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Internet of Things based Messaging Protocols for Aquaculture Applications - A Bibliometric Analysis and Review

Rupali Shete
Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune,
rupali.shete.phd2020@sitpune.edu.in

Anupkumar M. Bongale Dr.
Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune,
ambongale@gmail.com

Arunkumar Bongale Dr.
Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune,
arunbongale1980@gmail.com

Internet of Things based Messaging Protocols for Aquaculture Applications - A Bibliometric Analysis and Review

Rupali P Shete[1], Anupkumar M Bongale*[2], Arunkumar Bongale[3]

[1] PhD Scholar,Department of Computer Science and Information Technology, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Lavale, Pune, Maharashtra, India

rupali.shete.phd2020@sitpune.edu.in

[2] Department of Computer Science and Information Technology, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Lavale, Pune, Maharashtra, India

Corresponding Author: ambongale@gmail.com

[3] Department of Mechanical Engineering, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Lavale, Pune, Maharashtra, India

arunbongale1980@gmail.com

Abstract. Internet of Things (IoT) which connects real-world physical objects with various identities involves different technologies and research areas. As it is an integration of different standards and technologies with numerous capabilities, the implementation phase needs to consider important parameters of communication. In IoT this is achieved through messaging protocols. Each object has its own limitations in terms of sensing capability, storage capacity, connectivity, power utilization, etc. And hence when such objects are deployed for different applications,they need to perform well in terms of their various capabilities. Messaging protocols at this stage need to consider these diverse elements. One of such IoT enabling technologies can be categorised as communication technology and networks, wherein data transmission protocols such as Hypertext Transmission Protocol (HTTP), Constrained Application Protocol (CoAP),

Message Queue Telemetry Protocol (MQTT), MQTT for Sensor Networks (MQTT-SN), Advanced Message Queuing Protocol (AMQP) are used for data transmission. Each protocol has its own messaging architecture and standard. Any IoT application intends to provide optimum utilization of limited processing power and energy. In such a scenario integration and translation between various popular messaging protocols is needed. In this article bibliometric study for application like Aquaculture has been undertaken. The analysis done through Scopus database provides information about prominent countries involved in research field, highest citation documents, co-authorship links, funding sponsors etc. The bibliometric study conducted helped in understanding scope of the research field.

Keywords: Bibliometric Analysis, Aquaculture, MQTT, CoAP, Wireless Sensor Network.

1 Introduction

Internet of Things (IoT) marked its footprint in numerous applications. It has an enormous role to play, from industries to farming and home applications to healthcare [1, 28, 32]. Smart fish farming in aquaculture is one of the research fields where researchers contribute from different IoT perspectives. Research in this field is more concentrated on the increase in fish production for the ever-growing population [18, 33]. IoT plays an important role in farm environment monitoring and management, which further helps fish farmers make quick decision-making with machine learning prediction models. Manual monitoring of fish farming all the time is not a feasible solution. An IoT-based protocol model helps to perform this task efficiently [2]. Cultivation of aquatic organisms is done in aquaculture with a controlled process in fresh and saltwater environments [24, 34]. Sensor network helps to measure values such as dissolved oxygen, pH, temperature, turbidity, etc. of water. For further data transmission, communication protocols come into the picture. Due to network limitations, het-

erogeneous environment, data transmission protocols must be chosen suitably as a single protocol may not work with such a multi-faceted environment [5]. Many researchers have carried out their work in this area. Each messaging protocol has its messaging architecture and standard. Any IoT application intends to provide optimum utilization of limited processing power and energy. In such a scenario, integration and translation between various popular messaging protocols are needed. When data from the aquaculture system reaches gateway level, translation of messaging protocols is suggested, which can provide translation between other protocols such as Constrained Application Protocol (CoAP), Message Queue Telemetry Protocol (MQTT), and Extensible Messaging and Presence Protocol (XMPP) [13,39]. Protocol conversion study has been noted in [29]. Hypertext Transfer Protocol (HTTP) protocol used on the web platform alone can't be used for IoT applications. In IoT, data generated by sensors has to be sent to constrained devices under different circumstances [4]. In such cases, combinations of protocols CoAP, MQTT can be used. In RESTful web architecture, HTTP along with CoAP has been implemented. For fast and instant messaging, protocols such as Advanced Message Queuing Protocol (AMQP), XMPP have been implemented [7, 17, 23, 25, 31, 36]. A single protocol cannot be implemented for multitasking modules of the IoT applications. And aquaculture is also not an exception to this [21].

In fish farming, water quality monitoring is the most critical factor [3]. Dissolved oxygen is one of the important water quality parameters since the contamination and distress in water can cause adverse effects for fish farming [30]. In the same context, water quality monitoring data collected by sensors needs to be transmitted to IoT systems for further evaluation. Decisions based on these parameters can maintain the aqua environment healthy. Few of the authors worked on the network protocols for efficient bandwidth and congestion control. Authors have suggested a GSM network for sensor data communication to user phone [14, 22, 38]. Many researchers have done work in this area [9, 10]. Some of the authors focused on delay estimation with MQQT, Broker (Publish

Subscribe) [6, 12, 27], Congestion Control with CoAP [8, 16]. Researchers have also put limelight on real-time water monitoring, fishpond water quality measurement [15,20,26,37], Fuzzy logic for fault diagnosis in aquaculture [11], blockchain for secure data in fish farming [19]. With the advent of digital technology, smart data collection and monitoring is possible. Wireless Sensor networks are used in aquaculture ponds on the specific radio frequency band in IoT [6]. Forecasting models are being implemented using a similar technology [35]. From the research work in aquaculture, it is worth noting that this field has interdisciplinary parameters that help achieve the goal. This article aims to know the research work being carried out so far in aquaculture with different messaging protocols of the IoT. With the bibliometric survey, research data collected from articles, journals, and citations will help analyze and correlate the current scenario's knowledge.

The rest of the article is arranged as follows. Section 2 describes the preliminary data and keyword string used. Section 3 contains bibliometric information analysis and Network Diagrams. Section 4 mentions inferences of the current study, and in Section 5 conclusion is drawn.

2 Keyword Analysis and Preliminary Data

Scopus database is referred for bibliometric analysis. For data collection, a query with multiple parameters is used, as shown in Table 1.

