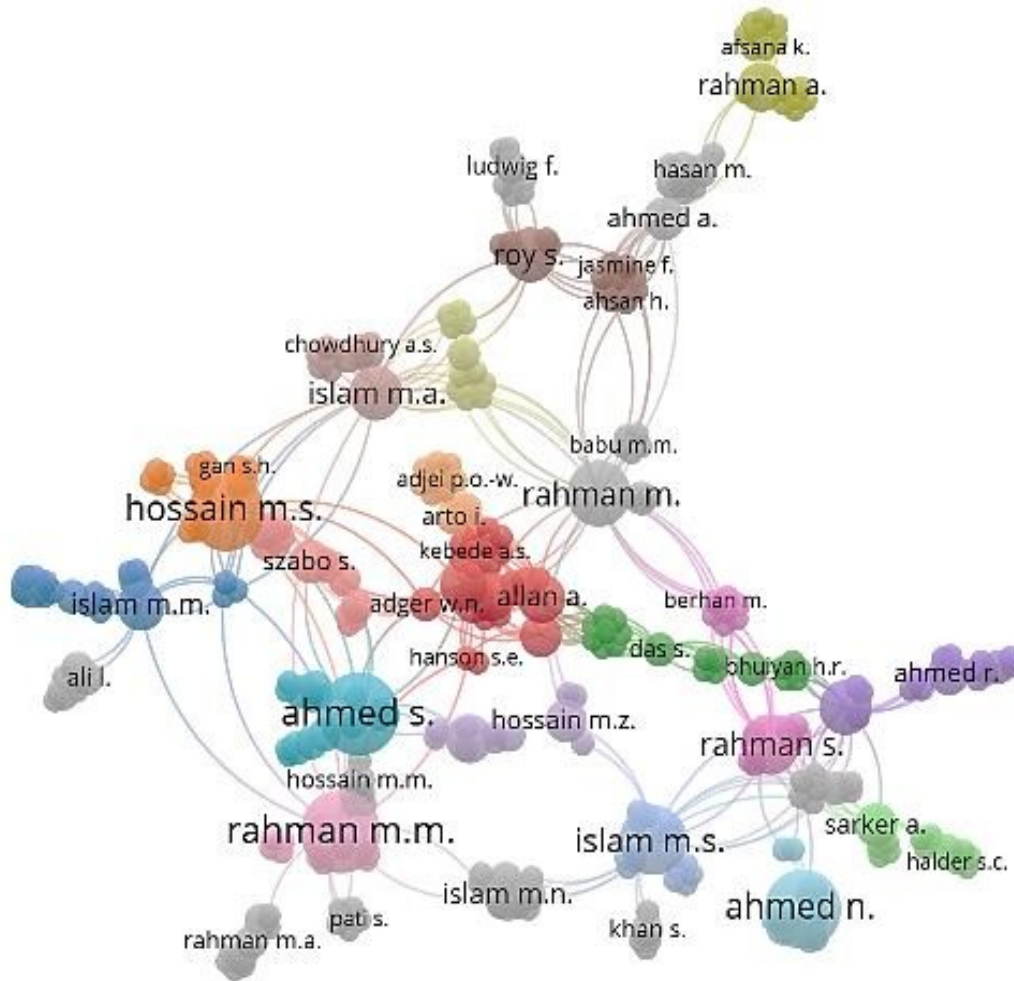


Figure 01: Author in terms of publication.

Top authors in terms of citation received in the publication

Statistical analysis has revealed a total of 1318 authors. Table 05 shows the top five authors in terms of receiving citations in their works. Ahmed n. has the most citations with a total of ten documents (303). Hoque A.T.M.R. is the second most cited author, with 182 citations in two publications. Huda S.M.S. and Sujauddin M. received 179 citations in a single article, while Hussam a. received 175 citations in a single publication.

Table 05: Top five authors in terms of citation received in the publication

| SL. | Id | Author | Document | Citations |
|-----|------|----------------|----------|-----------|
| 1 | 40 | Ahmed N. | 10 | 303 |
| 2 | 482 | Hoque,A.T.M.R. | 2 | 182 |
| 3 | 516 | Huda S.M.S. | 1 | 179 |
| 4 | 1162 | Sujauddin M. | 1 | 179 |
| 5 | 524 | Hussam A. | 1 | 175 |

Country in terms of Documents and Citations

Statistically, 72 countries have been identified. Figure 2 and 3 show that the top five countries submitting documents and receiving citations have been the most popular. There are 2645 citations to Bangladesh's 201 articles, putting it on top of the list. The U.S. is ranked second in 84 publications, with 1582 citations. The United Kingdom came in third place with 67 articles and 1730 citations. India receives 42 articles with 715 citations, whereas Australia receives 62 papers with 685 citations.

