

The Evolving Sanitation Entrepreneurial Ecosystem: A Bibliometric and Content Analysis of Global Trends and Future Research

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ABSTRACT

The field of sanitation has been extensively discussed in the literature from varied viewpoints. However, a comprehensive approach summarising the entrepreneurial facets of the sanitation industry is still fragmented. This study examines 375 papers published over 25 years. It attempts to identify significant studies and concepts that researchers have developed across time. A review of the literature on sanitation and its entrepreneurial ecosystem has been undertaken in the study. It incorporates bibliometric as well as content analysis. The bibliometric approach focuses on the quantitative aspects of the study, while content analysis looks at the literature qualitatively. Data analysis has been performed using the Scopus database. Further, VOSviewer software has been used to create various network maps. The highest number of papers were published in 2021, signifying growing research interest in the domain. *Environmental Monitoring and Assessment* is the journal of highest influence, and the most cited paper is about “Marketing to the Base of the Pyramid (BoP) Market.”

KEYWORDS:

Sanitation, Sustainable Development Goals, Entrepreneurship, Base of the Pyramid Market

1. INTRODUCTION

Sanitation is one of the essential components of human life since it preserves human health, increases life expectancy, and has been proven to have economic advantages (Naughton & Mihelcic, 2017). Its significance was emphasized in 1923 by Mahatma Gandhi, who stated that “sanitation is more important than independence” (PMO, India, 2008). Yet in 2020, 3.6 billion people at the base of the

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pyramid (BoP) worldwide lacked safely managed sanitation services, 494 million practised open defecation, 2 billion lacked safely managed drinking water services and 2.3 billion lacked basic handwashing services (WHO & UNICEF, 2021). Inadequate sanitation, hygiene and contaminated drinking water have been associated with the spread of diarrhea, cholera, typhoid, dysentery, hepatitis A, and polio (Murray et al., 2020; Drinking-Water WHO, 2022; Pullan et al., 2014). Consequently, the lives of billions of people at the base of the pyramid (BoP) in underdeveloped countries are negatively impacted by poor sanitation as a primary cause (London & Esper, 2014). The global economic costs of poor sanitation are estimated to be US\$260 billion annually (Hutton, 2013).

Sanitation is often considered a social taboo and rarely gets discussed openly in communities (Rosenqvist et al., 2016; Burt et al., 2021b, Gwara et al., 2020). The United Nation's Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) have given research and development in the field a much-needed breakthrough. In 2016, the SDGs succeeded the MDGs with a dedicated goal (Goal 6) to ensure the sustainability and availability of water and sanitation for all by 2030 (UNICEF, 2020). Yet several nations are falling significantly behind their set targets. UNICEF and WHO (2021) warned that unless progress quadruples, billions of people will not have access to clean water, sanitation, and hygiene by 2030. One of the primary reasons for the same has been attributed to weak and fragmented governance and delivery systems (United Nations, 2020).

Evidently, the supply-driven water and sanitation system is not meeting customers' needs. The absence of basic sanitation poses a significant public health concern, but it also presents a business opportunity (Bagire et al., 2021b; Amoah et al., 2021b; Mallory, Holm, et al., 2020b; Rao et al., 2020). As a result of persistent issues, there is a growing realization that the private sector is needed to address these challenges. Multi-stakeholder partnerships are identified as the cornerstone of the 2030 agenda for achieving the Sustainable Development Goals (NITI Aayog, 2021). Innovative collaborations across governments, enterprises, civil societies and UN agencies have been considered crucial in achieving the agenda (SDGF, 2016). According to the Toilet Board Coalition (2019), the sanitation economy has the capability to produce 3.8 trillion litres of fresh resources each year through the circular sanitation economy, which is regenerated from toilets and sanitation systems. In India alone, the sanitation economy is worth \$97.4 billion in 2021 and is estimated to stand at \$148.2 billion by 2030 (Toilet Board Coalition, 2021).

Research on the sanitation sector in the entrepreneurial ecosystem has increased over the past decade. However, the literature reveals that this topic is still in the nascent stage. The themes being considered over the years revolve around water, sustainable development, environmental monitoring and impact, waste management, private sector and several human-related aspects. Also, not much research has been done to show how entrepreneurship affects the sanitation industry or to measure how far research has come within a specific time period.

The primary objective of our study is to comprehensively identify and recognize the key contributors in the field of sanitation. Through an extensive review of existing literature, we aim to identify individuals, institutions, organizations, or research groups that have made significant contributions to the domain under study. This may include researchers, scholars, practitioners, policymakers, or other stakeholders who have played a pivotal role in advancing knowledge, practices, or policies related to the field. This study also seeks to assess the progress that has been made in the domain involving critical evaluation in the existing body of knowledge, research findings, and practical applications. We aim to analyze the extent to which the field has evolved, the impact of previous research contributions, and the current state of knowledge in the field.

Additionally, our study aims to identify the future research agenda for scholars in the field. We intend to highlight the gaps, challenges, and opportunities that exist in the current body of knowledge, and propose potential avenues for future research. This may include identifying areas where further research is needed, offering novel research questions or outlining emerging trends and directions for future investigation.

Overall, our study's objectives are geared towards providing a comprehensive assessment of the key contributors, progress made, and future research agenda in the domain under investigation. Through our research findings, we aim to contribute to the existing body of knowledge, provide insights for practitioners and policymakers, and guide future research efforts in the field. To achieve this, we combine bibliometric and content analysis to determine the progress made in the domain and major contributors, including journals, authors, and funding sponsors. The following sections include a brief review of the literature (section 2), research methodology (section 3), the results and analysis (section 4), the discussion (section 5) and the conclusion (section 6).

2. A BRIEF BACKGROUND ON SANITATION IN AN ENTREPRENEURIAL CONTEXT

2.1. The Effects of Insufficient Sanitation

The COVID-19 pandemic served as a stark reminder of the crucial role that sanitation, hygiene, and access to clean water play in preventing and controlling the spread of diseases. Handwashing, in particular, emerged as a highly effective measure for curbing the transmission of germs and illnesses such as COVID-19 (WHO, 2020; WHO & UNICEF, 2020). Inadequate sanitation has serious consequences for human health, including stunted growth and reduced cognitive ability in malnourished children. It is crucial to provide proper sanitation facilities and adequate nutrition, especially in low-income areas, to promote the health and well-being of individuals (Byford, 2014). Diarrhoea is the third most significant cause of mortality in children under five worldwide, with poor sanitation accounting for around 55 percent of these deaths (IHME, 2017). With better sanitation, people between the ages of 15 and 59 can have an extra 320 million productive days per year, 272 million school attendance days per year, and an extra 1.5 billion healthy days for children under the age of five adding up to \$9.9 billion in productivity gains per year (WHO, 2008). Sanitation was made a separate human right by the United Nations General Assembly in 2015 because it greatly impacts human development (United Nations, 2014). The economic benefits of sanitation aid human capital development (Hutton et al., 2007). There are 195 billion US dollars' worth of economic benefits to achieving universal sanitation every year (Hutton, 2012).

2.2 Sanitation in the Base of the Pyramid (BoP) Market

Poor sanitation is a primary cause of poor health and well-being for billions of people living at the base of the pyramid (BoP) in developing countries (London & Esper, 2014b). The base of the pyramid (BoP) denotes society's poorest socioeconomic category, which comprises four billion people and accounts for around 58.8% of the global population (Nidumolu et al., 2015). According to the literature on BoP, the poor should not be viewed as passive recipients of charity and development programmes but as active consumers, producers, and entrepreneurs (London, 2016). Innovative business models in sanitation can act as a catapult to addressing the issue. Griliches (1957) identified two major drivers of diffusion of innovation: technical and commercial 'availability' and customer 'acceptability'.

The BoP strategy is based on the idea that businesses must collaborate with a range of stakeholders. As Prahalad (2002) emphasised, numerous stakeholders, including government, non-governmental organisations (NGOs), communities, banks, and enterprises, must be involved to achieve higher possibilities. Community inclusion is reflected in earlier literature in which consumers are recognised as essential cocreators (Sanders & Stappers, 2008). The concept of creating economically viable companies to serve the base of the pyramid (BoP) has acquired a lot of traction in recent years (Prahalad & Hart, 2010). Scaling market-based sanitation solutions requires translating unmet needs of BOP consumers into market demand (Gebauer et al., 2017). Business models are important to attain success in the BoP market because they can transform innovations into poverty reduction outcomes (Chesbrough & Crowther, 2006).

The ambiguity among sanitation stakeholders concerning end-user acceptability of sanitation products and services is one of the impediments in the sanitation industry (Larsen et al., 2013). The end-user's risk perceptions are usually based on factual information but can also be influenced by attitudes, feelings, preferences and ethics (Daughton, 2004). Among these factors, sanitation services, particularly in low-income settings, provide distinct obstacles. The need to understand users' perspectives is critical, as maintenance and the number of users might impact sanitation services (Mazeau et al., 2013). Also, there is a lack of understanding on how to establish a profitable sanitation enterprise that benefits the poor (WSUP, 2017). Furthermore, water and sanitation projects have not successfully mobilized private capital (Hahm, 2019).

2.3 Waste Management From an Entrepreneurial Perspective

In developing nations, the majority of sewage waste is discharged into rivers without proper treatment, resulting in eutrophication as a common consequence due to the high levels of nutrients released into the environment (Jacobson et al., 2017). Surprisingly, global wastewater contains enough nutrients to replace 50 million metric tonnes of fertiliser, a significant portion of the approximately 262 million tonnes of fertiliser used worldwide each year (CGIAR, 2014; FAO, UN, 2019). Despite this potential resource, solid and liquid waste management (SLWM) remains a persistent challenge, as treatment plants often face shutdowns due to inadequate funding for operations (Strande & Brdjanovic, 2014).