Table 1: Keywords used for querying to Scopus DB
(Source:Scopus DB accessed on 8th April 2021)

Primary Keywords	IoT
Secondary Keyword using(AND)	Messaging Protocols
Secondary Keyword using(OR)	Aquaculture

The formulated query is as follows. (TITLE-ABS-KEY (iot) AND TITLE-ABS-KEY (messaging AND protocols) OR TITLE-ABS-KEY (aquaculture)

). This query was applied to scopus database on 8th April 2021 and the extracted details are mentioned in the Table 2. Total 372 documents are extracted from Scopus database. Among the 372, three articles are in Press and 369 are at final publications stage. Obtained documents are from the year 1995 to 2021. In the year 1995 one published document is noted and after a major time period next noted document is in the year 2008. Majority of the analysed published documents are in English. Table 2 represents the linguistic analysis of these documents.

Table 2: Linguistic Analysis details
(Source: Scopus DB accessed on 8th April 2021)

Sr.No.	**Publication Language**	**No. of Documents**
1	English	364
2	Chinese	7
1	Spanish	1

3 Bibliometric Analysis of Messaging Protocols

Scopus is the largest abstract and citation database. This database is a pool of peer-reviewed literature, scientific journals, books, and conference proceedings. Analysis done in this section is based on bibliometric information collected through *.csv* file from the Scopus database. The Collected information is represented based on the following parameters.

1. Documents by type, Publication by Year, Subject Area Classification, Source Statistics, Documents per Year by Source, Affiliation Statistics, Documents Published by Country, and Funding Sponsors.
2. Network Analysis is done to represent the relationship among various attributes from the collected information, including Author Keyword, Index Keyword, Highest Citations, Country Density, Country Linking, Bibliographic

Coupling. Further, this information is depicted in graphical format with VOSviewer and ScienceScape tools.

3.1 Bibliometric Information Representation

The formulated query is as follows. (TITLE-ABS-KEY (IoT) AND TITLE-ABS-KEY (messaging AND protocols) OR TITLE-ABS-KEY (aquaculture)). This query was applied to the Scopus database on 8th April 2021, and the extracted details are mentioned in Table 2. Total 372 documents are extracted from the Scopus database. Among the 372, three articles are in Press, and 369 are at the final publications stage. Obtained documents are from the year 1995 to 2021. In the year 1995, one published document is noted, and after a major period, the next noted document is in the year 2008. The majority of the analyzed published documents are in English. Table 2 represents the linguistic analysis of these documents.

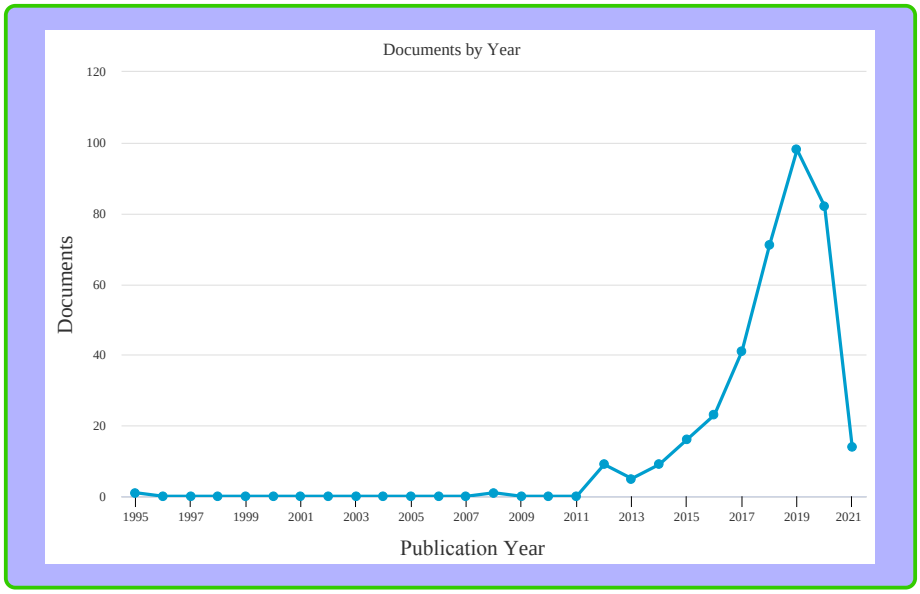

Fig. 1: Research articles published per year
(Source: Scopus DB accessed on 8th April 2021)

In Scopus, documents are published in various publications. Table 3 shows published documents categorization, including Conference, Book etc.

Table 3: Published Documents
(Source: Scopus DB accessed on 8th April 2021)

Types of Publications	**No.of Publications**
Conference Paper	227
Article	115
Conference Review	11
Review	9
Book Chapter	9
Editorial	1

From the Table 3 it can be noted that in Conference paper, researchers have published a maximum of 227 publications out of 372. The Articles which contain 115 publications followed by Conference Review which has 11 publications. There is scope for contribution in Review, Book Chapter and Editorial publication. Based on the similar lines Fig. 2 represents above data graphically in chart percentage.

Over time, research documents are published in various publications. Analysis of publications at various sources is done through the Scopus database, which is represented in Fig. 3. It can be observed that from 2016 onwards, the number of publications has been increased from two documents per year to five documents per year. Major contributing publications are from *Advances in Intelligent Systems and Computing*.

In any publication, the role of the author is prominent. The author contributes their work in research through documents. This representation is done in Fig. 4. Most of the authors have a minimum of two Scopus documents as their contribution. The highest contribution is by the first author who had seven Scopus documents, which indicates insights and scope of the work in this research area.

