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RESEARCH ARTICLE

A Bibliometric Analysis of Using Technology Acceptance Model in The Agriculture Field

Ayça Tümtürk[1], Cengiz Yılmaz[2]

[1]Manisa Celal Bayar Üniversitesi
[2]Konya Gıda ve Tarım Üniversitesi

Corresponding author:
Ayça Tümtürk, Manisa Celal Bayar Üniversitesi
E-mail address: ayca.tumturk@cbu.edu.tr

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ABSTRACT

The Technology Acceptance Model (TAM), developed by Davis in 1989, has been used in over 10000 academic studies. This study aims to analyze research on TAM used for adopting new technologies in agriculture through bibliometric analysis. Using the Web of Science database, 117 studies were reviewed using "technology acceptance model" and "agriculture" as keywords. The analysis covers authorship, citations, sources, countries, institutions, key terms, co-occurrences, themes, and author relationships. The findings indicate that the journal with the highest number of publications is "Sustainability", and the institution with the highest number of publications is Iowa State University. China is identified as the country with the most publications, while Germany is the country with the most citations. Additionally, the keyword "precision agriculture" stands out among the frequently used terms. As a result of bibliometric analysis, a general picture of the selected field was obtained.

Keywords: Technology Acceptance Model (TAM), Bibliometric Analysis, Agriculture

1. Introduction

The agricultural sector faces numerous challenges today, including increasing food demand, resource scarcity, climate change, and environmental sustainability. Developing and implementing new technologies is critical to overcoming these challenges. Technology acceptance is a concept used to understand how individuals or societies adopt a particular technology. Farmers' willingness to accept new technologies is critical to their successful implementation in agriculture. These technologies can help achieve positive outcomes such as increased productivity, reduced costs, and contributions to sustainability.

This study aims to reveal the scope of research examining technology acceptance in the agricultural field through a bibliometric analysis focusing on the Technology Acceptance Model (TAM).

TAM was first developed by Fred D. Davis in 1989. The model focuses on two main factors determining users' intentions to use a new technology: perceived usefulness and perceived ease of use. Perceived usefulness refers to the belief that using a specific technology will provide benefits, while perceived ease of use refers to the belief about how easily the technology can be learned and applied (Davis, 1989). The purpose of TAM, developed by Davis, is to understand technology acceptance and explain users' behavior (Davis 1989 as cited in Yılmaz & Tümtürk, 2015). Figure 1 illustrates the general structure of TAM.

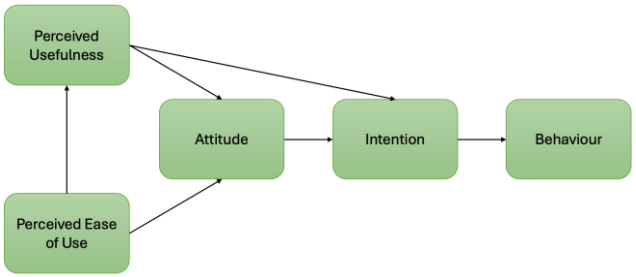


Figure 1: Technology Acceptance Model (Yılmaz and Tümtürk, 2015).

A search for “technology acceptance model” in the WoS database on June 12, 2024, returned 11,400 results. The distribution of these results across fields is shown in Figure 2.