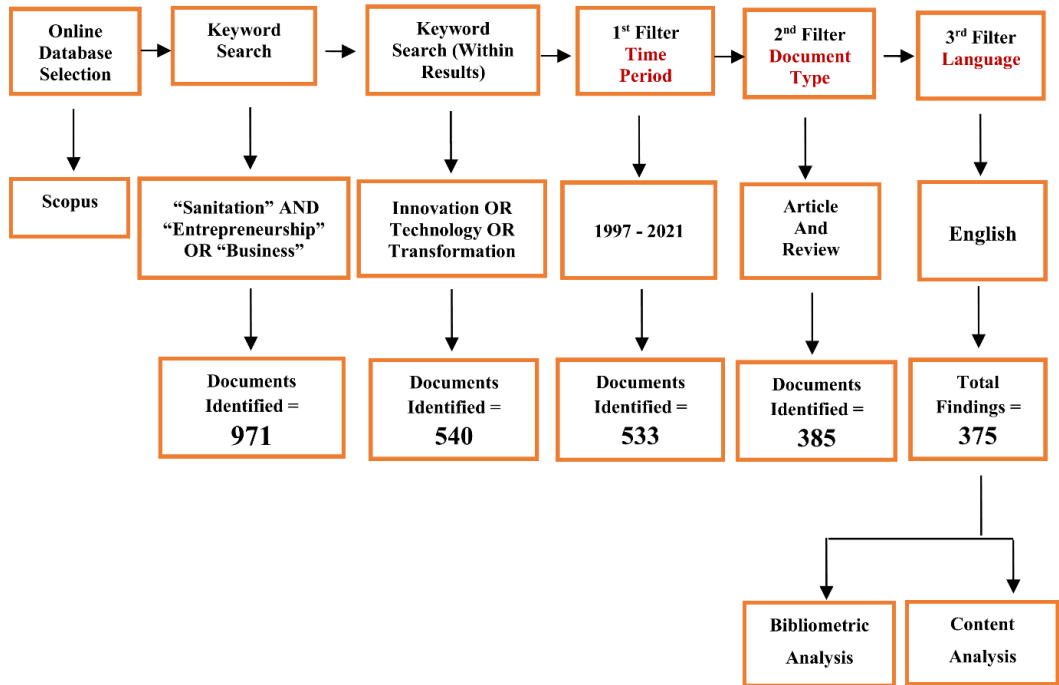
There is a drive to move to Circular Economy (CE) sanitation systems that provide nutrients for animal feed, agriculture, and clean energy due to a shortage of funding for sanitation and the increasing degradation of natural resources caused by improper waste disposal (Bruel et al., 2018). Revenues from these services might be used to pay for the upkeep of sanitary facilities while also encouraging proper waste management and pollution prevention (Toilet Board Coalition, 2016). Several business models along with theoretical methods and innovation with engagement of private sector have been proposed in the recent years. Amoah et al. (2021a) assessed the positive results linked to combined systems of treating wastewater and producing aquaculture. These systems aim to enhance both human nutrition and food security while also contributing to the cost recovery sustainability of wastewater treatment. Rao et al. (2020b) present findings on similar business models created throughout India and offer advice for scaling up and sustaining faecal sludge management. Chitrao (2020) exhibited how social enterprises can benefit farmers, rural artisans, and women.

India has made significant strides over the past few years in addressing its waste management challenges with the emergence of several sanitation enterprises. These enterprises aim to promote sustainable waste management practices, reduce landfill waste, reduce solid and liquid waste, and create job opportunities for informal waste workers. Saahas Zero Waste is one such enterprise that provides circular waste management solutions, including waste segregation, composting, and recycling for bulk waste generators. Chintan Environmental Research and Action Group is another enterprise that focuses on creating sustainable livelihood opportunities for waste pickers by integrating them into the formal economy through training, equipment access, and advocacy efforts. Ekam Eco Solutions is another sanitation enterprise working towards sustainable waste management in India. They provide customized waste management services such as septic tank treatment, sewage treatment plant (STP), and bio-remediation of rivers. Despite the progress made by these enterprises, challenges such as limited infrastructure and low public awareness still exist.

3. RESEARCH METHODOLOGY

To address the research questions, this study incorporates a bibliometric analysis in conjunction with content analysis (Kumar and Dubey, 2022; Kumar et al., 2023; Tiwary et al., 2021), which provides a statistical overview and helps in the presentation of the theoretical aspects. Our methodology of research has been presented in Figure 1 in accordance with the methodologies adopted by prominent authors (Yu et al., 2020; Kumar and Dubey's, 2021; Cavalcante et al., 2021).

Figure 1. The framework adopted for this study



3.1 Process of Data Collection

The initial step in gathering data was to choose a suitable database from which literature can be accessed. The research papers were gathered using the Scopus database (Elsevier, 2019). Scopus was chosen because it contains the majority of the journals in this discipline. Second, keywords were utilised to conduct database searches. The documents were searched on December 31, 2021 with the keywords “Sanitation” AND “Entrepreneurship” OR “Business”. Further, a keyword search within the results was applied in order to drive the orientation towards studies that focus on Innovation OR Technology OR Transformation. Henceforth, the first filter was applied to select the time frame of 25 years starting from 1997 till 2021. The second filter was applied to restrict the documents to only article and review for data quality assurance. The third filter was applied to select only the papers that have been published in the English language. Lastly, all documents were scanned to eliminate duplicate articles.

3.2 Search Data Summary

In the initial search, 971 documents were identified. After following the filtration process mentioned in Figure 1, 375 documents were selected for the study. Amongst these documents, 94.1% were articles, while 5.9% were review papers. The most prominent subject area was environmental science with 220 papers. All papers have been analysed and read critically in order to highlight the global trends and future research agenda in this field.

4. RESULTS AND ANALYSIS

Scopus database has been used to analyse search results in conjunction with VOSviewer software to construct the keyword co-occurrences network analysis. VOSviewer is a free software program that

helps to create maps using network data. It also assists in the visualization and exploration of these charts. Furthermore, the papers are classified according to year-wise publications, journals with maximum publications, keyword co-occurrence network analysis, prominent authors, most prolific countries, prominent institutions, highest contributing sponsors, and the highest number of citations.

4.1 Year-Wise Publication of Papers

This section will demonstrate the yearly statistics on the number of articles published. Figure 2 exhibits the growing literature on “Sanitation” and “Entrepreneurship”. With the most articles in 2021, we can deduce that the area has attracted a wide range of interest during the last 25 years. Between 1997 and 2006, the number of papers published was relatively low. Then, between 2006 and 2013, there was a substantial rise, with the number of papers increasing from 6 to 34. While the years 2014-2019 again experienced a dip in research interest but slowly showed an upward trend since 2020 with the onset of the pandemic. This demonstrates that researchers’ interest in this field has soared in recent years. In 2021, roughly 35 publications were published in this domain, which is considered healthy for any field seeking scholarly attention.

4.2 Journals With the Highest Publications

There are 375 papers analysed in this section that have been cited in at least one of the 160 journals. The top fifteen journals that published the most papers on sanitation in the entrepreneurial ecosystem are depicted in Figure 3. Springer Nature publishes the top-ranked journal Environmental Monitoring And Assessment, which has published 30 papers.

“Environmental Monitoring and Assessment” is an interdisciplinary, peer-reviewed journal that focuses on the evaluation of environmental quality in the context of water, sanitation, and hygiene (WASH) interventions. The journal covers a wide range of topics, including the development and application of monitoring methodologies, techniques, and technologies to assess the impacts of WASH interventions on environmental parameters such as water quality, soil quality, air quality, and ecosystem health. It encompasses research on water and sanitation infrastructure, effectiveness of WASH interventions, monitoring of waterborne diseases, wastewater treatment technologies, and policy and governance frameworks for WASH management. The journal encourages interdisciplinary research that integrates field-based monitoring, laboratory analysis, modelling, and statistical analysis to inform

Figure 2. Year-wise statistics of papers published

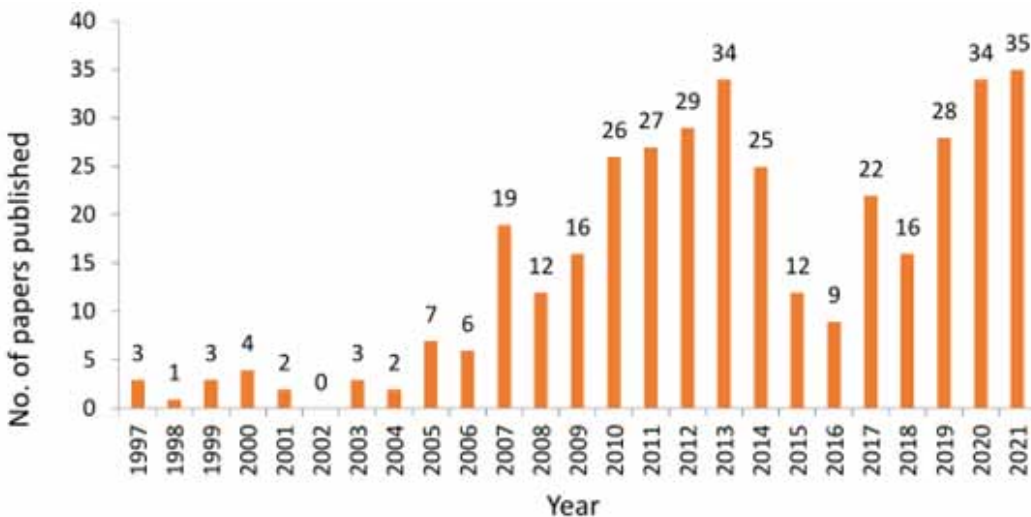
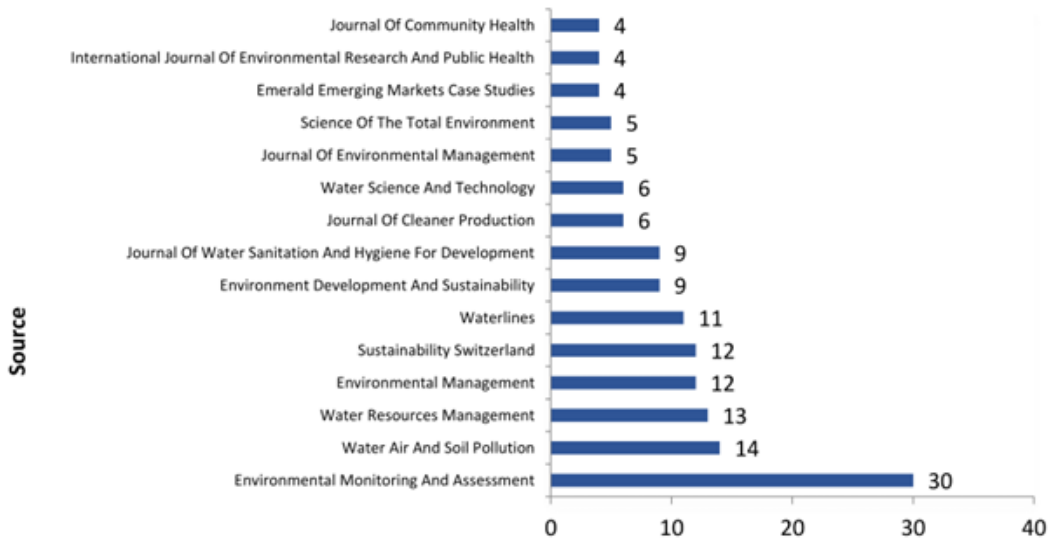