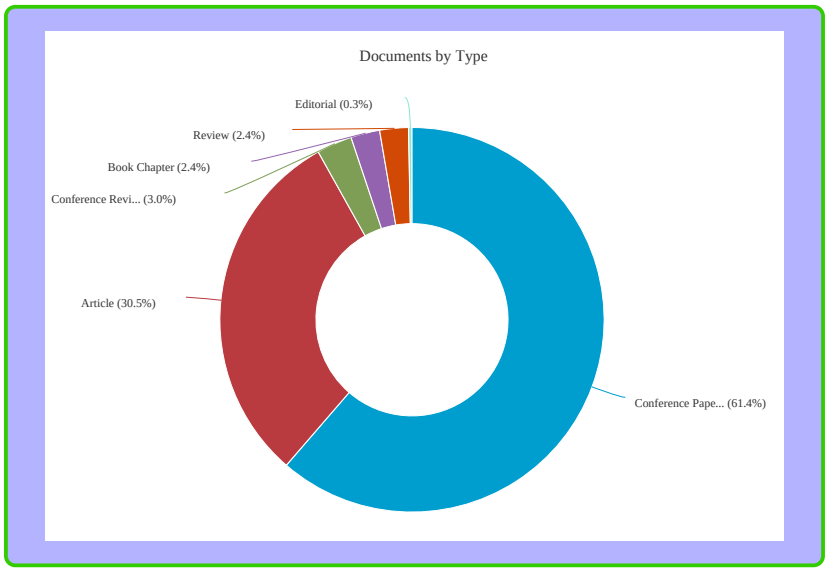

Fig. 2: Chart Representation of Documents Published per Year
(Source: Scopus DB accessed on 8th April 2021)

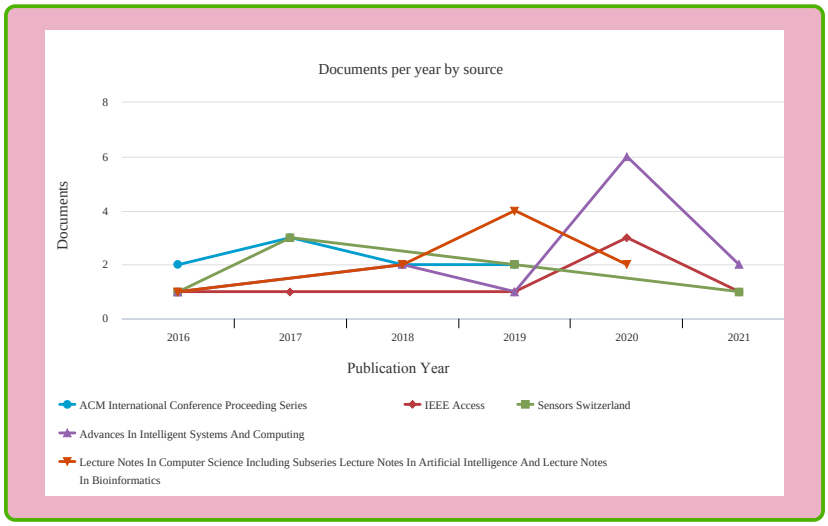

Fig. 3: Publications Statistics per Year
(Source: Scopus DB accessed on 8th April 2021)

In this bibliometric analysis, affiliations from various universities is also considered. The collected information is represented in Fig. 5. Analysis highlights,

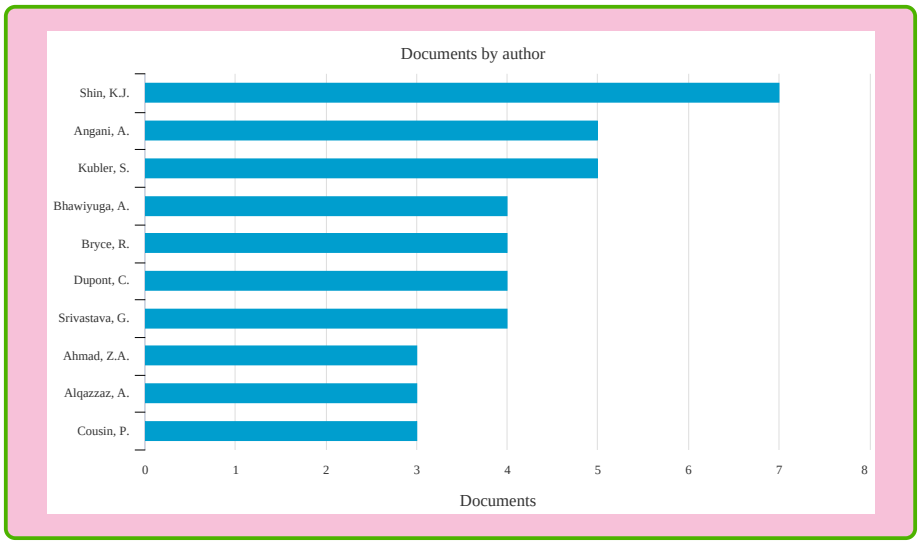

Fig. 4: Publication Count of Authors
(Source: Scopus DB accessed on 8th April 2021)

major contributing key affiliation by *Pusan National University* of South Korea which had published eight documents in Scopus.

From the retrieved database, one important parameter for analysis has been found that is, Country Contribution. As this is an upcoming research area, many countries are promoting research, and Fig. 6 is an implication. It is worth noting that India is a prominent key contributor in this Research field with 71 published documents followed by China with 39 documents.

Along with affiliation, country, author, another important factor is the subject area in which these documents are published. Fig. 7 depicts this scenario clearly, indicating the research work is being carried out in multidomain. *Computer Science*,*Engineering* is the leading subject area wherein research is going on. The other areas such as *Agricultural and Biological Sciences*,*Decision Sciences*,*Social Sciences*, *Mathematics*, *Physics and Astronomy Research* are also contributing domains towards the research.

Many countries promote the research through funding. There are funding sponsors who encourage research work. Fig. 8 shows funding sponsors statistics.

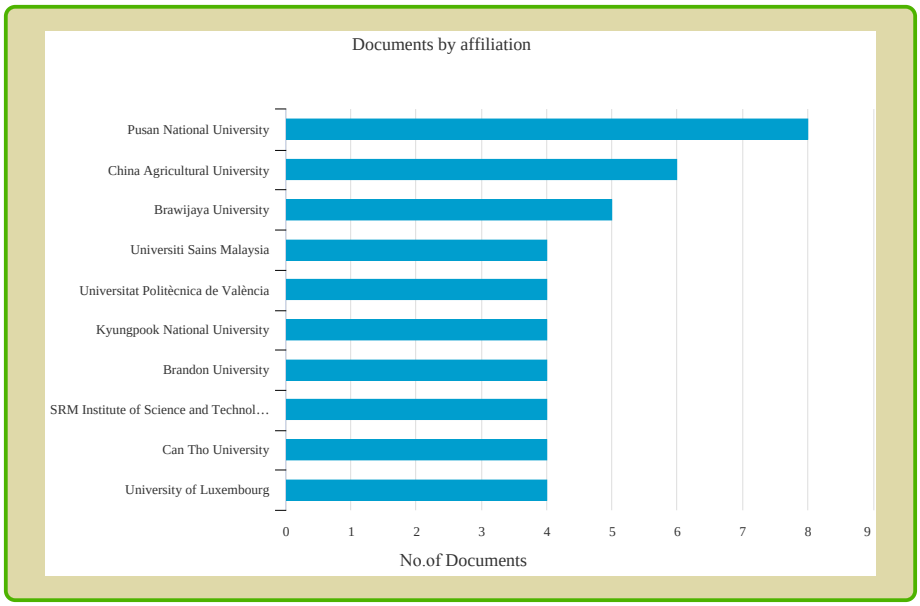

Fig. 5: Documents by Affiliation
(Source: Scopus DB accessed on 8th April 2021)

From statistics, it is clear that India provides an opportunity for researchers to contribute to the research area.