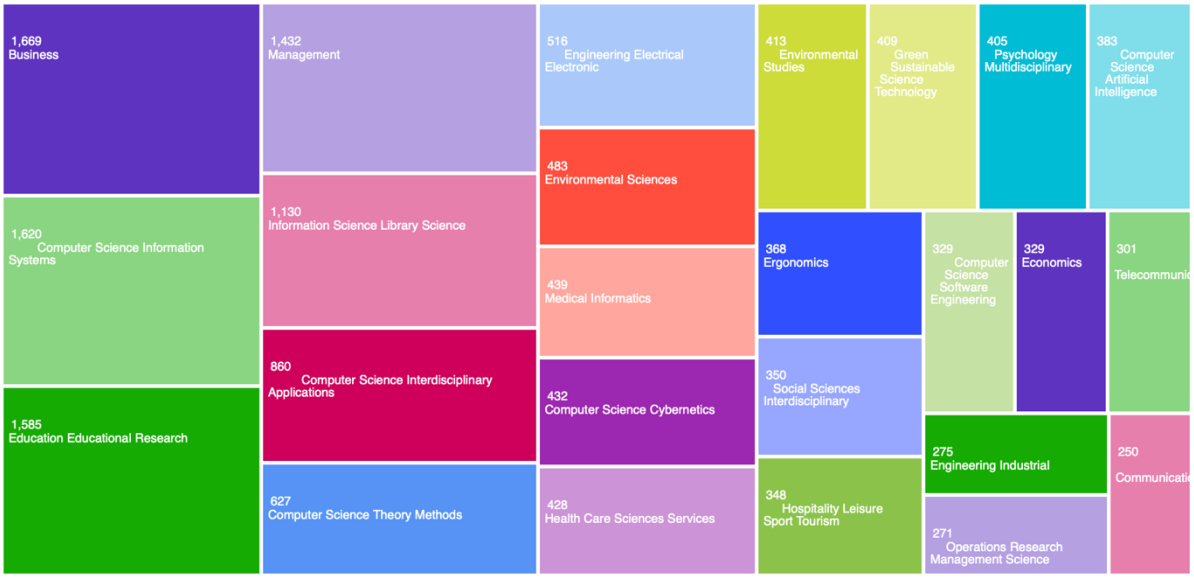


Figure 2: The 25 Fields Most Frequently Using TAM

Figure 2 demonstrates that the TAM model is a robust tool for understanding technology acceptance across all fields. In this context, TAM can also be applied to understand how individuals in the agricultural sector adopt technologies. Below are some studies that have used TAM in the agricultural field:

One of the first studies to use TAM for technology acceptance in agriculture was conducted by Ommani et al. (2009). This study investigated the adoption of sustainable water resources by farmers and was carried out in Iran. It compared TAM with models such as the diffusion, Marcus, and farm structure models. Another study conducted in 2009 in China involved data collected from 231 farmers, where TAM was used to assess the acceptance of information provided to aid decision-making. The study identified factors influencing the willingness to use information as perceived benefit, perceived ease of use, learning intention, risk preference, and prior knowledge experience (Zhang et al., 2009).

The most-cited publication is the study by Adnan et al. (2019), which examined how Green Fertilizer Technology (GFT) in rice production supports sustainable development in Malaysia. The researchers developed a conceptual framework to address the barriers to the low adoption rate of GFT by utilizing existing theories on innovation adoption. In addition to TAM, theories like the Theory of Planned Behavior (TPB) and the Theory of Reasoned Action (TRA) were also included in the study. The most recent study in this area was conducted by Mulaudzi et al. (2024), which evaluated social media usage among small farmers in the Mopani district of Limpopo Province, South Africa, using TAM. The study surveyed 383 randomly selected small farmers in the region and found that most farmers had positive perceptions of social media platforms' benefits and ease of use.

This study aims to present a bibliometric analysis of academic works that have used TAM in agriculture and analyze how this model has been applied to understand the adoption of agricultural technologies. During this analysis, the following research questions will be addressed:

- What is the distribution of academic studies using TAM in agriculture over the years?
- What are the most common sources for academic studies using TAM in agriculture?
- Which authors have published the most academic works using TAM in agriculture?
- Which studies using TAM in agriculture have received the most citations?
- Which institutions have published the most academic studies using TAM in agriculture?
- Which countries have published the most academic works using TAM in agriculture?