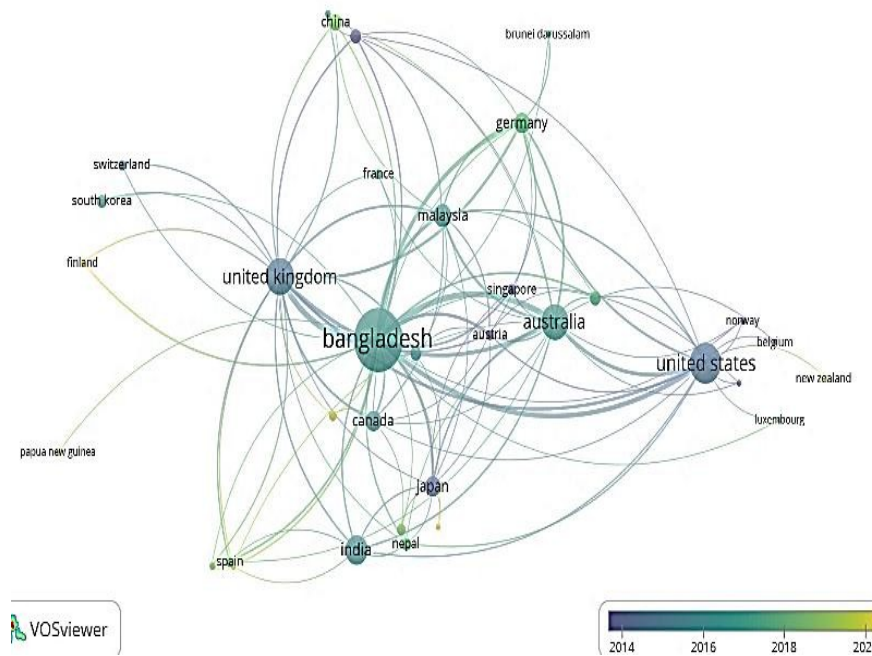


Figure 02: Countries in terms of publication

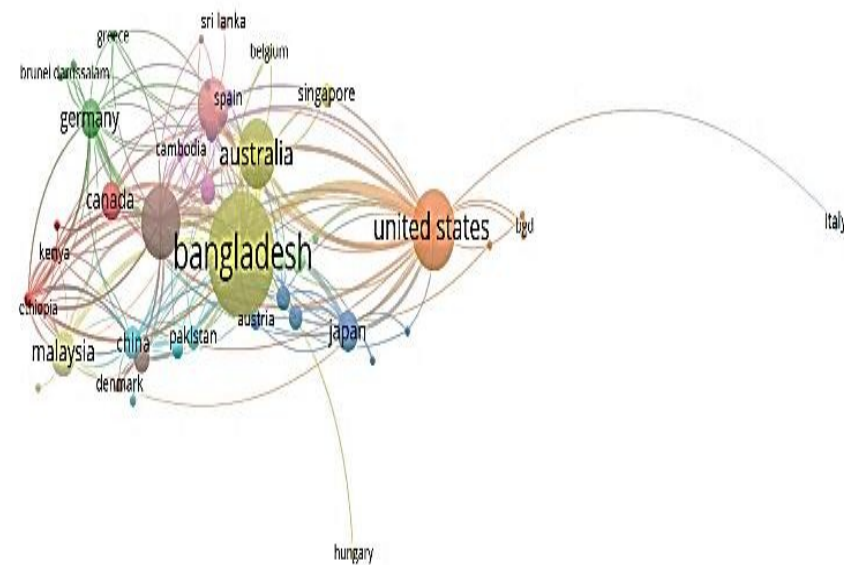


Figure 03: Countries in terms of citations

Top organizations in terms of document publication

The top 1074 organizations discovered using statistical analysis is listed below. The top five companies in terms of document publication are shown in Table 06. With five documents, the Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh takes first place with four publications, the Department of Environmental Sciences, Jahangirnagar University, Dhaka, 1342, Bangladesh, took second place. With three publications each, the Department of Coastal and Marine Fisheries at Sylhet Agricultural University (Sylhet, Bangladesh), the Department of Geography and Environment at the University of Southampton (Southampton, U.K.), and the Institute for Forestry and Environmental Sciences at the University of Chittagong (Chittagong, Bangladesh) come in third place.