Network Analysis is done using different keywords on the Scopus database. Fig. 9 shows network analysis focused on author keywords. Circles in the diagram represent keywords, and connected links emphasize keyword occurrences. From the figure, it is evident that Internet of things, aquaculture, aquaponics, MQTT, CoAP, smart fish farms are the main keywords found in the articles. Fig. 10 represents density visualization for the co-occurrence of author keywords which gives more clear idea about important keywords used in research documents. On a similar line, analysis of keywords over time has been depicted in Fig. 11.

Many papers have co-authors. Linking of co-authors with authors analysis gives an idea about an author's position in a collaboration network. For each of the three authors, the co-authorship link with others has been calculated. The largest set of 41 connected authors have been selected. The same relationship is

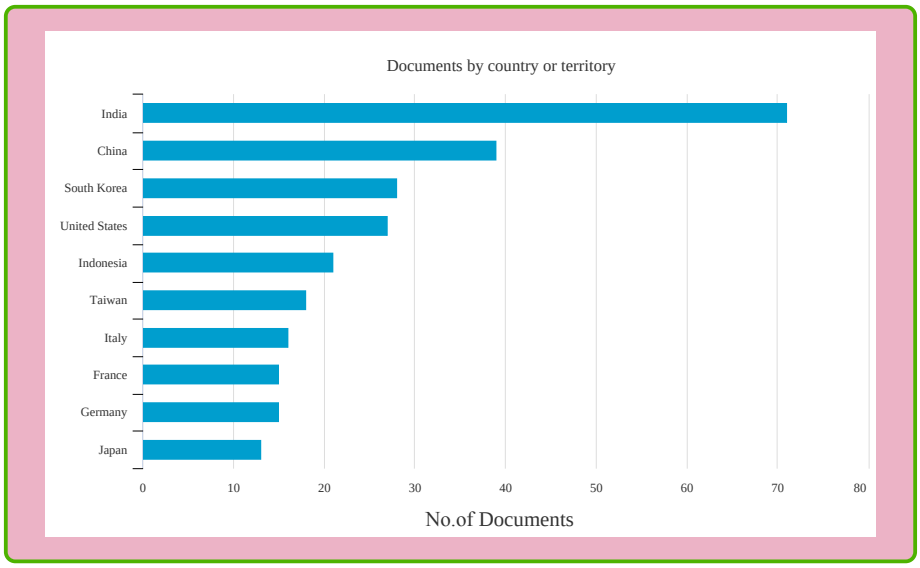

Fig. 6: Country Contribution Statistics
(Source: Scopus DB accessed on 8th April 2021)

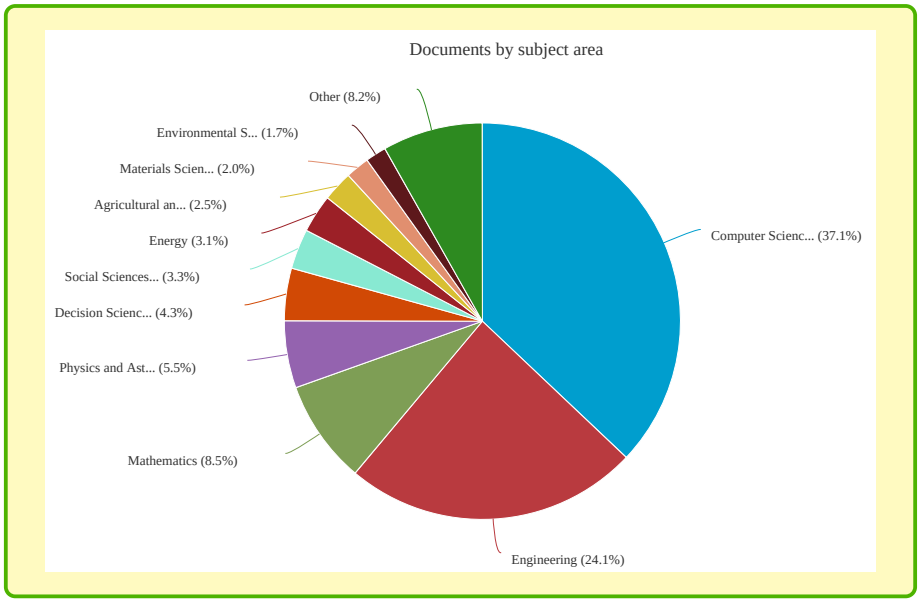

Fig. 7: Subject Area Statistics
(Source: Scopus DB accessed on 8th April 2021)

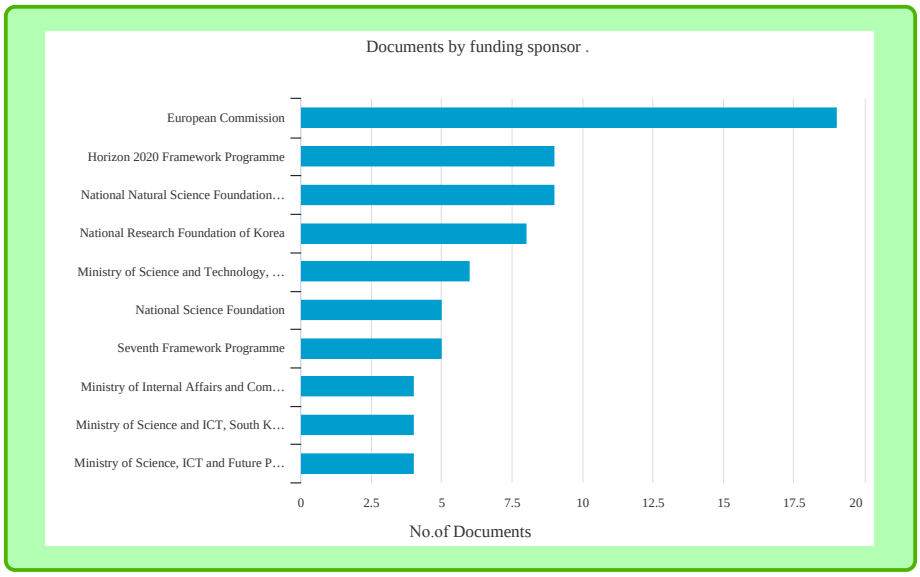

Fig. 8: Funding Sponsors Statistics
(Source: Scopus DB accessed on 8th April 2021)