2. Methodology

A bibliometric analysis was employed to address the research questions presented in the introduction. Unlike systematic literature reviews, bibliometric analysis is an analytical method used to obtain formal and quantitative data on the current state of a field and to track academic trends through visualization tools. Databases such as Web of Science (WoS), Scopus, or Google Scholar can be utilized for bibliometric

analysis, each offering unique advantages and disadvantages depending on the software used. In this study, the WoS database was used as the primary source. The analysis was conducted using the Biblioshiny tool within the RStudio software.

RStudio provides an integrated development environment for the R programming language. Biblioshiny is a web application developed as part of the Bibliometrix package in RStudio, explicitly designed for bibliometric analysis. This tool enables researchers to perform bibliometric analyses without writing code (Aria & Cuccurullo, 2017).

A search query combining the terms “technology acceptance model” AND “agriculture” in “all fields” was conducted on the WoS database on June 4, 2024. The query initially returned 127 results, of which ten were deemed irrelevant to the field and excluded from the analysis. The bibliometric analysis was thus based on 117 studies.

3. Findings

The table below (Table 1) provides essential details about the analyzed studies.

Table 1: Summary of the Reviewed Studies

DESCRIPTION	RESULTS
Main Information About Data	
Timespan	2009:2024
Sources (Journals, Books, etc)	89
Documents	117
Annual Growth Rate %	%9,68
Average Citations Per Doc	12,03
Main Information About Authors	
Authors	413
Authors of single-authored docs	6
Document Types	
Article	91
Article (early access)	3
Proceedings Paper	18
Review	5

According to Table 1, the first publication in this field appeared in 2009. A total of 89 sources contributed to the 117 documents analyzed. The average citation per document is 12. 413 authors contributed to these 117 documents, with 6 single authored. Among the papers, 94 are journal articles (3 are early access), 18 are conference proceedings, and 5 are review articles. The annual growth rate of publications in the field is 9.68%. The distribution of publications over the years is presented in Figure 3.

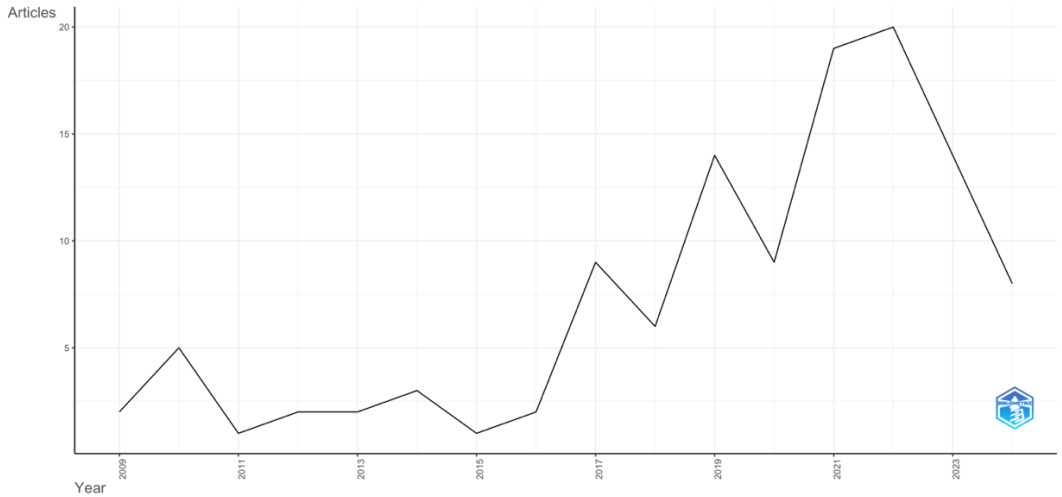


Figure 3: Yearly Distribution of Publications

Figure 3 shows that publications are spread over the years 2009–2024. The initial contributions to the field began in 2009 with two studies. A significant increase in publications is observed from 2016 onward, peaking in 2021 and 2022 with 19 and 20 publications, respectively. Although the number dropped to 14 in 2023, the annual growth rate indicates growing interest in this area. The rapid advancement of technology and its increasing relevance in agriculture might explain the rising research interest.
Figure 4 illustrates the three-field plot generated by the Biblioshiny program, displaying the relationships among sources, authors, and keywords.

