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A Bibliometric Analysis on SDG 14: Life below water

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Abstract. *Particularly when it comes to marine conservation, climate change and sustainable management have become major global concerns. The preservation of marine biodiversity and the fight against ocean pollution are at the heart of Sustainable Development Goal 14 (SDG 14)—Life Below Water—which is covered in this report. The historical backgrounds of marine conservation, the development of global programs, and India's role in promoting marine sustainability are all covered. The most significant study findings, problems, and suggestions for improving marine health are found through a thorough evaluation of the literature. To assess research trends, key contributors, and emerging themes in SDG 14 research, the paper employs bibliometric analysis. The results demonstrate that while regulations for marine conservation have advanced, there are still gaps in managing ocean acidification, adopting sustainable fishing, and integrating indigenous knowledge. This study helps create well-informed plans for accomplishing SDG 14 and guaranteeing long-term ocean sustainability by comprehending these research trends.*

Keywords: Marine, ocean, sustainability, conservation, research, SDG 14, biodiversity, pollution, climate, management, resources, development, ecosystem, collaboration, fishing.

1. Introduction

The limitless and mysterious world beneath the ocean's surface has fascinated people for more than a millennium as a source of wonder, creativity, and sustenance. From ancient societies that worshipped sea gods and goddesses in Mesopotamia, Egypt, the Indus Valley, China, and Greece to modern scientific research aimed at conserving marine biodiversity, the history of life beneath the surface is one of both wonder and exploitation. In 2015, the United Nations introduced SDG

14: Life Below Water to its list of Sustainable Development Goals (SDGs) in order to safeguard marine life and preserve it for future generations. However, the knowledge and conservation of life underwater have centuries-old roots in early literature, ancient history, and ancient policies.

Historical perspective

Marine life has its roots in ancient societies, when bodies of water were and still are revered as sacred and pure. The legends of Lord Vishnu's Matsya Avatar in ancient Bharat depict a fish-shaped savior who defends knowledge, humanity, and the delicate life on Earth from the looming natural tragedy of floods. In a similar vein, ancient societies such as the Mesopotamians worshipped Enki. Poseidon, the sea deity, was revered in Greek mythology. The significance of water and marine life is demonstrated by this inference. The vast descriptions of underwater aquatic life can be found in Greek literature. Many people believe that Aristotle founded modern biology. More than 500 marine species have been documented. And the sea's innumerable literary works.

Primitive Conservation and Global

Initiatives, With the goal of becoming wealthy and strong, the 19th and 20th centuries saw a sharp rise in the large-scale exploitation of maritime resources. The International Council for the Exploration of the Sea was established in 1902, marking the world's first initiative. The International Convention for the Regulation of Whaling, which aimed to stop the unsustainable hunting of whales, came next. With the formal approval of a framework for marine resource management at the United Nations Conference on the Law of the Sea in 1958, the organization played a major role in ocean governance. The United Nations acknowledged the effects of pollution on the maritime environment in 1972. Nonetheless, the drive to rescue lives underwater accelerated in the latter half of the 20th century and persisted into the 21st.

Life Under Water was implemented in 2015 as a component of the United Nations' 2030 Sustainable Development Agenda. To promote sustainable development, it focuses on tackling marine pollution, the ocean, seas, and marine resources. With a 7,517-kilometer coastline, India is an important contributor to the conservation of marine life and a rich, varied aquatic ecosystem. The nation's maritime industry contributes significantly to the food chain and sustains millions of livelihoods. At the moment, India is the world's biggest exporter of fish. In order to boost employment nationwide and encourage economic growth in coastal areas where the economy is mostly reliant on the oceans and other bodies of water, the current budget is also concentrating on improving these natural gifts.

Pollution, overfishing, coastal erosion, eutrophication, habitat degradation, and global warming are some of the issues that must be addressed. To preserve the marine ecology and encourage its growth, the Indian government has implemented a number of conservation initiatives and is also following the UN Sustainable Development Goals.

It is clear that sustainable development must be given top priority; SDG 14 is especially concerned with Life Below Water. Maintaining sustainability through the use of the sea, the ocean, and marine resources is the purpose. In addition to reducing, we must maintain the ocean and save marine life

and coastal ecosystems. Through a thorough literature review, this initiative aims to comprehend the crucial elements of SDG 14. This review will shed light on the current state of underwater life, the primary threats to it, and the measures being taken to mitigate those threats. The review will assist us in identifying research knowledge gaps and areas that would be worthwhile to pursue in the future. with the ultimate objective of contributing to the worldwide endeavor to accomplish SDG 14 and guarantee the sustainability and long-term health of our oceans. Through this inquiry, the project wishes to stress ocean health and international sustainability as the same, pointing out the fact.