depicted in Fig. 13. Further co-authorship relationship with countries has been analyzed. This analysis contributes to social networking. In this analysis, the 21 countries that have a minimum of five documents are selected. The representation of the same is shown in Fig. 14.

Information collected from various parameters can be co-related using Sankey Graph. The graph Fig. 12 conveys linked information of main authors, main keywords, and main journals. Analysis implies co-relation of the current research directions.

Citation is the basis of any publication. It directs towards the reference used in any research. Citation is useful for researchers to understand a connection to the source of information. Citation analysis is done on the database. It signifies the number of times an article is cited by other works. h-index is one of the impact metrics used for authors' performance evaluation. h-index is a numerical indicator containing the highest number of publications of a scientist who has received h or more citations. Fig. 15 shows 24 as the h index of documents.

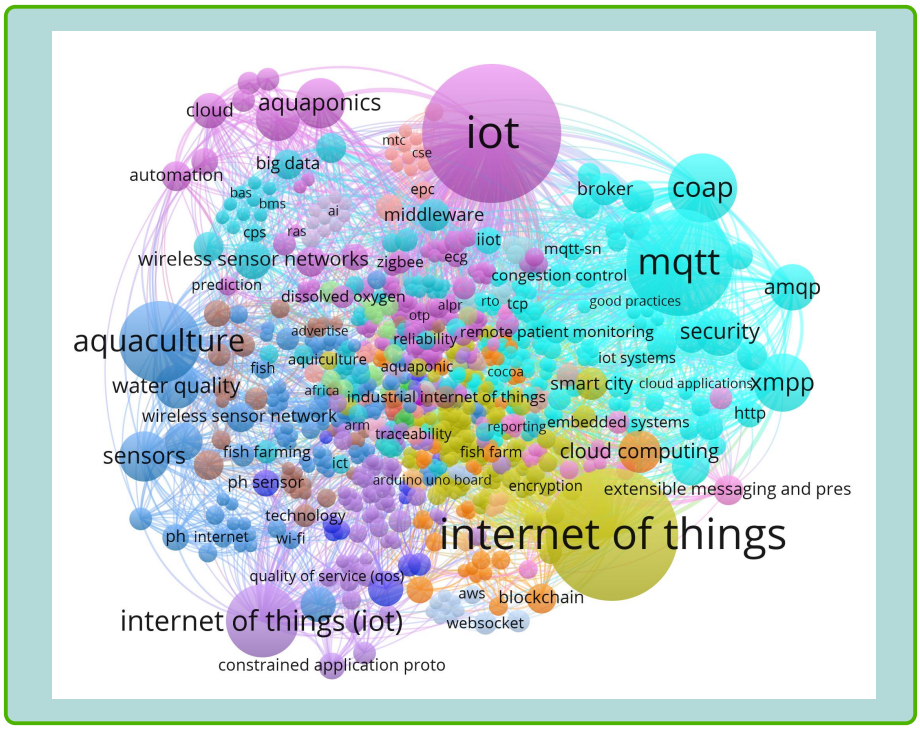

Fig. 9: Network Visualisation based on keywords
(Source: Scopus DB accessed on 8th April 2021 and Drawn using *VoSViewer*)

Here, an h-index of 24 means that the scientist has published at least 24 papers that have each been cited at least 24 times. The author's contribution and the significance of this research field's work can be understood.

Different publication sources can also be analyzed through citations. Fig. 16 is the representation of Sources Citation. It includes 270 sources of documents. Among these sources, 35 sources have the largest set of connected documents sources. Fig. 3 and Fig. 16 can be correlated for source publication information. The major contributing publication source seen is *2017 IEEE International Symposium on Systems Engineeing* which has 179 citations, followed by *IEEE Access* which has 87 citations.

Co-citations are used to analyze and visualize relations between publications. The larger the number of publications by which two publications are co-cited,

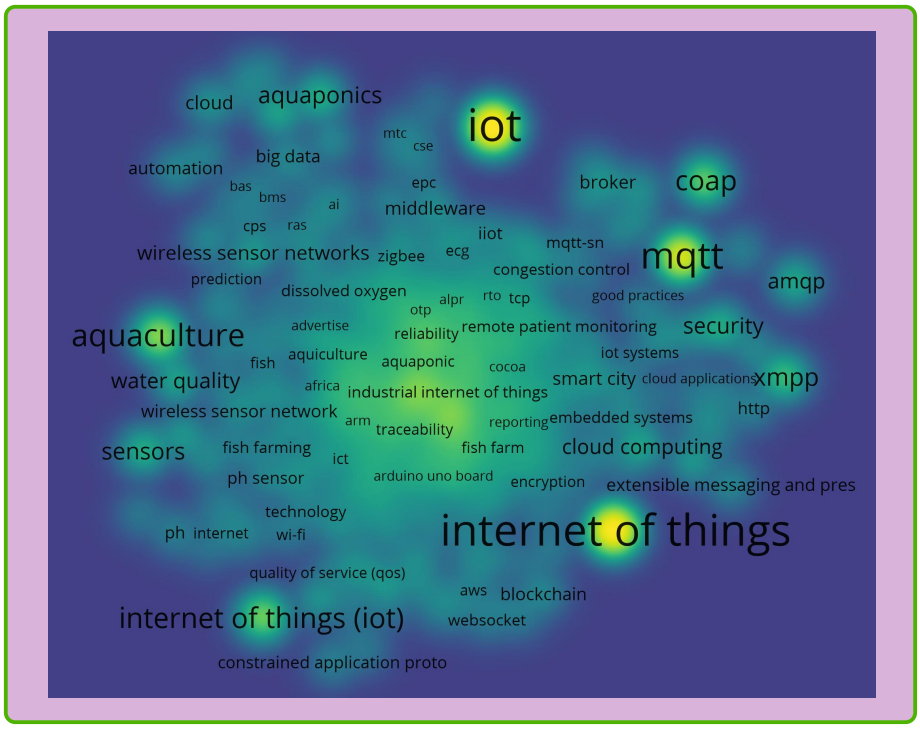

Fig. 10: Density Visualisation based on keywords
(Source: Scopus DB accessed on 8th April 2021 and Drawn using *VoSViewer*)