Table 06: Top five organizations in terms of document publication

| S.L. | Id | Organization | Documents | Citations |
|------|-----|--|-----------|-----------|
| 1 | 285 | Department of fisheries management, Bangladesh agricultural university, Mymensingh 2202, Bangladesh | 5 | 210 |
| 2 | 275 | Department of environmental sciences, Jahangirnagar University, Dhaka, 1342, Bangladesh | 4 | 194 |
| 3 | 215 | Department of coastal and marine fisheries, Sylhet agricultural university, Sylhet, 3100, Bangladesh | 3 | 67 |
| 3 | 570 | Geography and environment, university of Southampton, Southampton, so17 1bj, united kingdom | 3 | 163 |
| 3 | 658 | Institute of forestry and environmental sciences, university of Chittagong, Chittagong, 4331, Bangladesh | 3 | 22 |

Top organizations in terms of citation of the document

Table 07 demonstrates that the Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh, ranks first in document citations with 210. Department of environmental sciences, Jahangirnagar University, Dhaka, Bangladesh, had the second most citations with 194. Researchers at the Chittagong University Institute of Forestry and Environmental Sciences in Bangladesh and the Okinawa University Faculty of Science's Plant Ecophysiology Laboratory in Japan tied with 179 citations each. Msn 3e2 at George Mason University, Fairfax, VA 22030, and Manob Sakti Unnayan Kendro (M.S.U.K.) in Kushtia, Bangladesh, have 175 citations between the two institutions. Geography and environment, university of Southampton, Southampton, so17 1bj, United Kingdom, received 163 citations.

Table 07: Top five organizations in terms of citation of the document

| S.L. | Id | Organization | Documents | Citations |
|------|-----|---|-----------|-----------|
| 1 | 285 | Department of fisheries management, Bangladesh agricultural university, Mymensingh 2202, Bangladesh | 5 | 210 |
| 2 | 275 | Department of environmental sciences, Jahangirnagar University, Dhaka, 1342, Bangladesh | 4 | 194 |
| 3 | 656 | Institute of forestry and environmental sciences, Chittagong University, Chittagong, 4331, Bangladesh | 1 | 179 |
| 3 | 750 | Laboratory of ecology and systematics (plant ecophysiology section), faculty of science, biology division, Okinawa, 903-0213, japan | 1 | 179 |
| 4 | 199 | Department of chemistry and biochemistry, MSN 3e2, George mason university, Fairfax, va 22030, united states | 1 | 175 |
| 4 | 774 | Manob sakti unnayan kendro (msuk), kushtia, Bangladesh | 1 | 175 |
| 5 | 570 | Geography and environment, university of Southampton, Southampton, so17 1bj, united kingdom | 3 | 163 |

Co-occurrence of author keywords

The total number of author keywords (n= 1281) revealed that the most common co-occurrence keywords in Bangladesh were 8.74 percent (n=112 repeats), climate change 2.34 percent (n=30 repeats), adaptation 1.48 percent (n=19 repeats), sustainability 1.01 percent (n=13 repeats), and arsenic and environment 0.86 percent (n=11 repeats). Figure 4 represents the authors' keywords visualization map.