Figure 3. Top 15 journals with highest publications on sanitation entrepreneurial ecosystem



evidence-based decision making. By advancing the understanding of environmental monitoring and assessment in the context of WASH, “Environmental Monitoring and Assessment” contributes to the development of sustainable and evidence-based practices and policies in the field of WASH.

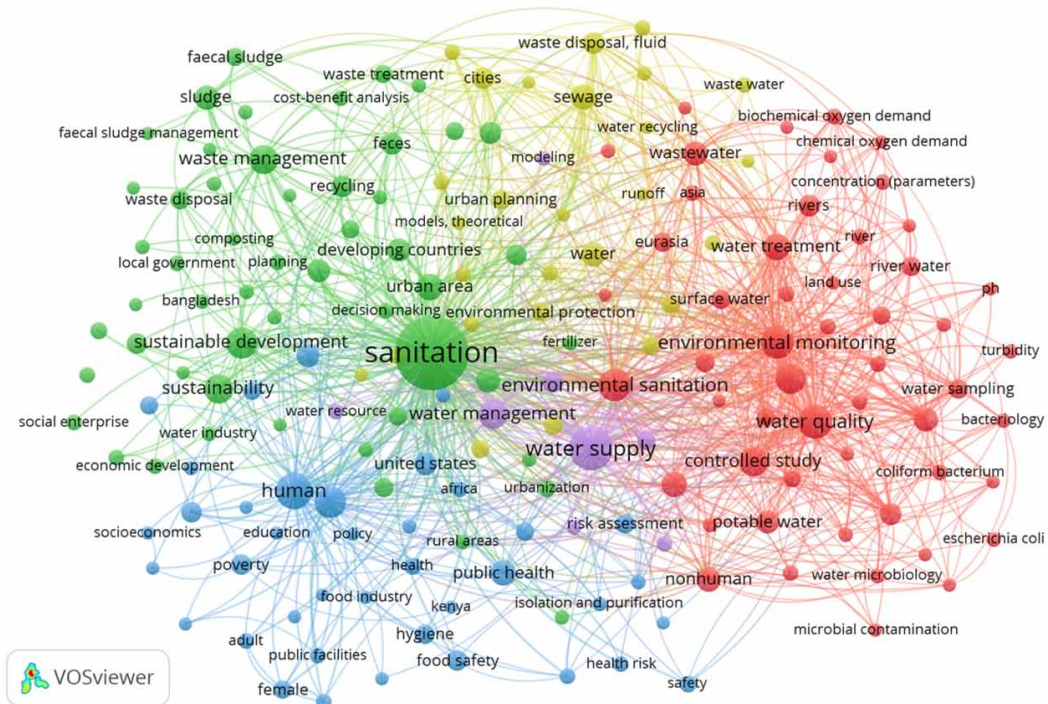
4.3 Keyword Co-Occurrence Network Analysis

A keyword co-occurrence network analysis is conducted to identify the commonly used terms in the literature. This type of analysis provides insights into the themes on which researchers have concentrated their work. The text-mining method in VOSviewer develops a map in which the distance between keywords indicates their relatedness (van Eck & Waltman, 2018). Studying network visualizations using VOS Viewer, a widely-used software for visualizing and analyzing networks, involves several key steps. Firstly, familiarize with the VOS Viewer interface and its functions for loading and importing network data. Next, create visualizations of the network data to gain an overview of the network structure. Then, explore various network properties using VOS Viewer’s features, such as node centrality and community detection. Customize visualizations by adjusting settings for node and edge appearance, and layout algorithm.

Finally, interpret and analyze findings in the context of research objectives, using VOS Viewer’s interactive features to further explore and analyze specific areas of interest within the network. Overall, VOS Viewer provides a powerful tool for effectively studying network visualizations and gaining insights from complex network data. The narrower the distance between two or more keywords, the stronger the connection between terms. Co-occurrences in the articles were examined to determine the relationship between keywords (Waltman et al., 2010).

As seen in Figure 4, researchers have used keywords like “water supply,” “environmental sanitation,” “human” “water quality,” “environmental monitoring,” “sustainability,” “sustainable development,” “waste management,” “sludge,” “controlled study” and “wastewater” in their work. We can notice that keywords related to entrepreneurship such as “social enterprise” are not a major highlight as only in recent years the approach towards sanitation is shifting from supply-driven to demand-driven. We have further discussed the keyword co-occurrences progression over different time frames in the content analysis section.

Figure 4. Keyword co-occurrence network visualization



4.4 Prominent Authors

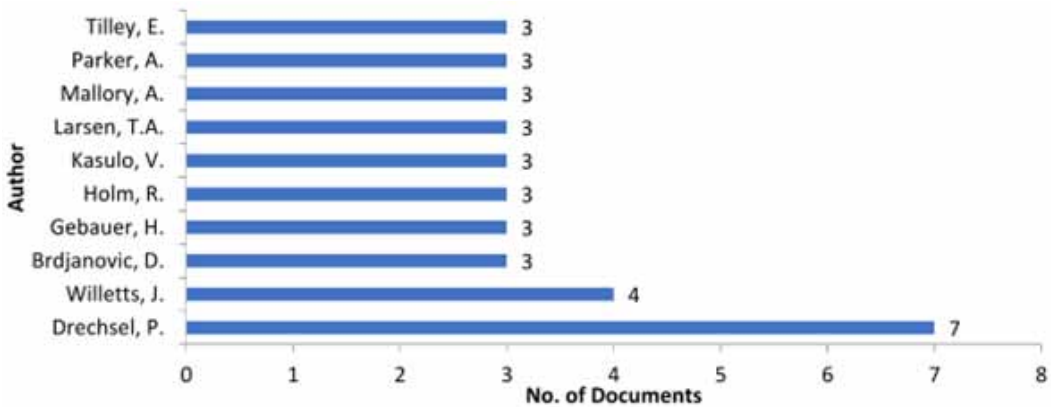
Figure 5 demonstrates the top ten authors in this domain. Pay Dreschel is the most contributing author to this field with seven publications. At present, the writer works at the International Water Management Institute (IWMI) Colombo as a Senior Fellow/Advisor specializing in Research Quality Assurance. Other notable authors have contributed at most four publications.

Pay Drechsel has emerged as a prominent Figure in the field of sanitation and entrepreneurship, making significant contributions through his research, practical applications, and policy advocacy. His work has focused on resource recovery and circular economy approaches, promoting innovative technologies and business models for turning sanitation waste into valuable resources for agriculture. Pay Drechsel has been a strong advocate for entrepreneurial approaches to sanitation, emphasizing the integration of economic incentives and employment opportunities into sanitation solutions. His policy advocacy efforts have influenced the development of guidelines and frameworks that promote sustainable sanitation practices. Furthermore, Pay Drechsel's capacity building efforts and interdisciplinary collaborations have fostered knowledge exchange and innovation in the field. Overall, his contributions have advanced the field of sanitation and entrepreneurship, promoting sustainable and economically viable solutions to address sanitation challenges.

4.5 Most Prolific Countries

The ecosystem of sanitation and entrepreneurship has drawn interest from several nations as it is a basic necessity that cannot be solely catered to by the government. Figure 6 demonstrates the top fourteen countries that have published at least ten papers. The United States is leading the charts regarding research inclination with 90 publications. The United Kingdom and India have also demonstrated high research interest in this field.

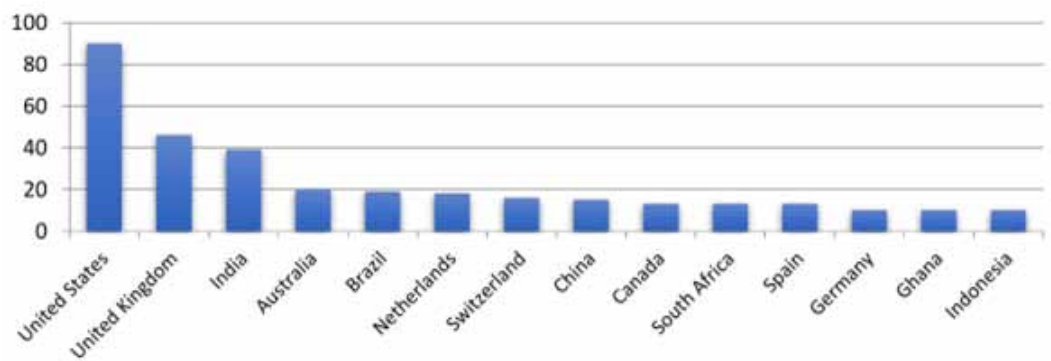
Figure 5. Top 10 authors with maximum publication on sanitation in the entrepreneurial ecosystem



The body of literature produced by the United States in the field of sanitation encompasses various types of publications, including research articles, reports, policy briefs, and technical guidelines. Within this corpus, several prominent themes have emerged, reflecting the evolving priorities and challenges encountered in addressing sanitation issues. One such theme is fecal sludge management (FSM), which focuses on sustainable and safe management of human waste in areas without access to centralized sewerage systems. U.S. publications have elucidated research findings, innovative technologies, and practical strategies related to FSM, encompassing on-site sanitation solutions, decentralized treatment options, and resource recovery from fecal sludge.