Research Gap—While a number of studies have addressed the importance of SDG 14, "Life Below Water," few research papers have systematically mapped out the evolution of the scholarly work using bibliometric analysis. There is very little consolidated insight into the intellectual structures, influential contributors, collaboration partners, and emerging research themes. This study focuses on addressing the gap by conducting a bibliometric analysis to identify key trends, research clusters, and underexplored areas within SDG 14 literature.

1. Research Questions
2. What are the major publication trends in SDG 14 research over the years?
3. Which journals, authors, and institutions contribute the most to SDG 14 literature?
4. How do different academic disciplines (e.g., marine biology, environmental science, economics) contribute to SDG 14 research?
5. What are the emerging topics and themes in SDG 14 research?
6. How extensive is international collaboration in SDG 14 studies?

2. Research Methodology.

A popular quantitative technique for assessing research trends, seminal studies, and networks of collaboration in a particular subject is bibliometric analysis (Egghe & Rousseau, 1990; Donthu et al., 2021). In order to examine research patterns on SDG 14: Life Below Water, this study uses bibliometric methodologies. It focuses on publication trends, notable authors, institutional collaborations, and keyword clustering.

In order to do this, information will be gathered from the two most respected academic databases, Clarivate Web of Science (WoS) and Scopus (Hoz-Correa, Muñoz-Leiva & Bakucz, 22018). Citation-based methods like co-citation analysis, bibliographic coupling, and keyword co-occurrence analysis are included in the aanalysis.

Data Collection

Data Sources: Web of Science (WoS) and Scopus databases.

Search Query: "Life Below Water" OR "SDG 14" OR "Sustainable Development Goal 14" OR "Marine Conservation" OR "Ocean Sustainability."

Search Fields: Title, Abstract, Keywords. Period: 2012–2024.

Language Filter: Only English-language papers.

Document Types: Articles, reviews, conference papers. Data Cleaning:

Filtering out irrelevant articles. Removing duplicates.

Unifying similar keywords (e.g., "marine biodiversity" and "ocean biodiversity").

Bibliometric Analysis Techniques

Co-Citation Analysis: Identifies key research papers frequently cited together, revealing foundational studies in marine conservation and SDG 14. Bibliographic Coupling: Examines how recent studies are connected through shared references, highlighting emerging research themes. Keyword Co-Occurrence Analysis: Uses VOSviewer to visualize clusters of research topics within SDG

Display collaboration between authors based on shared publication

1. **Nodes (Authors):** Each node represents an author. The names next to the nodes indicate the authors involved in the network.
2. **Edges (Connections):** The lines between nodes signify co-authorship. Thicker or more numerous connections imply frequent collaborations.

3. Network Structure:

1. Authors like *Puchovsky, MMilosh,*and *Torero, JJosé,*appear central, suggesting they have collaborated with multiple researchers.
2. Other notable contributors include *Wieczorek, C*Christopher;*Hall, John R*R.;*Watts, John M*M.;and *Harada, Kazunori*, who are also well-connected.
3. The interconnected nature of the graph suggests a collaborative research group or academic community.

This visualization highlights a strong research network where certain authors act as central figures, potentially leading or frequently collaborating within the domain. The dense cConnectivitysuggests interdisciplinary work or a well-established academic collaboration. If this network relates to your research, it might indicate key influencers or potential

4. Clusters (Color Groups):

- The **green cluster** appears to focus on **marine science and ecology**, including journals like *Marine Ecology Progress Series*, *Frontiers in Marine Science*, and *PLOS ONE*.
- The **blue cluster** is likely centered on **environmental science and pollution**, with key journals such as *Marine Pollution Bulletin*, *Environmental Science & Technology*, and *The Science of the Total Environment*.
- The **red cluster** seems to relate to **earth and space sciences**, including

Nature, Science, Geology, *and* Astrobiology.

5. Connections (Edges):

- Journals that are **closely linked** have strong citation relationships, meaning they are frequently cited together in research papers. There is noticeable connectivity between the **green and blue clusters**. suggesting a relationship between marine ecology and environmental pollution research.

- The **red cluster connects with the green and blue clusters**, indicating that geosciences and planetary sciences are linked to both marine and environmental research.

  This visualization highlights the **interdisciplinary nature** of research related to marine science, environmental sustainability, and geosciences. It shows which academic journals are most influential within these fields and how different disciplines intersect in scholarly work. If your research is related to **marine sustainability (SDG 14)**, this network can help identify key journals to follow or target for publication. Highlights the frequently co-cited papers, indicating key foundational studies.