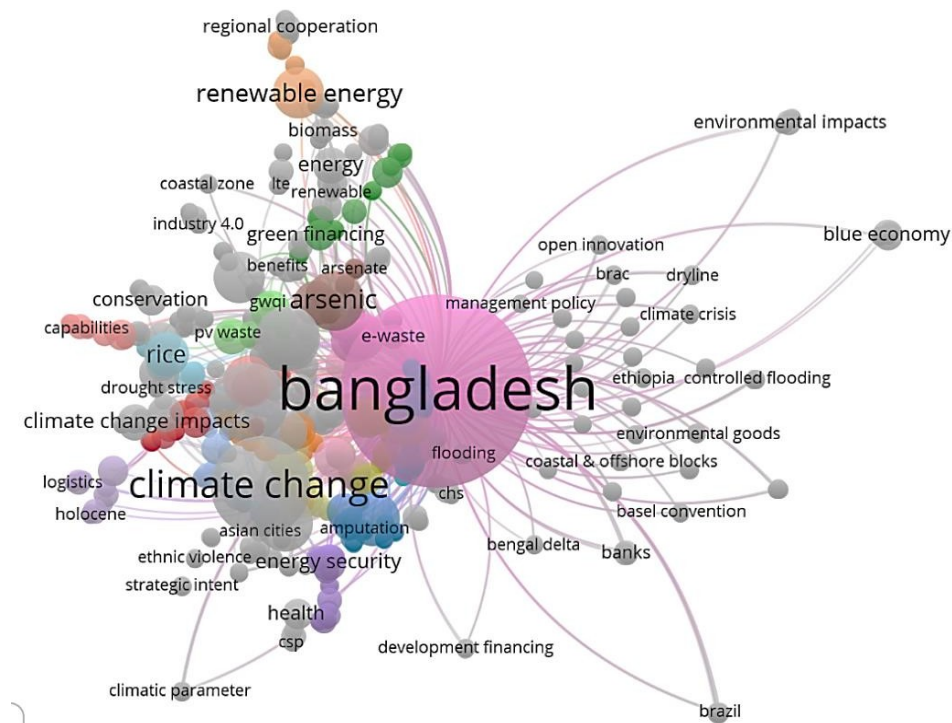


Figure 4: Co-occurrence of author keywords

Co-occurrence of all- keywords

A total of 3812 keywords have been found. Bangladesh 6.14 percent (n=234 repeats), Climate change 1.78 percent (n=68 repeats), Article 1.55 percent (n=59 repeats), Sustainable development 1.47 percent (n=56 repeats), and Human 1.42 percent (n=54 repeats) are the most common terms. The visualization map for all keywords is shown in Figure 5.