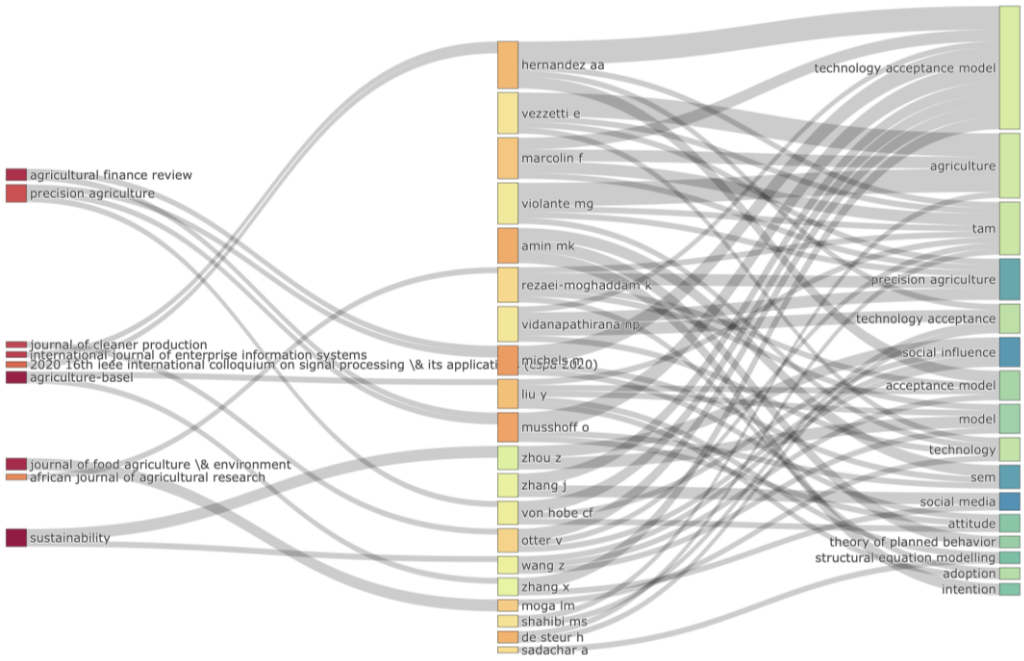


Figure 4: Three-Field Plot (Sources, Authors, Keywords)

According to Figure 4, the most productive authors in the field include Alexander A. Hernandez, Enrico Vezzetti, Federica Marcolin, and Maria Grazia Violante. Among the nine listed sources, the top four are *Precision Agriculture*, *Agricultural Finance Review*, *Agriculture-Basel*, and *Sustainability*. The four most commonly used keywords are "technology acceptance model," "agriculture," "TAM," and "precision agriculture". The keywords are similar to those used in bibliometric analysis. Among them, "precision agriculture" stands out. Precision agriculture involves utilizing technologies to enhance crop performance and environmental quality (Pierce & Nowak, 1999).

Table 2 highlights the top 10 sources regarding publication volume, including the number of articles, H-index values, and total citations.