Another notable theme in U.S. publications on sanitation is urban sanitation, with an emphasis on tackling sanitation challenges in rapidly expanding urban areas. Publications from the U.S. have expounded on approaches to urban sanitation planning, infrastructure development, and service delivery models that are sustainable, inclusive, and equitable. These publications have highlighted the need for improving sanitation access and services in informal settlements and slum areas, addressing issues of social equity and environmental sustainability. Furthermore, U.S. publications on sanitation have also addressed the interconnections between sanitation and other global challenges, such as public health, gender equity, social inclusion, and environmental sustainability. These publications underscore the significance of integrated approaches that consider the broader socio-environmental context and acknowledge the interdependencies between sanitation and other developmental goals.

Figure 6. Top 14 countries who have published at least 10 papers in sanitation in the entrepreneurial ecosystem



4.6 Prominent Institutions and Sponsors

Figure 7 demonstrates the most prominent institutions that have contributed to research in this field. There has been much traction towards “sanitation” and “entrepreneurship,” with 160 institutions actively participating in publishing. The most notable institution in the field is the Eawag - Swiss Federal Institute of Aquatic Science and Technology. Other institutes such as University of Technology, Sydney, Cranfield University, and Delft University of Technology published at least 5 papers.

Eawag has made noteworthy contributions to the field of sanitation through their pioneering research, technological innovations, and policy advocacy. Eawag’s innovations include the development of advanced technologies for on-site and decentralized sanitation, such as urine-diverting toilets and nutrient recovery systems. Their research on fecal sludge management provides evidence-based guidance for safe and sustainable waste treatment and disposal practices. Eawag’s expertise also extends to the formulation of sanitation policies and governance frameworks, informed by their research findings. They engage in capacity building efforts through training programs and disseminate knowledge through scholarly publications and workshops. Additionally, Eawag actively collaborates with international partners to foster global cooperation in advancing sustainable and inclusive sanitation practices. Overall, Eawag’s contributions to the field of sanitation encompass a multidisciplinary approach, encompassing research, innovation, policy advocacy, capacity building, and international collaboration.

4.7 Highest Contributing Sponsors

According to Figure 8, The Bill and Melinda Gates Foundation is the leading sponsor in this field, having made the largest contributions to date. The organization works closely with government officials, business leaders, and technologists to drive the development of innovative toilet and waste treatment technologies, service delivery methods, and policies that have the potential to revolutionize sanitation standards and practices at both local and national levels. With a focus on collaboration and innovation, the foundation is committed to improving the lives and health of individuals and communities worldwide.

The foundation has been actively working in LMICs such as India, China and Africa on issues directly or indirectly related to sanitation. They advocate for safer sanitation through fecal sludge management, a sewer less strategy, and invest in citywide sanitation in underserved areas like

Figure 7. Most prominent institutions that have contributed to research in sanitation in the entrepreneurial ecosystem

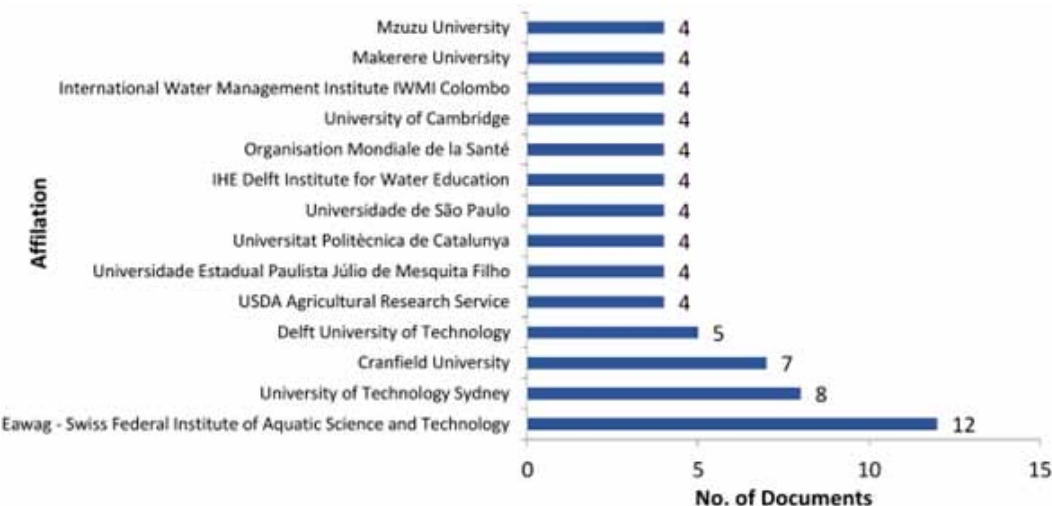
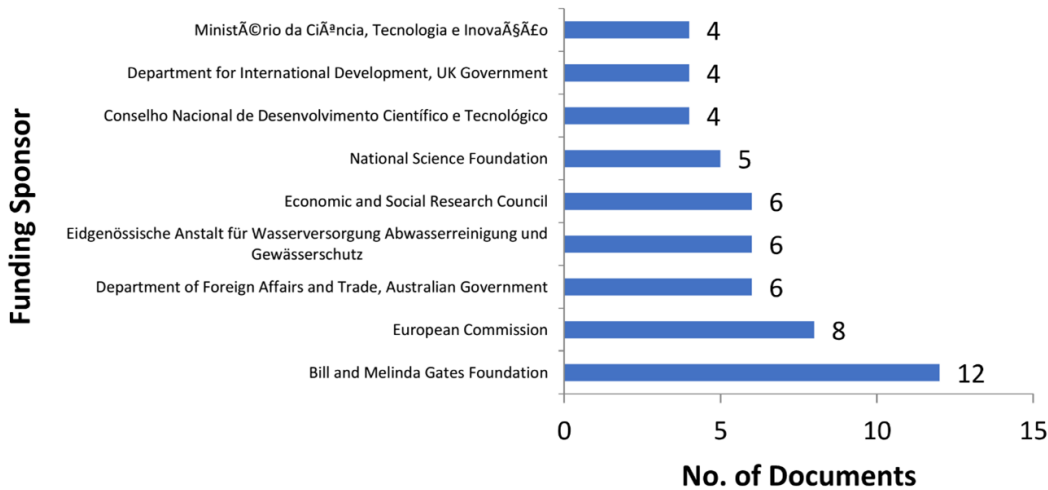


Figure 8. Most contributing sponsors towards sanitation in the entrepreneurial ecosystem



slums and informal settlements. The foundation also supports transformative technologies such as reinvented toilets and omni-processors that have the potential to revolutionize how human waste is managed at scale, with minimal reliance on water and electricity. Furthermore, they conduct research to generate data and evidence to inform effective strategies and approaches in the field of sanitation.

4.8 Papers With the Highest Number of Citations

Table 1 contains a list of the twenty most referenced papers based on Scopus content. The papers that had no clear connection to the study’s goal were excluded. The most cited paper totalling 117 citations is “marketing to subsistence consumers: Lessons from practice” which is published in the Journal of Business Research. This study looks at the techniques and methods that are now being used in subsistence markets by commercial and social enterprises. The findings lead to recommendations for current marketing methods utilised by corporations and organisations that are effective in subsistence markets. Other nineteen papers focused on keywords such as “resource recovery”, “waste management”, “water”, “public private partnerships”, “Industry 4.0”, “circular economy”, “sustainable development goals”, “scaling up”, “social businesses”, “developing markets”, “financial sustainability”, “wastewater management”, “economic development” and “paradigm shift”.

5. CONTENT ANALYSIS AND NETWORK VISUALISATION

Our next objective is to evaluate and analyse the content chronologically from 1997 till 2021, accounting a period of 25 years. As previously stated, the number of publications in the early years were quite low. Post 2007, the interest in this research domain picked momentum and experienced upward and downward trends ever since. In addition, we have divided the articles into six time periods with the constraint that we advance to the next period if the total number of articles published in a given period surpasses 60: 1997–2008, 2009–2011, 2012–2013, 2014–2017, 2018–2020, and 2021 are the time frames considered. Further, for network visualisation between the significant keywords discussed from time to time, VOSviewer software has been used.