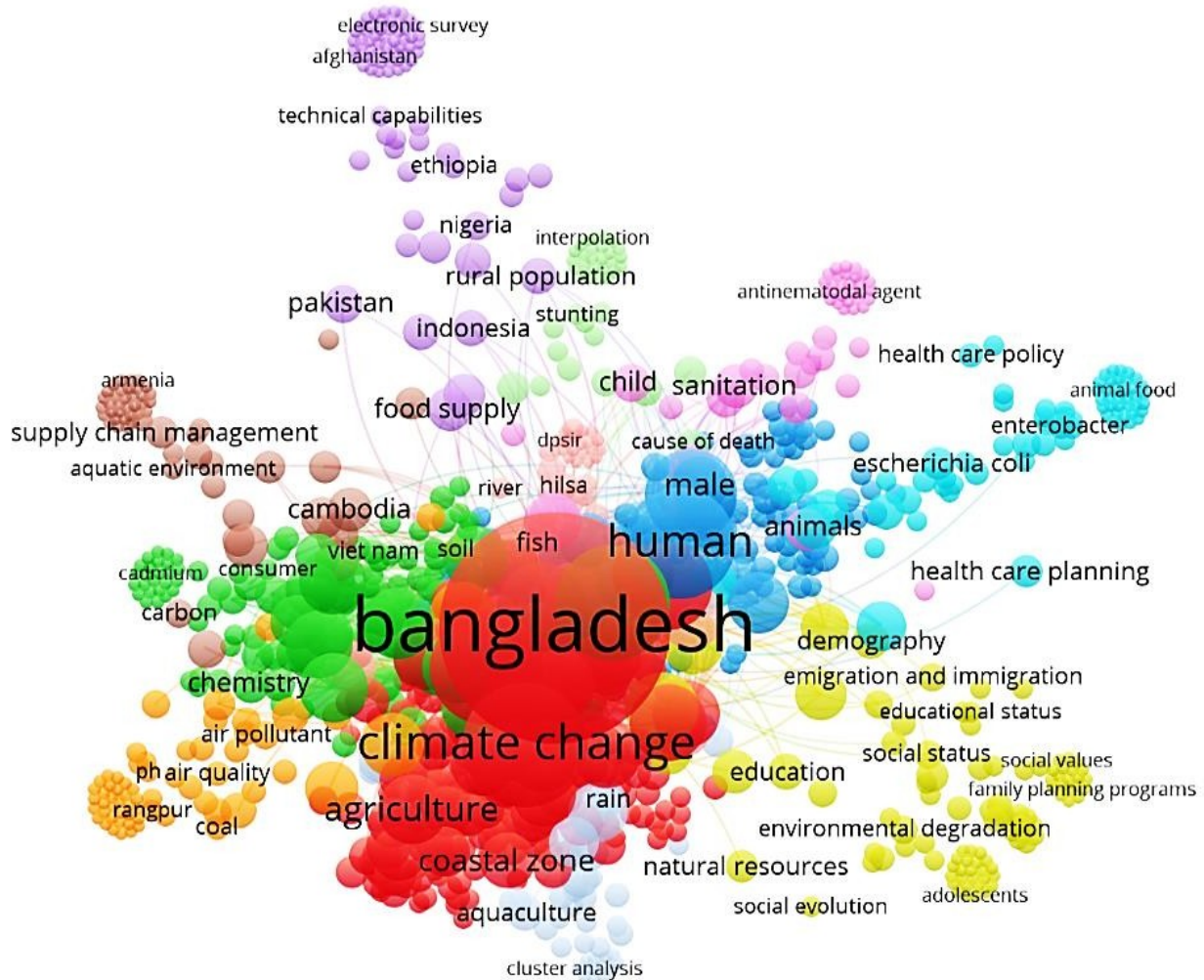


Figure 05: Co-occurrence of all keywords

5. Discussion and Conclusions

Environmental challenges have become a significant problem in emerging economies, especially in Bangladesh. Economic development with sustainability has received more priority on the policy-making table to preserve resources for the future generation. Various environmental challenges move pushing countries into vulnerable. Especially Bangladesh, Maldives, Nepal, and India will be the worst victims because of their geographical and demographical characteristics (Karthikheyan, 2010; Nicholls et al., 2016). Academic experts also have started interdisciplinary work to address the impact of environmental challenges (Corner et al., 2014). This study explores the top authors, countries, and organizations contributing to environmental challenge research in Bangladesh's published documents and citations. By August 26, 2021, the total number of papers published in this issue will be 3,531 on these seven South Asian countries' Scopus databases. India has the highest number of publications numbering 2,235, and Bangladesh stands just after it with 415.

Ten types of documents cover all these publications in Bangladesh. The article is the dominant type that covers 66.99% of the papers; other notable types are Review, Conference Paper, Book Chapter, and Book with the respective proportion of 9.88%, 8.43%, 7.95%, and 4.34%. The rest of the five forms are insignificant which contain less than 1.00% each. These documents are from five different sources: Journal, Book, Conference Proceeding, Book Series, and Trade Journal. The most common source is the journal that contains 77.83% of publications. Book and Conference Proceeding come next in the choice list with 11.81% and 7.95%, respectively. Book Series and Trade Journal are the least popular source with less than 3.00% share together. In terms of accessibility, 135 documents have open access out of 415. Others are in the forms of Gold, Hybrid Gold, Bronze, and Green.

The top author in this study, Nesar Ahmed, has 303 citations in 10 published documents. As of August 26, 2021, he is working as a research fellow in the School of Life and Environmental Sciences at Deakin University. He started contributing in this field in 2010, and his last publication was in 2018. His work combines six articles and four reviews, where one article and one review have open access. The most cited document title is "Integrated rice-fish farming in Bangladesh: Meeting the challenges of food security," published in 2011. This article is aimed at combating food challenges for sustainable food supply. His other important work sources are Ocean and Coastal Management, Australian Journal of Agricultural and Resource Economics, Aquaculture International, and Marine Policy.

Rafiqul Hoque is the second most citation achiever: professor in the Institute of Forestry and Environmental Sciences, University of Chittagong. He has two articles on environmental challenges issues in Bangladesh. The most cited one has 179 citations, and the work is on household waste management in Chittagong. That article was also contributed by two other authors S.M.S. Huda, and Mohammad Sujauddin. Their respective workstations are Chittagong University and Northsouth University. These co-authors are also on the top-cited list with this single contribution. The rest of the authors, Abul Hussam and Abul K. M. Munir, have contributed in a single article as co-authors. Their affiliated organizations are George Mason University and Manob Sakti Unnayan Kendro (M.S.U.K.), Kushtia. The work explains the effective filter that gives arsenic-free water.

In terms of published documents, Saleh Ahmed holds the second position with six documents after Nesar Ahmed. Currently, he is working as an assistant professor at Boise State University in the School of Public Service. His works consist of four articles, one note, and one book chapter with one open-access article. His top-cited article is on the sustainability concern of Dhaka, the capital city of Bangladesh, published in 2018, has five citations. The author shows concern about the living condition in city slums that requires social justice and sustainability. The following three authors have four documents, each in the top list with more than 100 citations individually.

Allan A., who has 103 citations in four documents, works in the Centre for Water Law, Policy and Science, University of Dundee. His top-cited article is on the integrated sustainability concerns Bangladesh's social and environmental dynamics as one of the largest deltas. They consider the delta a vulnerable coastal area that will be affected severely by the sea level rise due to the greenhouse effect. Their study aimed to find sustainable development of the delta areas that benefit all the residences, including the most vulnerable groups. They present a framework to analyze the ecosystem services of inland and offshore capture fisheries, agriculture, mangroves, and aquaculture that signify the principal biophysical and socio-ecological components and their interaction. The methodology of the study covers scenario analysis, biophysical and socio-economic modeling.

Another author with the same number of published documents is Dr. Saleemul Huq: the Director of the International Center for Climate Change & Development (I.C.C.C.A.D.), Independent University, Bangladesh. He has three articles and one review, where three documents have free access. His most cited paper published in 2009 addressed the need to link two principles strategies for climate change: mitigation and adoption. They criticized that the world treated these principles isolated and emphasized the possible synergic effect by linking these two policies simultaneously. His other works concentrate on the Rohingya and sustainability crisis, climate change adaptation in Bangladesh, and knowledge flows in climate change adaptation.