Table 2: Top 10 Sources by Publication Volume

Sources	Number of Articles	H-index	Total Citations
SUSTAINABILITY	13	7	213
AGRICULTURE-BASEL	6	3	30
COMPUTERS AND ELECTRONICS IN AGRICULTURE	3	3	29
JOURNAL OF FOOD AGRICULTURE \& ENVIRONMENT	3	1	2
AGRICULTURAL FINANCE REVIEW	2	1	8
COGENT FOOD \& AGRICULTURE	2	1	19
INTERNATIONAL JOURNAL OF ENTERPRISE INFORMATION SYSTEMS	2	1	3
JOURNAL OF CLEANER PRODUCTION	2	2	97
LAND USE POLICY	2	2	120
PRECISION AGRICULTURE	2	2	89

Table 2 shows which journals the literature is concentrated in and which ones are more influential. The H-index refers to a source having h publications; each cited at least h times. A high H-index and citation count reflect the impact of a journal's publications within the field. *Sustainability* leads with the highest number of publications (13 articles) and 213 citations, with an H-index of 7, highlighting its significant influence. Other journals, such as *Land Use Policy* and *Journal of Cleaner Production*, also exhibit high citation counts and H-index values. However, some journals, such as the *Journal of Food Agriculture & Environment* and the *International Journal of Enterprise Information Systems*, have fewer publications and lower H-index values. Figure 5 illustrates the annual publication trends of the sources listed in Table 2.

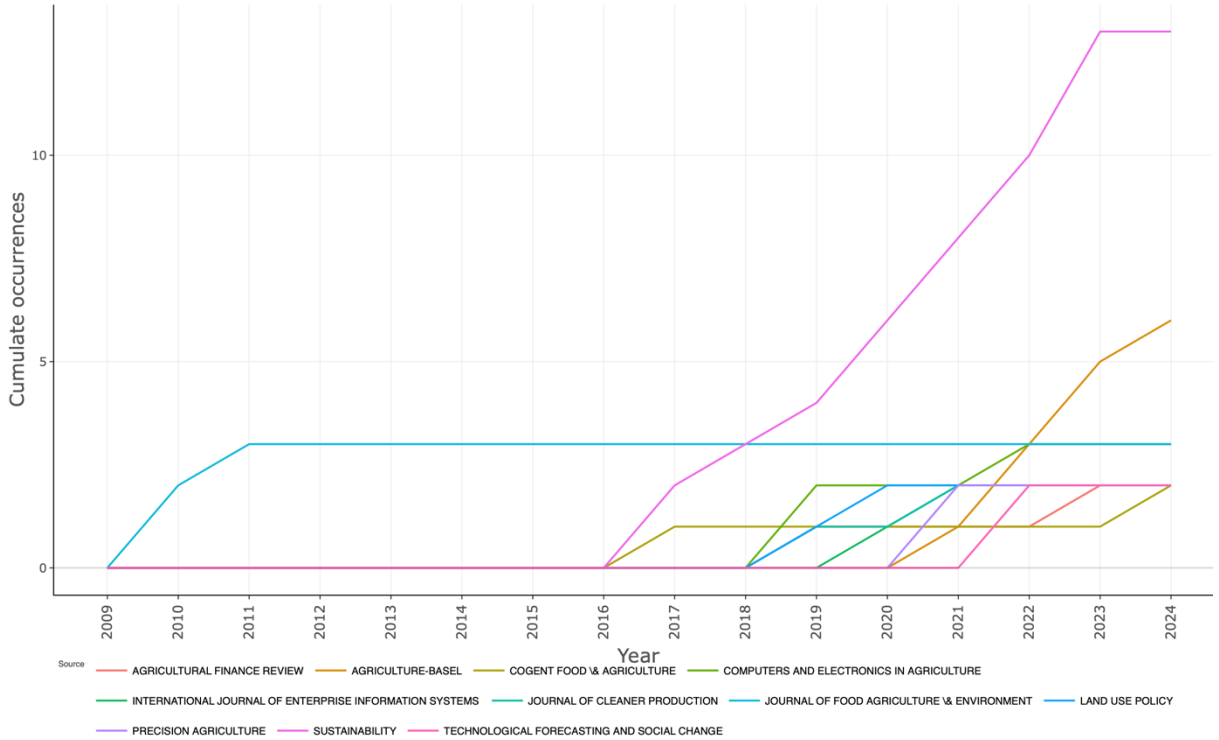


Figure 5: Publication Trends of Top 10 Sources Over the Years

Figure 5 highlights *Sustainability* as the most influential journal in the field. While *Agriculture-Basel* shows a lower H-index and citation count, its entry into the field in 2021 signals potential for future impact. The overall increase in the publication output of these sources in recent years is noteworthy.