Fig. 11: Keywords occurrence over the year
(Source: Scopus DB accessed on 8th April 2021)

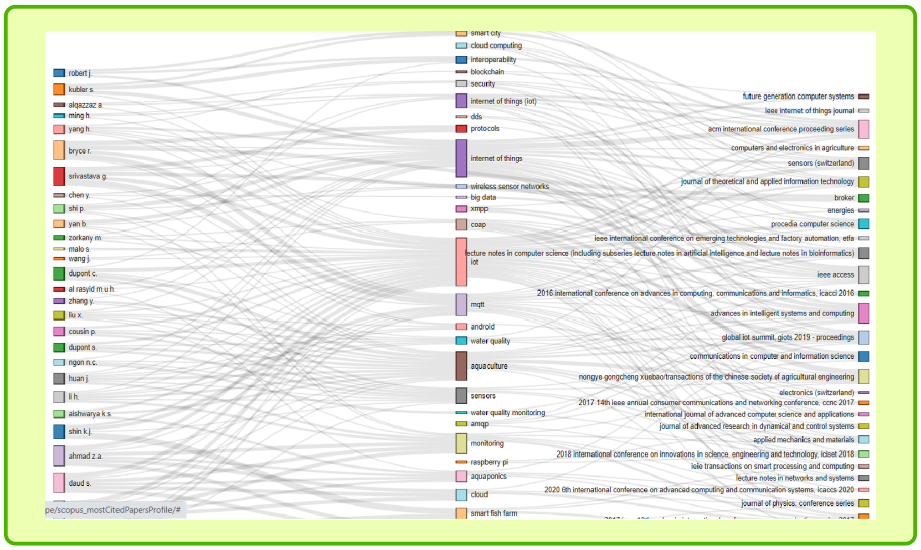

Fig. 12: Sankey Graph - Main Authors,Main Keywords and Main Journals (Source: Scopus DB accessed on 8th April 2021)

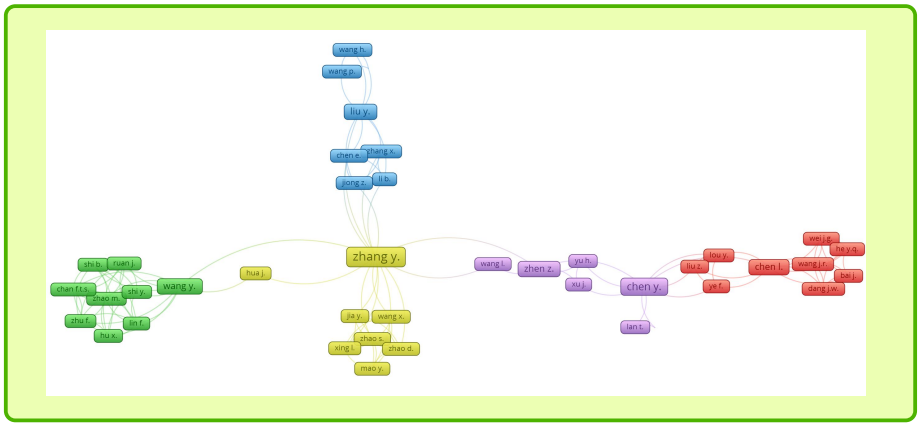

Fig. 13: Visualisation of Co-authorship link with authors (Source: Scopus DB accessed on 8th April 2021 and Drawn using *VoSViewer*)

the stronger the co-citation relation between them. Fig. 17 is representation of co-citation cited authors. Out of 13153 authors, 561 authors have a minimum of five citations.

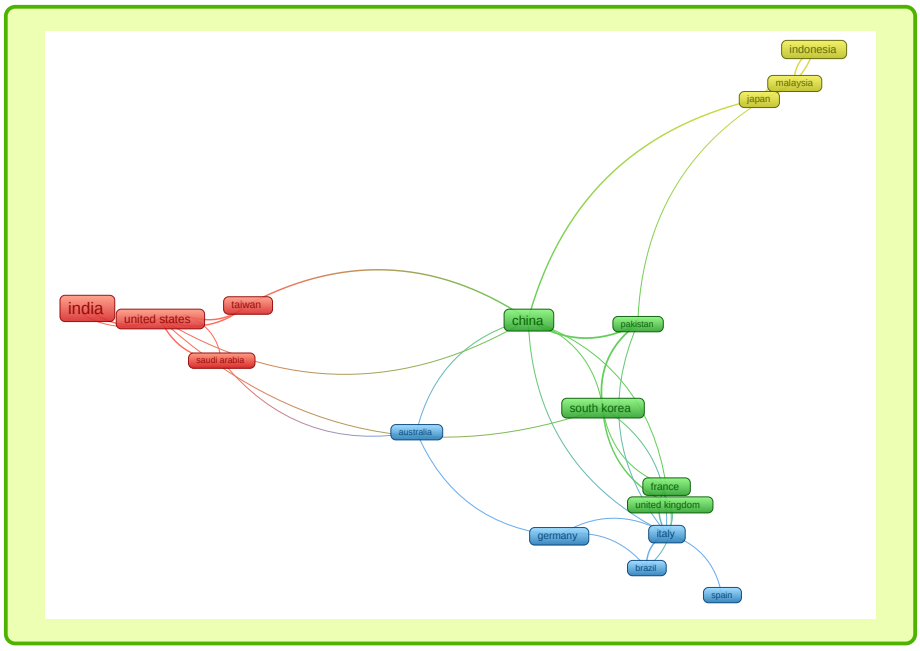

Fig. 14: Visualisation of Co-authorship link with Countries (Source: Scopus DB accessed on 8th April 2021 and Drawn using *VoSViewer*)