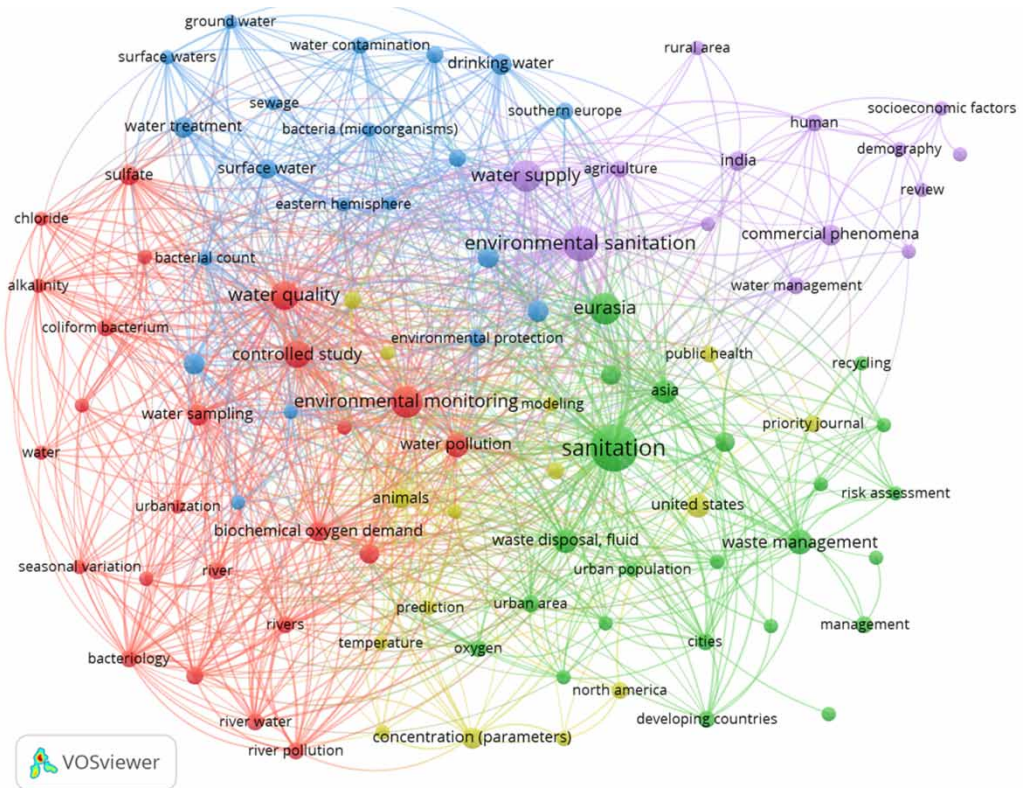
Table 1. Most referenced paper in sanitation and entrepreneurial ecosystem

S. No.	Document Title, Author, and Year of Publication	Total Citations
1	“Marketing to subsistence consumers: Lessons from practice” (Weidner et al., 2010b)	117
2	“A value proposition: Resource recovery from faecal sludge - Can it be the driver for improved sanitation?” (Diener et al., 2014b)	109
3	“Financial sustainability in municipal solid waste management - Costs and revenues in Bahir Dar, Ethiopia” (Lohri et al., 2014)	101
4	“City Blueprints: 24 Indicators to Assess the Sustainability of the Urban Water Cycle” (van Leeuwen et al., 2012b)	93
5	“Capital and operating costs of full-scale fecal sludge management and wastewater treatment systems in Dakar, Senegal” (Dodane et al., 2012)	79
6	“Industry 4.0 based sustainable circular economy approach for smart waste management system to achieve sustainable development goals: A case study of Indonesia” (Fatimah et al., 2020c)	76
7	“Reuse of domestic greywater for the irrigation of food crops” (Finley et al., 2008)	70
8	“Bathroom greywater characterization and potential treatments for reuse” (Chaillou et al., 2010)	62
9	“Youth, waste and work in Mathare: Whose business and whose politics?” (Thieme, 2010)	56
10	“Environmental Assessment of Sewer Construction in Small to Medium Sized Cities Using Life Cycle Assessment” (Thieme, 2010b)	43
11	“The 2011 Toilet Wars in South Africa: Justice and Transition between the Exceptional and the Everyday after Apartheid” (Robins, 2014)	42
12	“Making urban excreta and wastewater management contribute to cities’ economic development: A paradigm shift” (Koné, 2010)	41
13	“Strategies for building resilience to hazards in water, sanitation and hygiene (WASH) systems: The role of public private partnerships” (Johannessen et al., 2014b)	36
14	“Why small and medium chemical companies continue to pose severe environmental risks in rural China” (He et al., 2014)	36
15	“A spatial analysis of pit latrine density and groundwater source contamination” (Wright et al., 2012)	36
16	“Assessment of groundwater quality in Puri City, India: An impact of anthropogenic activities” (Vijay et al., 2010)	36
17	“Scaling up social businesses in developing markets” (Bocken et al., 2016b)	35
18	“Unravelling the Linkages Between Water, Sanitation, Hygiene and Rural Poverty: The WASH Poverty Index” (Giné Garriga & Pérez Foguet, 2013)	35
19	“Pollution and self-cleansing of an urban river in a developing country: A case study in Dar es Salaam, Tanzania” (Mbuligwe & Kaseva, 2005)	34
20	“Motivating metrics for household water-use feedback” (Liu et al., 2015)	33

5.1 Insights From the Year 1997-2008

In the time-period of 1997-2008, researchers reported 62 papers. The keyword highlighted in these papers are described in Figure 9. The major themes in these years were “water supply”, “water quality”, “water pollution”, “waste management” and “environmental sanitation”. In the first theme, which is “water supply”, terms like “drinking water”, “water contamination”, “sewage”, “surface water”, “water treatment”, “eastern hemisphere” and “bacteria” have been majorly mapped. The second theme “water quality” consists of concepts like “bacterial count”, “sulfate”, “chloride”, “alkalinity”, “coliform bacteria”, and “water sampling”. In the third theme “water pollution”, concepts like “urbanization”,

Figure 9. Visualization of the keyword co-occurrence network from 1997 to 2008



“biochemical oxygen demand”, “river pollution”, “seasonal variation” and “temperature” have been marked. The fourth theme involves topics such as “risk assessment”, “priority journal”, “recycling”, “public health”, “management”, “waste disposal, fluids”, “urban area”, “public health”. Besides this, the fifth theme “environmental sanitation” consists of concepts such as “rural area”, “agriculture”, “human”, “socioeconomic factors” and “water management”.

Evidently, research in this phase on sanitation in the entrepreneurial ecosystem was focused only on the sanitation aspects. Hirschowitz and Orkin (1997) noted fundamental issues in South Africa as inequality and relative impoverishment. Africans had poorer access to water, sanitation and electricity. Cross and Morel (2005) identified that it was becoming challenging for water utilities in Africa to provide adequate services to deprived areas. Global development programmes were sought to be essential to eliminate historical disparities. Zeytoun (2000) in the early 2000s foresaw that the world will need to spend \$600 billion to \$800 billion on water, sanitation, irrigation, and electricity in the next decade. Tumwine et al. (2003) researched that more people use toilets in urban areas than in rural areas.

Abey Suriya et al. (2007) concluded that sanitation services in underdeveloped Asian nations did not meet the human right to a standard of living that is compatible with dignity and health. Pujari et al. (2007) noted that in urban cities in India, on-site sanitation was being gradually adopted, posing a greater danger to groundwater supplies in the vicinity of the system. The absence of adequate sanitation, unprotected river locations, and a high degree of anthropogenic activity were cited as the primary causes of water quality degradation (Avvannavar & Shrihari, 2007).

Buttenheim (2008) looked into impact of increased cleanliness on children’s health in metropolitan Bangladesh. Evidence showed that toileting for children matters more than toilet

behaviour for adults. Osunianu (2008) concluded that without government participation, stakeholder control, and strong support for community-driven initiatives, no real change in water and sanitation service can occur.

5.2 Insights From the Year 2009-2011

A total of 69 papers were published between 2009 and 2011. Figure 10 shows the keyword co-occurrence analysis of these papers. The major themes observed in this period are “water supply”, “water quality management”, “water pollution”, “environmental monitoring” and “sustainable development”. In the first theme “water supply”, some new sub topics have emerged such as “ground water”, “nitrate”, “iron”, “effluents potable water” and “fertilizer”. The second theme “water quality management” consist of “water quality monitoring”, “coliform bacteria”, “E.coli”, “health risk”, “bacteria”, “turbidity” and “numeric world”. In the third theme “water pollution”, sub-topics are “non-human”, “waste water”, “health risk”, “phosphorus”, “recycling” and “microbial contamination”. The fourth theme “environment monitoring” consists of concepts like “environment assessment”, “effluents”, “metropolitan area”, “quality control”, “feces”, and “eutrophication”. The last theme “sustainable development” consists of sub-topics from entrepreneurial perspective which are “management”, “stakeholder”, “cost benefit analysis”, “urban planning”, “policy making”, “human”, “public facilities”, “methodology”, “models” and “developing world”. It can be seen how the major themes were evolving more towards business perspective. Some of the subtopics are similar as in

Figure 10. Visualization of the keyword co-occurrence network from 2009 to 2011

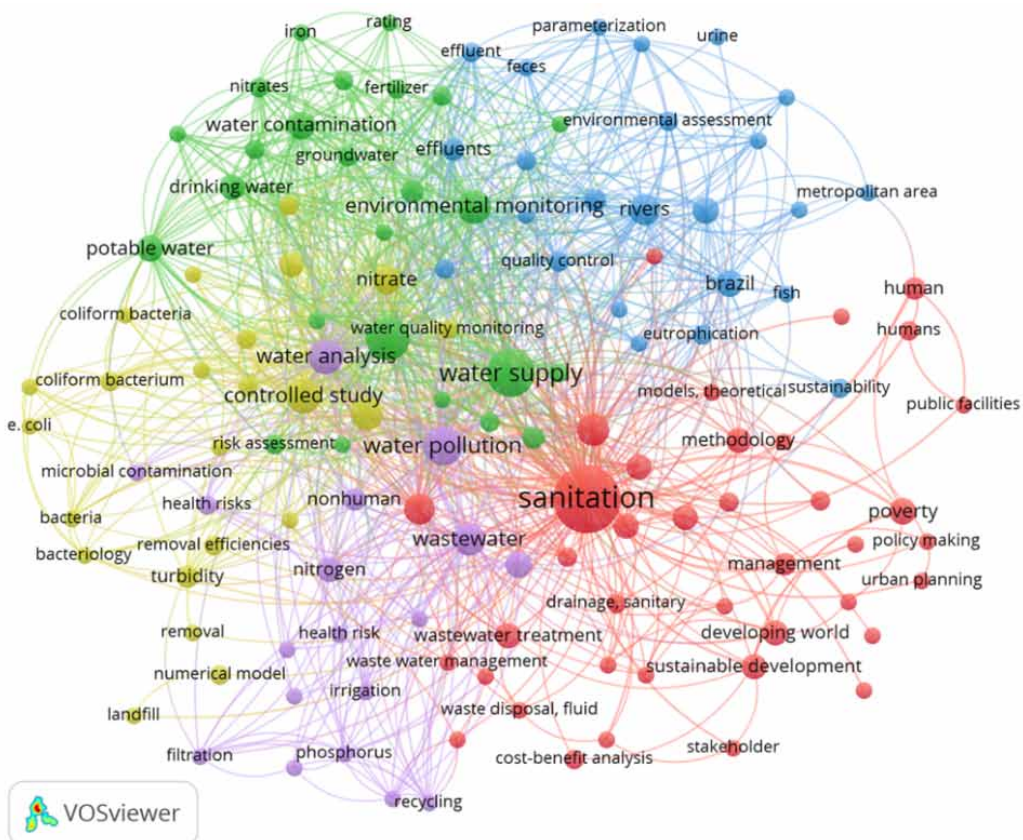


Figure 9. Figure 10 and 11 show how the subtopic “human” in “sustainable development” emerged as major theme.