The third author having the same number of documents is Robert J. Nicholls: the Director of Tyndall Centre for Climate Change Research at the University of East Anglia. His work consists of three articles and one book, and all have open access. He is one of the co-authors in the previously discussed article on the integrated sustainability of Bangladesh as a delta. His second-best cited work is with A. Allan, which anticipates climate change impacts using a participatory scenario approach with multiple scales published in 2018. They wanted to discover the future migration and adaption in three deltas: Ghana, India, and Bangladesh. His other works consist of an article on the adverse effects of climate change for coastal Bangladesh and a book on questions generated by climate change and their possible answers in deltas.

In our study, Bangladesh has the highest contribution as a country, where 201 documents are published with a citation of 2,645. Other countries are the United States, the United Kingdom, Australia, and India, with respective documents of 84, 67, 62, and 42. Department of Fisheries Management of Bangladesh Agricultural University is the top organization from both aspects: number of papers and citation. It contributed five documents that have 210 citations. Department of Environmental Sciences of Jahangirnagar University is the second in both lists. It has four documents with 194 citations. Three organizations contributed three documents each, and they are the Geography and Environment of the University of Southampton (163 citations), Department of Coastal and Marine Fisheries of Sylhet Agricultural University (67 citations), and Institute of Forestry and Environmental Sciences of the University of Chittagong (22 citations).

The keywords address the significant concepts that the author explores throughout the research (Liao et al., 2017). The number of all keywords in this study is 7,197, where the keyword "Bangladesh" has the highest occurrence. Other keywords are climate change, article, sustainable development, human, humans, India, developing countries, and sustainability with the respective occurrence number of 68, 59, 56, 54, 38, 35, 34, and 31. Environmental challenges as a dynamic field of study demand much interdisciplinary and diverse research. Previous studies documented that Government policies and interventions are reasonably incorporated to mitigate the environmental challenges in Bangladesh, but better enforcement with monitoring and controlling mechanisms are absent.

However, further research should consider how better enforcement can be improved for confirming environmental sustainability in Bangladesh. In addition, river pollution, pollution costs, budgets, and river governance are very concerning issues in Bangladesh, and further researchers might find an impetus to contribute to these emerging issues. Moreover, some vital factors related to environmental pollution for Bangladesh, such as industrial waste, plastic pollution, and corporate environmental sustainability, are not in the keyword list. Rajshahi and Sylhet appear 1 and 2 times in the keyword list and none for Bangladesh's northwest or north-eastern part. The industrialization and deforestation impact on the greenhouse effect has also been proven as an underrated research area. Therefore, apprehending the pollution control mechanism, these mentioned issues should be considered by the prospective researchers.

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Data Availability Statement

The data used to support the findings of this study are available from the corresponding author upon request.

References

- Ahmed, K., Shahbaz, M., Qasim, A. and Long, W. (2015). The linkages between deforestation, energy, and growth for environmental degradation in Pakistan. *Ecological Indicators*, 49, pp.95-103. doi:10.1016/j.ecolind.2014.09.040
- Alam, M.W. and Xiangmin, X.(2019). *Marine Pollution Prevention in Bangladesh: A Way*

Forward for Implement Comprehensive National Legal Framework. *Thalassas: An International Journal of Marine Sciences*, 35(1), pp.17-27.

Arifuzzaman, M., Hannan, M.A., Rahman, M.R. and Rahman, M.A. (2019). Laws Regulating Water Pollution in Bangladesh. *Journal of Sociology*, 3(1), pp.15-24.

Baten, M.A. and Titumir, R.A.M. (2016). Environmental challenges of trans-boundary water resources management: the case of Bangladesh. *Sustainable Water Resources Management*, 2(1), pp.13-27.

Begum, B.A. and Hopke, P.K. (2018). Ambient air quality in Dhaka Bangladesh over two decades: Impacts of policy on air quality. *Aerosol and Air Quality Research*, 18(7), pp.1910-1920.

Call, M.A., Gray, C., Yunus, M. and Emch, M. (2017). Disruption, not displacement: Environmental variability and temporary migration in Bangladesh. *Global environmental change*, 46, pp.157-165.

Chowdhury, M.M.I., Rahman, S.M., Abubakar, I.R., Aina, Y.A., Hasan, M.A. and Khondaker, AN (2021). A review of policies and initiatives for climate change mitigation and environmental sustainability in Bangladesh. *Environment, Development and Sustainability*, 23(2), pp.1133-1161.

Corner, A., Markowitz, E., & Pidgeon, N. (2014). Public engagement with climate change: the role of human values. *Wiley Interdisciplinary Reviews: Climate Change*, 5(3), 411-422.