Clusters (Colour Groups):

- The **green cluster (left side)** represents a group of researchers who are frequently cited together, likely in the fields of **marine science,**

environmental science or geochemistry.

- The **red cluster (right side)** consists of another set of researchers frequently co-cited, possibly focusing on **planetary science, astrobiology, or space exploration**.
  - The **blue node** (Tan, Shuya) is a more isolated author with fewer direct connections, indicating they may be cited in both fields but not as frequently as the central figures.

Central Authors (Bridging Both Fields):

- **Postberg, Frank**, **Glein, Christopher**, and **Hillier, Jon K.** are at the **center of the network**, acting as bridges between the two major research clusters.
  - This suggests their work is interdisciplinary, linking **marine/environmental science** with **planetary/astrobiological research**.

Connections (Edges):

- Authors with **thicker connections** have stronger co-citation relationships, meaning their research is often referenced together in scholarly works.
  - The network's **figure-eight shape** suggests two somewhat distinct research communities that intersect through key authors.

This visualization reveals how **different scientific disciplines (e.g., marine science and planetary science) interconnect through shared research interests**. The central authors likely contribute to topics that **bridge environmental science and astrobiology**, such as

studies on habitable environments in space, ocean worlds (e.g., Europa or Enceladus), or geochemistry in extreme conditions.

Central Node (United States):

- The **United States** is the most central and highly connected node, indicating that it is the most frequently cited country or has the most collaborations with other countries.
  - This suggests that a large volume of influential research originates from or is connected to the United States.

Connections (Edges):

- Countries like **Germany, China, the United Kingdom, and Japan** have strong ties with the United States, meaning they frequently co-author papers or cite U.S.-based research.
  - The connections between other countries (e.g., **Germany and Spain,**

Netherlands and China) indicate regional or thematic research collaborations.

Clusters (Color Groups):

Different colors suggest distinct research communities or regional collaboration trends.

For example:

The **red cluster (Germany, Spain, Finland, United States)** might indicate research collaboration in **science and technology**.

The **green cluster (China, Italy, Australia)** might be more focused on engineering or environmental sciences.

The **blue and yellow clusters (Japan, Netherlands, UK)** may represent additional specialized research fields.

Structure (Star-Like Pattern):

The **flower-like structure** suggests that many countries collaborate directly with the U.S., but **fewer direct links exist between some of the other countries**.

This indicates that while the U.S. is a major hub in research, some countries may still have limited direct collaboration with each other.

This visualization suggests that **the United States plays a dominant role in academic research and citation networks**, acting as a hub connecting various countries. The network also highlights key international research collaborations, with countries forming clusters. based on common research interests or geographical proximity. Maps collaboration among universities and research institutions

Nodes and Connections:

- Each **node** represents an institution involved in research collaboration.
- The **edges (lines)** indicate co-authorship relationships between these institutions.
- The presence of connections between all nodes suggests **strong collaboration.**

among these institutions.

Main Institutions in the Network:

- **Tara Ocean Foundation** and **Tara Oceans** appear to be closely linked, likely working on marine or biological research.
- **The European Molecular Biology Laboratory (EMBL)** is also involved, known for its work in genetics and molecular biology.
- **European Marine Biological Research (possibly EMBr)** suggests a focus on oceanic and marine biodiversity research.

Structure and Interpretation:

- The network forms a **small but interconnected cluster**, indicating a **tight-knit research collaboration**.
- This suggests a **specialized research field**, likely in **marine biology, oceanography, or molecular biology related to marine ecosystems**.
- The **Tara Ocean Foundation and Tara Oceans** are likely central players, as they connect with all other institutions.

This network visualization highlights a **collaborative research ecosystem in marine and biological sciences**, with key European institutions working together. The **strong co-**

Authorship links suggest that these organizations frequently publish research together, likely contributing to significant advancements in **marine biodiversity, genetics, and ocean**

Central Role of the United States:

- The **United States** appears as the largest and most connected node, indicating its central role in global research collaboration.
- It has strong connections with **Germany, the United Kingdom, Canada, Japan, and France**, suggesting frequent co-authorship with these countries.

Regional Clusters and Collaboration Patterns:

- **North American & Latin American Cluster** (Red Cluster):
- **Canada, Brazil, and Kuwait** are closely linked, showing an active collaboration network.
- **European Cluster** (Green & Yellow Cluster):
- **Finland, Sweden, Denmark, and Germany** form a connected sub-network, suggesting strong research ties within Europe.
- **Asian & Global Cluster** (Blue Cluster):

- **Japan, Turkey, and France** have strong links, indicating interdisciplinary and cross-border research efforts.

Peripheral Countries:

- **Chile, Panama, and Iceland** have some collaboration links but are not as central as other countries.
- **Denmark and Sweden** are positioned on the edge, meaning they collaborate but not as extensively as larger hubs like the U.S. or Germany.