Weidner et al. (2010) recognized that more than 4 billion individuals reside in substandard housing, lack access to proper sanitation, safe drinking water, and healthcare, have limited education, and earn low incomes. Inadequate sanitation was identified by the World Health Organization as the primary cause of numerous child deaths around the globe, and the advancement of sanitation delivery fell considerably behind the other objectives of the millennium development goals (MDGs). Small private suppliers, typically very local, dominated the sanitation market (Schaub-Jones, 2010).

Foppen and Kansime (2009) recognized that although Africa is reported to be the least urbanized continent, it has the highest rate of urbanization. Turrén-Cruz et al. (2019) focused their research on finding the most sustainable strategies for sanitation in urban slums. Erni et al. (2009) identified that farmers in developing countries face highly contaminated surface water due to inadequate urban sanitation.

Nauges and van den Berg (2010) analyzed the cost structure of water utilities across 14 nations with varying levels of economic growth. Adams et al. (2010) identified that in the water sanitation network, *Legionella*'s risk has led to creating a new business combining technological aspects and bacteriological control. Leong and Hancer (2010) recognized that that in order for students to be effective in a global business environment, they will require theoretical knowledge, skills, and competencies. Expertise in sanitation protocols, multinational operations, and international leadership were also cited as essential.

The concept of multi-stakeholder partnerships was first introduced at the World Summit on Sustainable Development held in Johannesburg in 2002. The water and sanitation industry has the greatest number of such partnerships in practice (Wertz et al., 2010). There is an unexplored potential for public-private partnerships that focus on recovering costs through the reuse of human waste. (A. Murray et al., 2011).

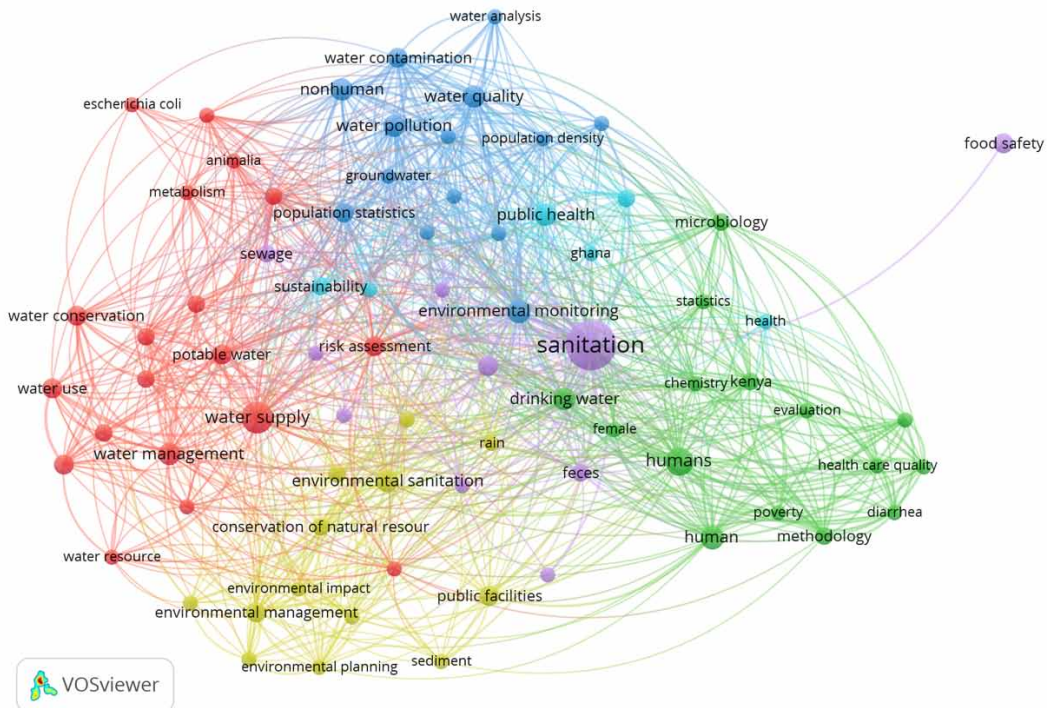
5.3 Insights From the Year 2012-2013

In the phase of 2012-2013, 63 papers have been reported. The network visualization of the these papers is presented in Figure 11. The major keywords identified are “water supply”, “water quality”, “human”, “environmental sanitation”, and “environmental monitoring”. The first theme “water supply” consists of sub-topics such as “potable water”, “water management”, “water use”, “water resources”, “water conservation” and “*Escherichia coli*”. The second theme which is “water quality” consists of terms like “water pollution”, “water contamination”, “population statics” and “sewage”. The third theme “human” consists of “poverty”, “methodology”, “diarrhoea”, “health care quality”, “evaluation”, “statistics” and “drinking water”. The fourth theme “environment sanitation” involves topics such as “conservation of natural resources”, “environmental impact”, “rain”, “environmental planning”, “environmental management”, “public facilities”, and “sediments”. The last theme based on “environment monitoring” shows how “public health”, “sustainability”, “Ghana”, and “population statistics” are mapped. This demonstrates that new research segments emerged between first and the second period of our analysis.

Climate change, population expansion, rising consumption and urban development have been highlighted as the primary causes of growing pressure on water management (van Leeuwen et al., 2012). On-site sanitation has become the primary method of sanitation in cities that are rapidly urbanising. However, this technique has severely harmed groundwater, notably its quality (Pujari et al., 2011).

The supply-driven approach used in water supply and sanitation operations does not meet customer demands (Baye et al., 2012). Systems face underuse concerns, inadequate maintenance, and insufficient cost recovery. Capacity building and empowerment methods were included in the measures conducted to cause communities to demand sanitation and hygiene services (Kariuki et al., 2012).

Figure 11. Visualization of the keyword co-occurrence network from 2012 to 2013



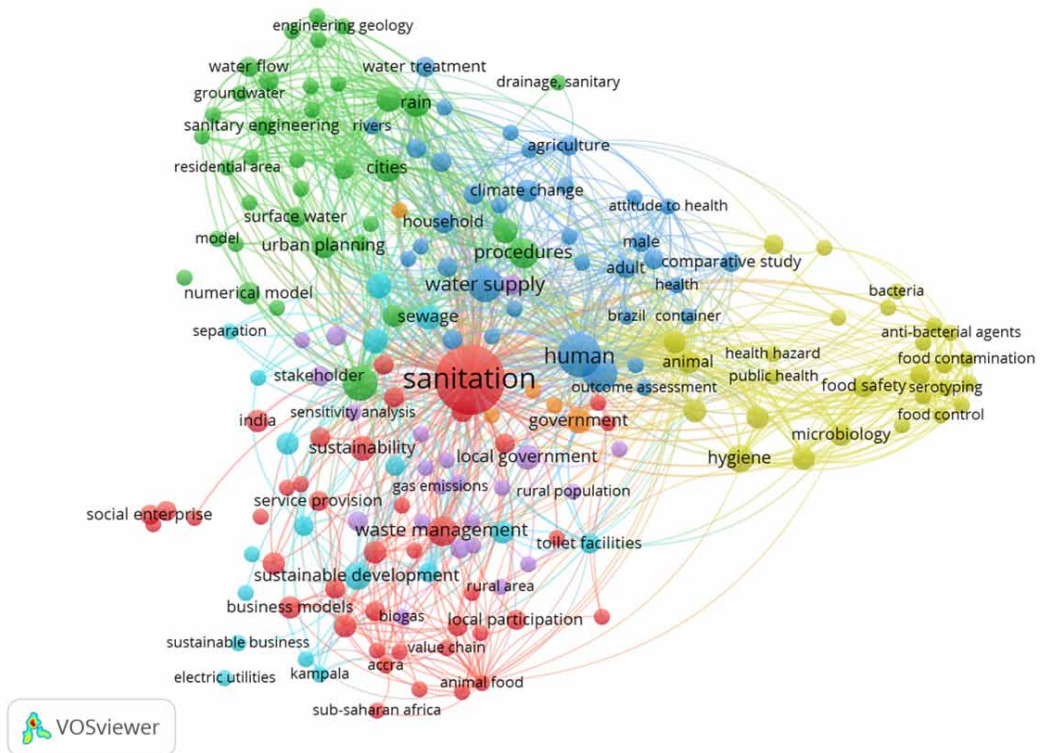
Due to their potential detrimental effects on both humans and natural environments, there was growing concern about the rising trend of new micropollutants in the environment. The situation has given rise to the likelihood of people being exposed to the adverse effects of inadequate access to clean water and proper sanitation, particularly in countries where a significant proportion of the population still faces such challenges (O. Tijani et al., 2013).

5.4 Insights From the Year 2014-2017

A total of 68 publications were published between 2014 and 2017. In Figure 12, the keywords of these works are highlighted. The major themes are “hygiene”, “urban planning”, “human”, “waste management” and “sustainable development”. The first theme “hygiene” consists of terms such as “health hazard”, “public health”, “food control”, “food contamination”, and “bacteria”. In the second major theme “urban planning”, sub topics are “engineering geology”, “water flow”, “sanitary engineering”, “stakeholder”, “residential area”, and “drainage system”. The third theme “human” involves updated sub topics from Figure 3. In the following theme sub topics such as “climate change”, “attitude to health”, comparative study”, “water treatment”, and “health” have been mapped. The fourth theme “waste management” has grown more towards the entrepreneurial perspective. It includes sub-topics such as “local participation”, “value chain”, “business model”, “service provision”, “social enterprises”, “sustainability” and “food safety”. Besides this, the fifth theme “sustainable development” involves the sub topics such as “sustainable business”, “electric utilities”, “toilet facilities”, and “separation”. Hence, Figure 12 describes a lot of private sector involvement with planning and innovation.