Faroque, S. and South, N. (2021). Water Pollution and Environmental Injustices in Bangladesh. *International Journal for Crime, Justice and Social Democracy*, 10(2).

Haque, M. A., Islam, M. A., Hasan, M. N., & Akanda, A. K. M. E. A. (2019). Bibliometric analysis of the e-Journal of library philosophy and practice during the period of 2014-2018. *Library Philosophy and Practice*, 3028.

Haque, M.A. and Zhang, X. (2021). Research trends of ICT and Bangladesh: A bibliometric Approach. *Bangladesh Journal of Library and Information Science*, 2(3), 67-88.

Haque, N. (2017). Exploratory analysis of fines for water pollution in Bangladesh. *Water Resources and industry*, 18, pp.1-8.

Hasan, M.K., Shahriar, A. and Jim, K.U. (2019). Water pollution in Bangladesh and its impact on public health. *Heliyon*, 5(8), p.e02145.

Hasan, M.K., Shahriar, A. and Jim, K.U. (2019). Water pollution in Bangladesh and its impact on

public health. *Heliyon*, 5(8), p.e02145.

Hasan, N.A., Heal, R.D., Bashar, A. and Haque, M.M. (2021). Face masks: protecting the wearer but neglecting the aquatic environment?-A perspective from Bangladesh. *Environmental Challenges*, 4, p.100126.

Hasnat, G.T., Kabir, M.A. and Hossain, M.A. (2018). Major environmental issues and problems of South Asia, particularly Bangladesh. *Handbook of environmental materials management*, pp.1-40.

Hajduk, S. (2017). Bibliometric analysis of publications on city logistics in international scientific literature. *Procedia Engineering*, 182, pp.282-290.

Hossain, F. and Moniruzzaman, M. (2021). Environmental Change Detection Through Remote Sensing Technique: A Study of Rohingya Refugee Camp Area (Ukhia and Teknaf Sub-district), Cox's Bazar, Bangladesh. *Environmental Challenges*, p.100024.

Hossain, M.A., Reza, M.I., Rahman, S. and Kayes, I. (2012). Climate change and its impacts on the livelihoods of the vulnerable people in the southwestern coastal zone in Bangladesh. In *Climate change and the sustainable use of water resources* (pp. 237-259). Springer, Berlin, Heidelberg.

Hossain, S., Rahman, M.A., Chowdhury, M.A. and Mohonta, S.K. (2021). Plastic pollution in Bangladesh: A review on current status emphasizing the impacts on environment and public health. *Environmental Engineering Research*, 26(6), pp.210-231.

Huq, M.E., Fahad, S., Shao, Z., Sarven, M.S., Khan, I.A., Alam, M., Saeed, M., Ullah, H., Adnan, M., Saud, S. and Cheng, Q. (2020). Arsenic in a groundwater environment in Bangladesh: Occurrence and mobilization. *Journal of environmental management*, 262, p.110318.

Islam, M., Tamanna, S., Rahman, M., Ali, M.A. and Mia, I. (2021). Climatic and Environmental Challenges of Tea Cultivation at Sylhet Area in Bangladesh. In *Climate Change in Bangladesh* (pp. 93-118). Springer, Cham

Islam, M.S., Tseng, M.L., Karia, N. and Lee, C.H. (2018). Assessing green supply chain practices in Bangladesh using fuzzy importance and performance approach. *Resources, Conservation and Recycling*, 131, pp.134-145.

Issah, O. and Rodrigues, L.L. (2021). Corporate Social Responsibility and Corporate Tax Aggressiveness: A Scientometric Analysis of the Existing Literature to Map the Future. *Sustainability*, 13(11), p.6225.

Kafy, A.A., Dey, N.N., Al Rakib, A., Rahaman, Z.A., Nasher, N.R. and Bhatt, A. (2021). Modeling the relationship between land use/land cover and land surface temperature in Dhaka, Bangladesh using CA-ANN algorithm. *Environmental Challenges*, 4, p.100190.

Karthikheyan, T. C. (2010). Environmental challenges for Maldives. *South Asian Survey*, 17(2), 343-351.

Khan, M.N., Islam, M.M., Islam, M.R. and Rahman, M.M. (2017). Household air pollution from cooking and risk of adverse health and birth outcomes in Bangladesh: a nationwide population-based study. *Environmental Health*, 16(1), pp.1-8.

Kurata, M., Takahashi, K. and Hibiki, A. (2020). Gender differences in associations of household and ambient air pollution with child health: Evidence from household and satellite-based data in Bangladesh. *World Development*, 128, p.104779.