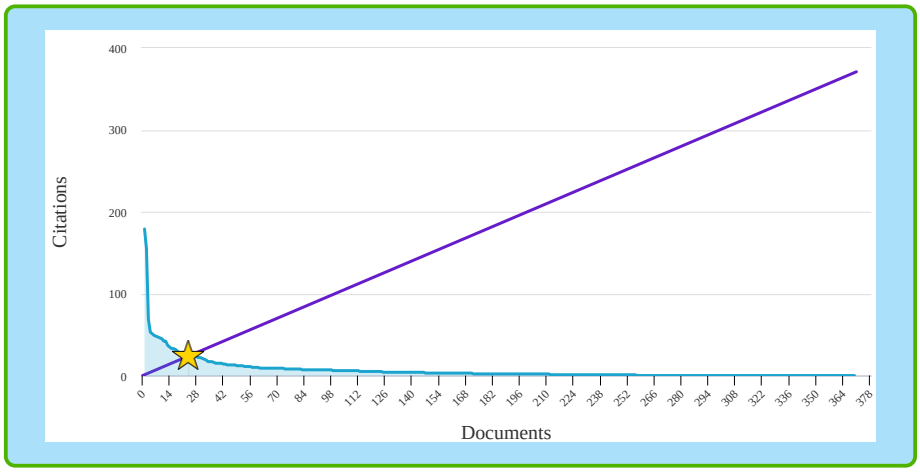

Fig. 15: h-index of documents

Country Citation analysis is done on VOSviewer tool. The record of 76 countries has been noted through the database. From the largest set of connected

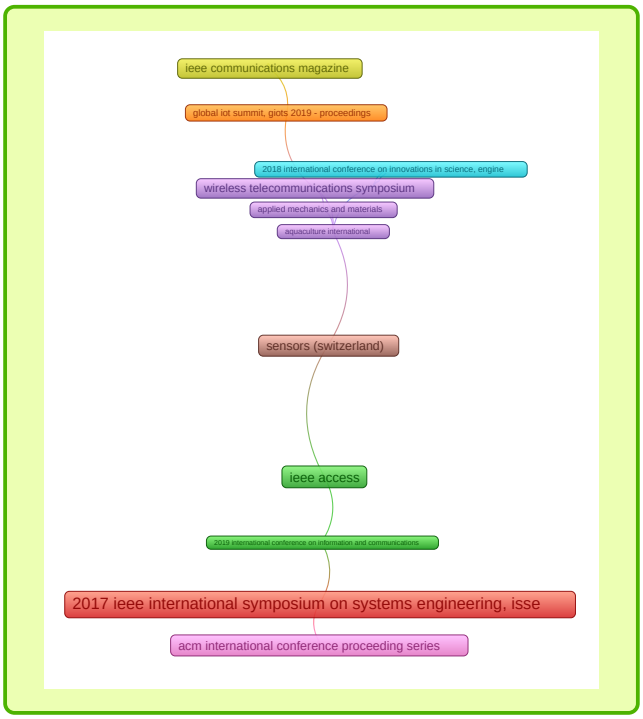

Fig. 16: Network Visualisation of Sources Citation
(Source: Scopus DB accessed on 8th April 2021 and Drawn using *VoSViewer*)

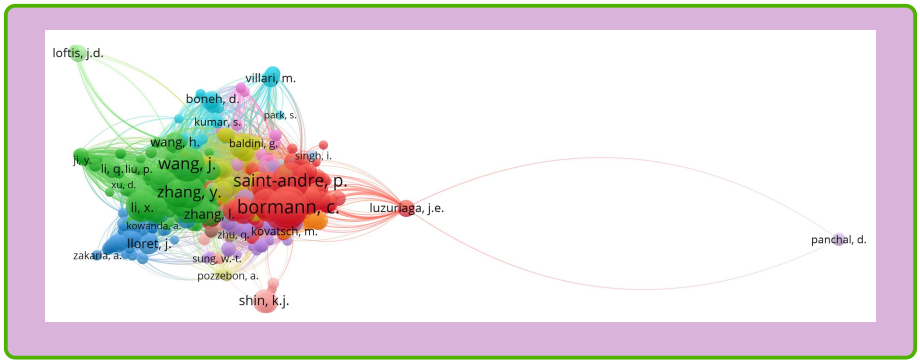

Fig. 17: Visualisation of Co-citation cited authors
(Source: Scopus DB accessed on 8th April 2021 and Drawn using *VoSViewer*)

countries analysis, 30 countries are found out. India is in the first position with

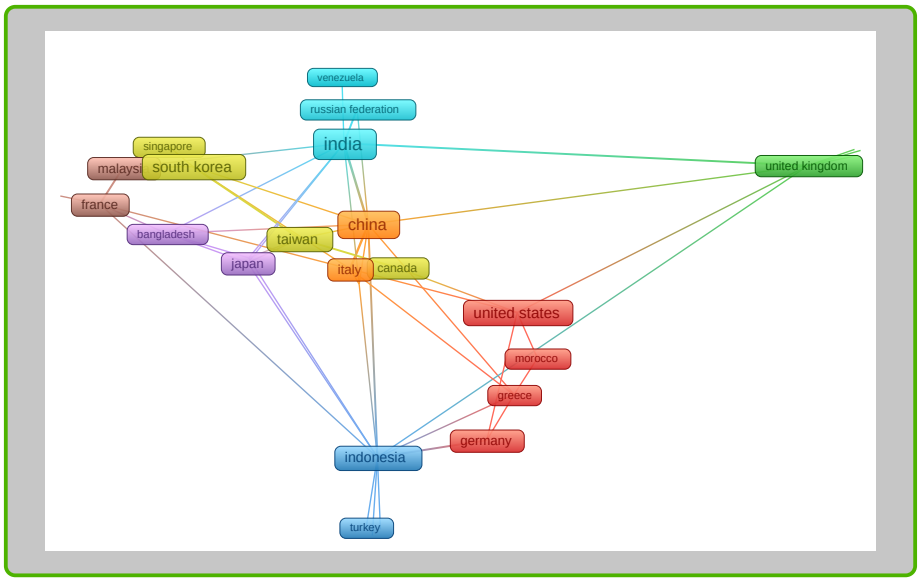

Fig. 18: Visualisation of Country Citation
(Source: Scopus DB accessed on 8th April 2021 and Drawn using *VoSViewer*)

71 documents and 259 citations. China is in second position having 39 documents and 432 citations. Fig. 18 is the representation of the same.