Interpretation:

- This visualization highlights **international collaboration patterns in academic research**.
- The **United States serves as the main hub** for research partnerships.
- Different **regional clusters** indicate **specialized research collaboration within certain areas** (e.g., North America, Europe, and Asia).
- Countries with **fewer connections** might be involved in more specialized or localized research but still contribute to the global scientific community.

This network shows how scientific collaboration transcends borders, with **major research-producing countries forming strong partnerships** while smaller nations contribute in niche areas. It can be useful for identifying **potential research partnerships and global research trends** in various fields.

Two Distinct Clusters:

The network is divided into **two main groups**:

- **Red Cluster (Left Side)**: Represents one set of closely collaborating authors.
- **Green Cluster (Right Side)**: Represents another group of collaborating researchers.
- These two groups have **some connecting nodes**, indicating limited collaboration between them.

Highly Connected Authors:

The **central nodes in each cluster** represent key authors with many co-authorship links.

- In the **green cluster**, authors like **Frank Postberg, Christopher R. Glein, and Jon K. Hillier** seem to be leading researchers.
- In the **red cluster**, authors such as **Takazo Shibuya, Zenghui Zou, and Takuya Saito** appear to have strong collaborations within their group.

Cross-Cluster Links:

- While the two clusters are mostly separate, there are some **weaker connections.** Between them.

- These connections indicate **occasional collaboration** between researchers from both groups.

Interpretation:

- This network shows a **segmented co-authorship structure**, where **two research groups collaborate internally more than externally**.
- The **red cluster** and **green cluster** might represent **different research topics, institutions, or geographic regions**.
- Researchers in **central positions** (with many connections) play a crucial role in

knowledge dissemination and collaboration within their groups.

This visualization can help identify **key researchers in a field**, **potential collaborators**, and **gaps in cross-group research interactions**. If the goal is to **enhance collaboration**, fostering links between the two groups could lead to **broader interdisciplinary research efforts**.

Linear Structure:

- Unlike dense co-authorship networks, this visualization forms a **linear chain**, suggesting a **progression of knowledge** over time.
- The flow of citations moves from left to right, showing how research builds upon earlier works.

Repeated "Anonymous" Entries:

- Many citations are attributed to **"Anonymous,"** which might indicate:
- Sources without explicitly listed authors.
- A dataset issue where author names were not correctly parsed.
- Editorials, reports, or other non-traditional scientific papers.

Cluster Color Coding:

- Different colors represent **distinct clusters of related citations**.
- Possible interpretation:
- **Yellow cluster (left)**: Related to geophysics (e.g., *Journal of Geophysical Research*).
- **Red & Blue cluster (center-left)**: Focus on geological evolution.
- **Purple cluster (center-right)**: Associated with *Science* (2004).
- **Green cluster (right side)**: Connected to *Nature* (2005) and other studies.

Key Citation Links:

- The **central nodes act as key transition points** between earlier and later research.
- The **middle of the chain** (e.g., *Science, 305 (2004)*) might be a **highly influential paper** that connects multiple research themes.

This network likely represents **the evolution of research in a specific field**, where key papers serve as **bridges** between different studies. The **linear structure** suggests a **strong chronological progression**, meaning newer papers heavily rely on previous foundational works. If this data is meant for bibliometric analysis, **cleaning up "Anonymous" citations** and verifying metadata could improve insights.

Limitations

1. The analysis is solely based on the Scopus database, which may not have considered relevant research indexes.
2. Bibliometric analysis only focuses on quantitativerelationships over qualitative insights, possibly overlooking nuanced content.
3. The use of English literature may lead to bias.
4. Bibliometric Tools

VOS viewer: Used for network visualization of citation relationships, co-authorship, and keyword clustering.

Bibliography (R-based tool): For additional bibliometric insights.

6. Conclusion

The report's conclusions emphasize how crucial it is to address maritime sustainability concerns in order to achieve SDG 14. Although historical and contemporary efforts have made significant progress, enduring concerns like overfishing, marine pollution, and climate change continue to threaten ocean health. The importance of multidisciplinary initiatives, the sea's economic worth, and policy-focused approaches in promoting sustainable ocean management are all reflected in the bibliometric analysis. India is in a unique position to lead conservation efforts because of its extensive coastline and maritime sector. Future research must focus on strengthening global collaboration, integrating indigenous and local knowledge, and developing more effective monitoring instruments. Last but not least, maintaining maritime ecosystems is essential for maintaining biodiversity, economic stability, and environmental balance worldwide, confirming the need for ongoing work and innovation in ocean sustainability.

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