Liao, Y., Deschamps, F., Loures, E. D. F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0-a systematic literature review and research agenda proposal. *International Journal of production research*, 55(12), 3609-3629.

Mehedi, S., Rahman, H. and Jalaludin, D. (2020). The relationship between corporate governance, corporate characteristics and agricultural credit supply: evidence from Bangladesh. *International Journal of Social Economics*.

Moktadir, M.A., Ali, S.M., Kusi-Sarpong, S. and Shaikh, M.A.A. (2018). Assessing challenges for implementing Industry 4.0: Implications for process safety and environmental protection. *Process Safety and Environmental Protection*, 117, pp.730-741.

Mourshed, M., Masud, M.H., Rashid, F. and Joardder, M.U.H. (2017). Towards the effective plastic waste management in Bangladesh: a review. *Environmental Science and Pollution Research*, 24(35), pp.27021-27046.

Naz, S., Page, A. and Agho, K.E. (2015). Household air pollution and under-five mortality in Bangladesh (2004–2011). *International journal of environmental research and public health*, 12(10), pp.12847-12862.

Nicholls, R. J., Hutton, C. W., Lázár, A. N., Allan, A., Adger, W. N., Adams, H., ... & Salehin, M. (2016). Integrated assessment of social and environmental sustainability dynamics in the Ganges-Brahmaputra-Meghna delta, Bangladesh. *Estuarine, Coastal and Shelf Science*, 183, 370-381.

Pan, X., Yan, E., Cui, M. and Hua, W. (2018). Examining the usage, citation, and diffusion patterns of bibliometric mapping software: A comparative study of three tools. *Journal of informetrics*, 12(2), pp.481-493.

Pourret, O., Hursthouse, A., Irawan, D.E., Johannesson, K., Liu, H., Poujol, M., Tartese, R., van Hullebusch, E.D. and Wiche, O. (2020). Open Access publishing practice in geochemistry: overview of current state and look to the future. *Heliyon*, 6(3), p.e03551.

Proshad, R., Ahmed, S., Rahman, M. and Kumar, T. (2017). Apportionment of hazardous elements in agricultural soils around the vicinity of brick kiln in Bangladesh. *Journal of Environmental and Analytical Toxicology*, 7(439), pp.2161-0525.

Rahman, M.M., Mahamud, S. and Thurston, G.D., (2019). Recent spatial gradients and time trends in Dhaka, Bangladesh, air pollution and their human health implications. *Journal of the Air & Waste Management Association*, 69(4), pp.478-501.

Rana, M.M.P. and Ilina, I.N. (2021). Climate change and migration impacts on cities: Lessons from Bangladesh. *Environmental Challenges*, p.100242.

Sarker, S., Bhuyan, M.A.H., Rahman, M.M., Islam, M.A., Hossain, M.S., Basak, S.C. and Islam, MM (2018). From science to action: Exploring the potentials of Blue Economy for enhancing economic sustainability in Bangladesh. *Ocean & Coastal Management*, 157, pp.180-192.

Siddiqui, S.A., Jakaria, M., Amin, M.N., Al Mahmud, A. and Gozal, D. (2020). Chronic air pollution and health burden in Dhaka city. *European Respiratory Journal*, 56(2).

Suhi, S.A., Enayet, R., Haque, T., Ali, S.M.,Moktadir, M.A. and Paul, S.K. (2019). Environmental sustainability assessment in supply chain: an emerging economy context. *Environmental Impact Assessment Review*, 79, p.106306.

Sultana, A., Paul, A.K. and Nessa, M.U.(2020). The Status of Noise Pollution in the Major Traffic Intersections of Khulna Metropolitan City in Bangladesh and its Possible Effect on Noise-Exposed People. *European Journal of Environment and Earth Sciences*, 1(5).

The World Bank (2018). Clean and Resilient Growth in Bangladesh. Retrieved from: www.worldbank.org/en/news/feature/2018/09/16/clean-and-resilient-growth-in-bangladesh.

Trading Economics (2021). Bangladesh-Physicians. Retrieved from: <https://tradingeconomics.com/bangladesh/physicians-per-1-000-people-wb-data.html>.

Van Eck, N. J., & Waltman, L. (2013). VOSviewer manual. Leiden: Univeriteit Leiden, 1(1), 1-53.

Zafar, T.B., Ding, W., Khan, G.M., He, L. and Hao, C. (2019). Environment Protection Strategies and Climate Change Adaption for Sustainable Development: An Overview of Bangladesh. International Journal of Science and Business, 3(3), pp.107-113.

Zainuldin, M.H. and Lui, T.K. (2021). A bibliometric analysis of C.S.R. in the banking industry: a decade study based on Scopus scientific mapping. International Journal of Bank Marketing.