Fig. 19 is the density representation of the highest cited documents. Total 372 documents are noted. Analysis reveals that out of 372 documents, 61 documents have a minimum of ten or more citations. Document titled *Choice of effective messaging protocols for IoT systems: MQTT, CoAP, AMQP and HTTP* has maximum of 181 citations, followed by another document titled *Semantic Gateway as a Service Architecture for IoT Interoperability* which has 156 citations.

When two publications cite or reference, a common third publication bibliographic coupling network is created. This coupling with links shows the similarity of work in the specific subject matter. Coupling strength gets higher with more common citations for reference work. Analysis of bibliographic coupling with countries has been shown in Fig. 20. From the record of 76 countries, 21 countries that have a minimum of five documents are chosen. India is once again at

the top position among other countries in this analysis. Among the major 21 selected countries, India has coupling with 20 countries for 71 documents.

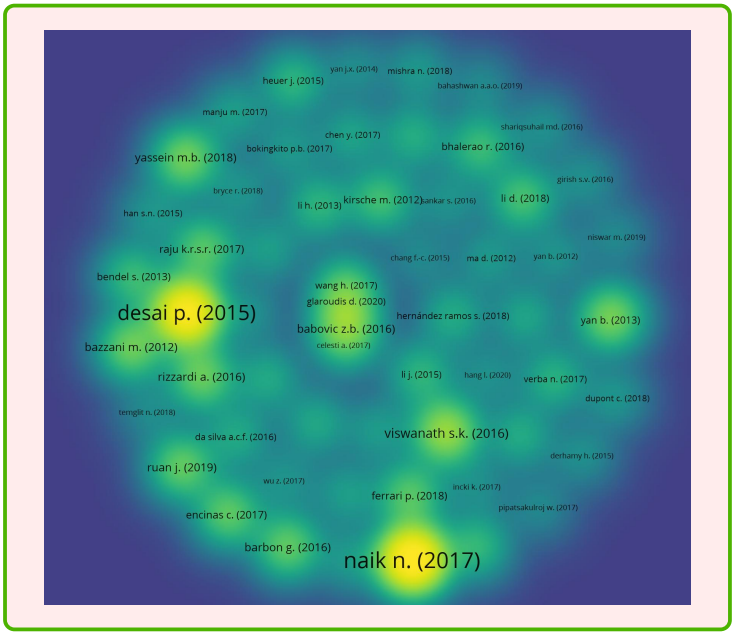

Fig. 19: Density Representation of Highest Cited Documents
(Source: Scopus DB accessed on 8th April 2021 and Drawn using *VoSViewer*)

4 Inferences of the Current Study

IoT has been at an advanced stage in the fields in which it has made its entry. Technologies are allowing interoperability to implement these rapid changes in respective domains. Aquaculture is such a field where from a traditional approach, people are moving towards modern IoT-enabled farms. The focused area in this study reveals that research in IoT messaging protocols in different domains are evolving more and more. But the standardization at application level protocols is still a missing part. In analysis, it is found that review contribution is noticeably less. The current study is based on data retrieved on a particular

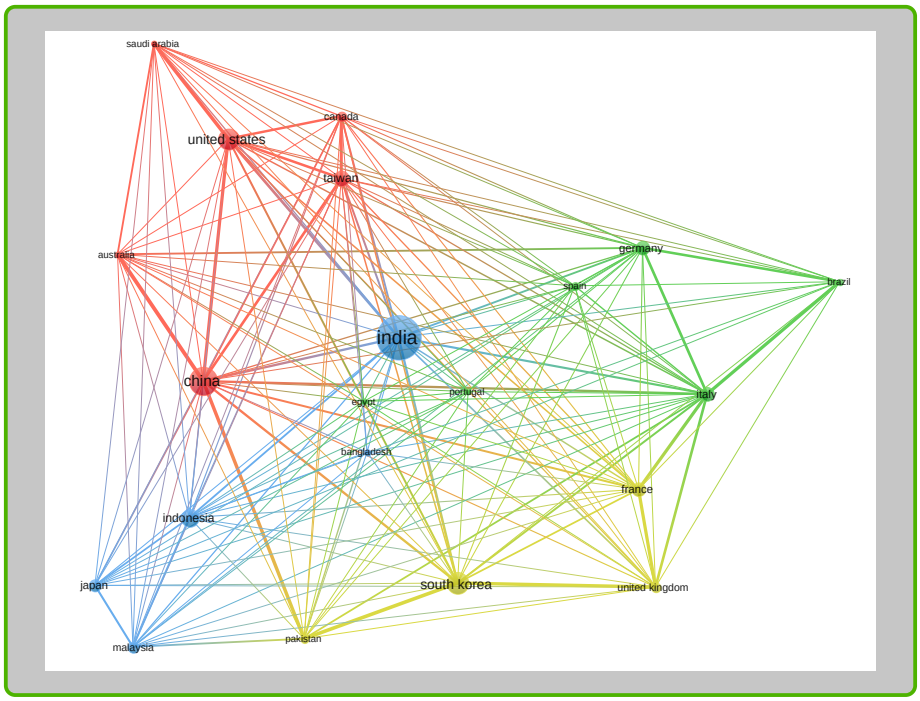

Fig. 20: Biobiographic Coupling of Country
(Source: Scopus DB accessed on 8th April 2021 and Drawn using *VoSViewer*)

data, which can be further improved with updated database entries. This change can help readers to get recent publication information.

5 Conclusion

Bibliometric analysis done in this paper helps to gain insights into different parameters of the research area. The research carried out by different authors, countries, multiple funding sponsors, and publishers reveal the need and importance of this research area. Even though messaging protocols are used in IoT applications, the analysis represents 37% of work is done in the Computer Science discipline. Environmental science and agricultural fields, which are supposed to be leading disciplines, have found only 1.7% and 2.5% work in this research area, respectively. Scopus database suggested only thirteen documents

in Environmental Science and 19 in Agricultural and Biological Sciences. This reveals opportunities for research in the area. Through this study, the authors gained knowledge to identify multiple factors for further investigation. From another perspective, particularly in Aqua or Smart fish farming, more co-relation of authors and links are noticed, indicating this field's broad scope for research. Further, this study can be extended with other databases such as Web of Science, which can provide more bibliometric insight for further research.

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