In recent decades, the right to water and sanitation has gained prominence and is no longer overshadowed by other related rights (Satterthwaite, 2014). Meier et al. (2014) discussed challenges in implementing human rights-based water and sanitation policies. Fred et al. (2014) indicated that lessons

Figure 12. Visualization of the keyword co-occurrence network from 2014 to 2017



learned from Ghana's past sanitation strategy necessitate the need for public-private collaboration in sanitation management. Johannessen et al. (2014) introduced several public-private partnership (PPP) initiatives to strengthen resilience in water, sanitation, and hygiene (WASH) systems.

Micro, small, and medium-sized private and social enterprises have become key players in the water, sanitation and hygiene sectors (Gero et al., 2014). Lohri et al. (2014) identified that the financial viability of the solid waste management scheme outsourced to a private waste firm in Bahir Dar resulted in a large annual shortfall that needs to be resolved to prevent the collapse of public-private partnerships (PPP). R. Holm et al. (2014) identified the opportunities, barriers, and threats in taking up sanitation as a business. Diener et al. (2014) examined the potential for resource recovery from novel methods of fecal sludge treatment.

London and Esper (2014c) noted that the quality of life for billions of individuals at the base of the pyramid (BoP) in developing countries is adversely impacted by inadequate sanitation. Their research leads to a deeper understanding of measuring the efficacy of a sanitation intervention and analysing the impact of an enterprise-led strategy on poverty alleviation. Gebauer, Haldimann, et al. (2017) explored how having a variety of business models can be crucial for success in base of the pyramid marketplaces.

Ushijima et al. (2015) suggested a postmodern sanitation concept aimed at addressing the world's sanitation issues by creating a sanitation value chain that generates and increases the value of human excreta and incentivises individual users. Bocken et al., (2016) explored the scaling of social enterprises through market penetration, market growth, product development, and diversification. Rao et al. (2020a) explored that a business model where benefits are accrued by resource recovery and reuse (RRR) can fund upstream sanitation services. Tobias et al. (2017) pointed out that while

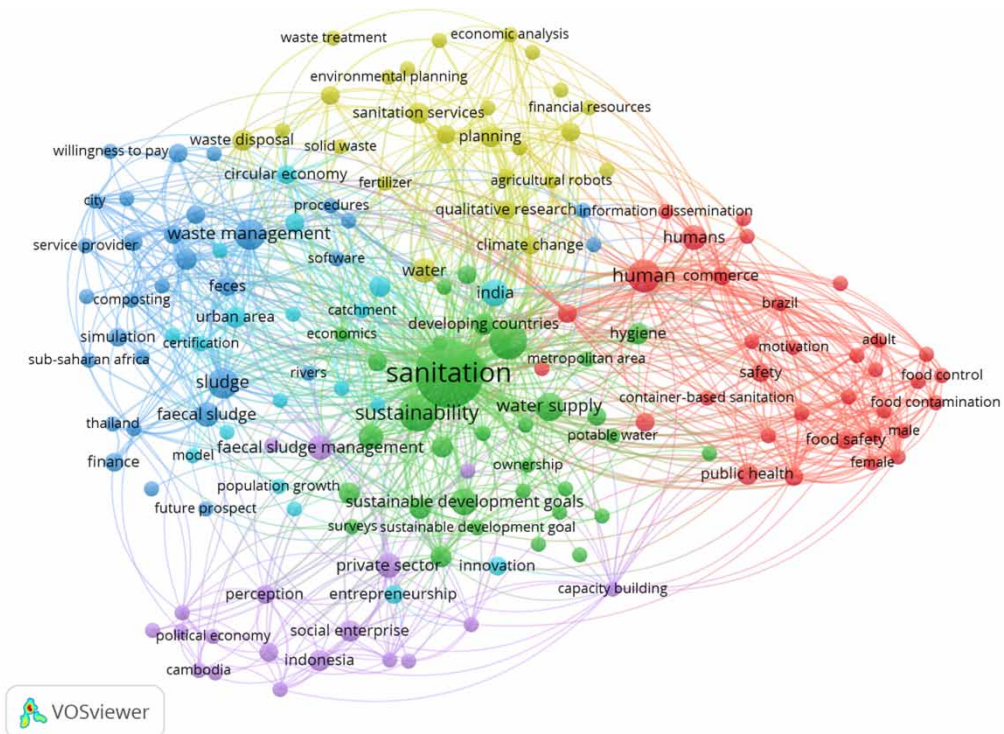
there are proposals for affordable and sustainable sanitation systems, they are still in the early stages of development and need to be tested for acceptability and feasibility.

5.5 Insights From the Year 2018-2020

In the phase 2018-2020, 78 papers have been reported. The keyword highlights are networked in Figure 13. The major themes in these papers are “sanitation service”, “sustainability”, “human”, “waste management”, and “private sector”. The first theme, “sanitation service” consists of subtopics such as “environmental planning”, “financial resources”, “qualitative research”, “fertilizer”, “solid waste”, “economic analysis” and “waste disposal”. The second theme “sustainability” involves subtopics such as “economics”, “developing countries”, “sustainable development goals”, “surveys”, “potable water” and “ownership”. In the third theme “human” concepts like “commerce”, “Brazil”, “motivation”, “food contamination”, “food control”, “container-based sanitation”, “dissemination” and “safety” are networked. The fourth theme “waste management” has evolved from basic terminologies to method development. It has progressed to concepts such as “willingness to pay”, “waste disposal”, “service provider”, “finance”, “fecal sludge”, “urban area”, “procedures” and “circular economy”. The fifth theme, “private sector” involves subtopics such as “innovation”, “social enterprise”, “capacity building”, “perception”, “political economy” and “fecal sludge management”. This shows how the research on sanitation’s entrepreneurial ecosystem developed over time, from identifying the issue to developing a sustainable business plan with involvement of private sector.

Murta et al. (2016) found that the lack of consumer demand, inadequate capacity building possibilities, a lack of funding choices, and low government support were the main problems affecting the viability of rural Indonesian sanitation firms. Privatization of sanitation services can profit from the local government’s inability to meet demand, as Holm et al. (2018) pointed out in their study.

Figure 13. Visualization of the keyword co-occurrence network from 2018 to 2020



Indarti et al. (2019) looked at the experiences of 18 women business owners, community organisers, and public sector workers who worked on projects related to water, sanitation, and hygiene (WASH).

Mallory, Akrofi, et al. (2020b) qualitatively investigated the challenges and prospects of shifting towards more sustainable systems by studying five distinct Circular Economy (CE) techniques for sanitation in India. Mallory, Holm, et al. (2020c) collected and analysed 112 financial values of resource recovery from 43 scholarly and grey literature articles. Fatimah et al. (2020a) observed that advancements in Information and Communication Technology (ICT) and the Internet of Things (IoT) have enabled a new generation of techniques that can enhance the efficiency and effectiveness of the global waste management system in developed countries. In a similar vein, Moya et al. (2019) investigated projects that utilize container-based sanitation methods to produce and sell human excreta fertilizers, while Rao et al. (2020a) provided insights into the business models that have been established in various regions of India, with recommendations for scaling up sustainable faecal sludge management (FSM). These studies showcase practical examples of sanitation solutions that employ diverse stakeholder organizational strategies, all with a strong emphasis on sustainability.

5.6 Insights From the Year 2021

In 2021, 35 papers were published, showing the growth in the sanitation entrepreneurial ecosystem. The major co-occurrence keywords are highlighted in Figure 14. The major themes networked are similar in Figure 13 i.e. “sustainable development”, “human”, “waste management”, and “private sector”. In first theme “sustainable development” sub-topics such as “entrepreneurship”, “cost benefit analysis”, “peri urban area”, “sustainable development goals”, “human resource management”, environmental economics”, and “resource recovery” are involved. The second theme “human” consists of different sub topics as in Figure 13. The research reported revolves more around covid-19. The sub topics such as “commercial phenomenon”, “covid 19 pandemic”, “innovation”, “social enterprise”, “water”, and “environmental impact” are linked. In the third theme “waste management”, the concepts mapped are “public health”, “economic aspects”, “food waste”, “investment”, “pandemic”, “plastic waste” and “social distancing”. Besides these, a newly emerged theme in Figure 13 and Figure 14 “private sector” consists of concepts like “practice guidelines”, “fecal sludge”, “domestic waste”, “cities”, and “sewage”.

Amoah et al. (2021a) provided actual business scenarios demonstrating that a variety of business models may be used to achieve safe water reuse for fish production, with varying degrees of fish-water interaction to protect public health. Tommy et al. (2021) examined the gap between CSR and SDGs through an analysis of the yearly financial statements of non-financial firms listed on the Indonesian Stock Exchange (IDX) and the companies’ sustainability reports.

Bagire et al. (2021c) emphasised a prescriptive approach derived from action research involving several partners in a project aimed at developing businesses into sustainable enterprises using the RRR waste management model. Goyal et al. (2020) demonstrates how social enterprises may assist in meeting socioeconomic requirements at the base of the pyramid and contribute to the achievement of the SDGs.

6. DISCUSSION

The literature review provides a detailed analysis of sanitation and its entrepreneurial ecosystem evolution. Initially, the literature revealed meagre studies from an entrepreneurial perspective of the sanitation industry but in the last decade, there has been an exponential rise in the field. From Figure 9 to Figure 14, the research has been seen emerged from identifying the real issues of sanitation then providing the sustainable development plans as theoretical models and innovations with the help of involvement from private sector. In the period of 1997-2008, 2009-2011 and 2012-2013, broad sanitation concerns such as “water quality,” “waste management,” and “hygiene” are addressed. In

Figure 14. Visualization of the keyword co-occurrence network of the year 2021

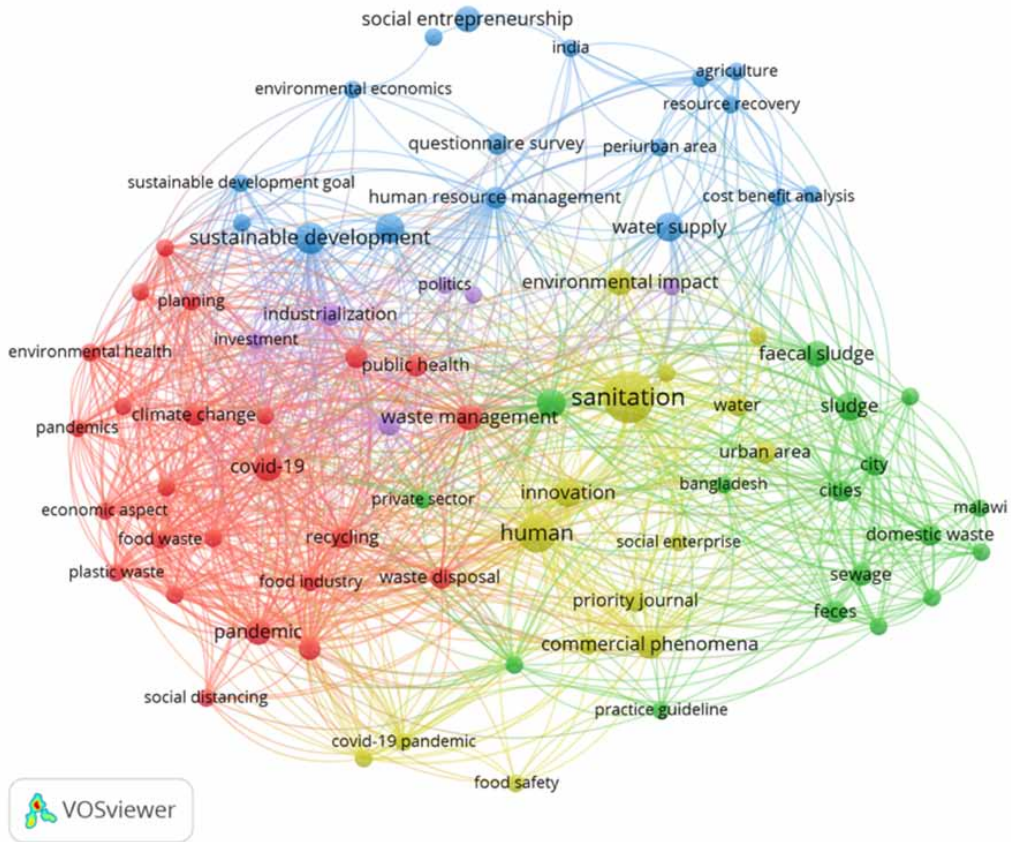


Figure 12, i.e. between 2014 and 2017, academics focused on concerns of “ownership,” “innovation” and “sustainable business”. The support requirement as “local participation” with “business models” in “waste management” are called attention to. In 2018-2020 and 2021, participation of “private sector” is emphasized with support as “practice guidelines” and “political economy”.

It can be seen that initially “sustainable development” is a major theme while “human” and “stakeholder” are within sustainable development. In due course of time “human” and “private sector” evolved as major themes. Between 1997 and 2008, no significant changes occurred in the study’s focus on sanitation, but some significant themes emerged, including “urban planning” and concepts such as “models”, “theoretical”, “statistics”, “policy making” and “socioeconomic”, all of which fall under the umbrella of “sustainable development.” In the period of 2009-2011, “sustainable development” has been introduced in “sanitation” and a great emphasis is placed afterwards. It is 2018 and onwards, when the sanitation services are boosted with an idea of “private sector” involvement.

Many researchers have reported wide range of methodologies, innovations and theories to resolve the sanitation voids sustainably. Medeiros et al. (2021) introduced the concept of urine recovery as a means of promoting multi-sectoral integrated resource management. This approach helps to conserve natural resources, prevent pollution, and utilize urine as a fertilizer to optimize the water-energy-nutrient nexus. Singh et al. (2021) investigated the private sector's involvement in the faecal sludge emptying and transportation business and conducted a financial study of enterprises in

Khulna, Bangladesh. The findings have led to the clear recognition of the benefits of private sector involvement by policy, institutional, and regulatory frameworks. The advantages include resource mobilization to meet increasing investment needs, service cost reduction through competition, and enhancement of efficiency and innovation. Dirix et al. (2021) demonstrated that it is possible to achieve sustainable closure of the sanitation chain in a low-income and vulnerable country such as Madagascar, while also catering to the needs of the lowest socioeconomic class. They describe the creation of a treatment facility that incorporates planted humification beds and the private sector's management process to enable sustainable utilization.

Moving to cultural beliefs in sanitation practices such as use of human waste as a source of fertilizer, researchers have pin down several factors influencing it and several methodological issues were identified. Burt et al. (2021c) have created a preference-ranking model to understand the characteristics of faecal sludge-derived fertiliser that lead to its acceptability in Karnataka, India. They utilised standard economic models to discover cultural behaviours and power imbalances at the heart of the waste industry. Chitrao (2020b) bridged the gap by locating and combining published research on farmers' readiness to pay for human excreta-derived agricultural material. Gender, education and experience were shown to be common factors influencing farmers' willingness to pay. According to the research, pelletization, fortification, labelling, packaging and certification are all important aspects of product creation. Commercialization on a large scale can be accomplished by incorporating context-specific socioeconomic, religious and cultural impacts on the assessment of readiness to pay.

Numerous studies also highlight the role of government in policy formulation and operational guidelines. Aguilar et al. (2022b) offered a framework for strengthening government ability to conduct resource recovery from organic waste streams in the municipality of Chía, Colombia, through a participatory approach including local stakeholders. Mpanang'ombe et al. (2021b) discussed how subsidies could be proposed as a way to boost pit emptying in low-income communities. Gero and Willetts (2020) highlighted the role of government in securing the conducive environment of water, sanitation and hygiene (WASH) markets. Their findings show that local governments can play a role in supporting businesses through training and business development.

8. CONCLUSION

This study aims to analyse 25 years of Scopus-indexed literature on entrepreneurship in sanitation. The article selection procedure and the analysis methods have been organised in a systematic framework (Figure 1). Further, bibliometric analysis is applied to determine the impact of journals, authors, nations, institutions and funding sponsors in the domain. In addition, an extensive content analysis has been incorporated, which has been divided into categories based on the publishing volume in concurrence with different time periods. It presents the global perspective through the lens of several authors across time (Figure 5-11). According to the findings of the study, there is a proliferation of research in the field (Figure 2), and the past five years have been particularly significant since the orientation towards entrepreneurship has intensified.

This review sets a standard for future cutting-edge research by providing an overview of the most significant studies in an interdisciplinary field. Its aims to assist researchers in identifying broad research gaps in the reported literature and provide a direction for future study in the broad fields of sanitation and entrepreneurship. The agenda for future research has been elaborated in Table 2.

Table 2. Agenda for future research on the entrepreneurial ecosystem of sanitation

Paper Title	Research Questions
(Adewunmi et al., 2023)	<ul style="list-style-type: none"> • What multi-stakeholder approaches can be adopted to recycle waste for co-production of public services in informal settlements?
(Costanza, 2022)	<ul style="list-style-type: none"> • How can we investigate the mental models of a wider number of key informants, investing suppliers and institutional stakeholders?
(Ramanadhan et al., 2022)	<ul style="list-style-type: none"> • How can we make stakeholder engagement less challenging for highly technical solutions? How can local intermediaries become more resilient towards disconnects to support engagement?
(Aguilar et al., 2022)	<ul style="list-style-type: none"> • Which of the various stakeholders should be in charge of monitoring the development of governance capacity? • In what ways may insights from governance capacity assessments be effectively integrated into local urban planning processes, and what are the ramifications for waste resource recovery?
(Mooijman et al., 2021)	<ul style="list-style-type: none"> • Is there a way to transform the externally funded project into a self-sustaining and profitable social enterprise? Is it possible to raise the budget to enhance marketing activities further?
(Mpanang'ombe et al., 2021)	<ul style="list-style-type: none"> • What explicit and implicit criteria can be employed in the market for selecting customers? • What is the impact of these explicit and implicit criteria on service levels and pricing?
(Amoah et al., 2021)	<ul style="list-style-type: none"> • How to forecast and control the damage caused by industrial wastewater to water animals and find out its impact on food chain?
(Olusanmi et al., 2021)	<ul style="list-style-type: none"> • What factors can help corporate organizations to improve their business in wastewater management?
(Mallory et al., 2020)	<ul style="list-style-type: none"> • In the short to medium term, how can we find a balance between the increased value of the circular economy for sanitation and the new problems it brings?
(Mallory, Holm, et al., 2020)	<ul style="list-style-type: none"> • How can we estimate the costs of fecal sludge management and sanitation provision?
(Fatimah et al., 2020b)	<ul style="list-style-type: none"> • How to outline the potential success of SDGs while employing waste management?
(Bagire et al., 2021)	<ul style="list-style-type: none"> • How to motivate the researchers and scientists to develop new technologies or systems specifically for the RRR/FS sector? • How can we close the awareness gap among residential consumers on briquettes?
(Burt et al., 2021)	<ul style="list-style-type: none"> • How can innovations in treatment technologies and business models be made when stigma and sustainability are taken into account? For example, how can caste-based differences, non-transparent practises, and unsafe waste handling, which are typical of informal reuse today, be eliminated?
(Filimonau, 2021)	<ul style="list-style-type: none"> • How can waste management in the hospitality industry be improved by using new ways to procure food that are better for the environment and can be adapted to disasters?

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