Table 3 provides information about the top 15 authors with the most publications.

Table 3: Top 15 Authors by Productivity and Impact

Authors	Publication Number	H-İndex	G-İndex	M-İndex	Total Citations
MICHELS M	3	3	3	0,5	40
MUSSHOFF O	3	3	3	0,5	40
AMIN MK	2	1	2	0,091	6
DE STEUR H	2	2	2	0,286	17
HERNANDEZ AA	2	2	2	0,4	9
MARCOLIN F	2	2	2	0,5	57
MOGA LM	2	1	1	0,067	2
OTTER V	2	2	2	0,5	34
REZAEI-MOGHADDAM K	2	2	2	0,133	65
SHAHIBI MS	2	1	1	0,167	1
VEZZETTI E	2	2	2	0,5	57
VIOLANTE MG	2	2	2	0,5	57
VON HOBE CF	2	2	2	0,5	32
WANG Z	2	2	2	0,333	45
ZHANG J	2	2	2	0,125	10

Table 3 includes metrics such as the author's names, the number of publications, H-index, G-index, M-index, and the total number of citations. The G-index, like the H-index, places greater weight on highly cited papers, while the M-index represents the ratio of an author's H-index to their career duration. For instance, Michels M. and Musshoff O. have each published three articles with identical performance metrics (H-index, G-index, and M-index values), reflecting an equal citation impact of 40. On the other hand, despite having two publications, Amin MK shows lower performance metrics, indicating limited citation influence within the field. In contrast, Rezaei-Moghaddam K., Marcolin F., Vezzetti E., and Violante MG demonstrate high productivity and significant citation impact.

Figure 6 illustrates the productivity of the top 10 authors over time.

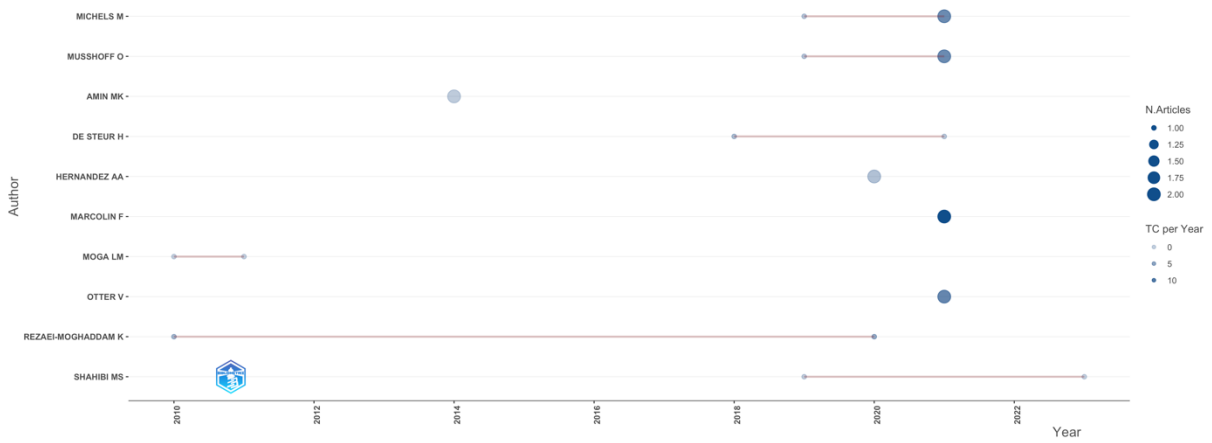


Figure 6: Productivity of Top 10 Authors Over Time

Figure 6 reveals that Rezaei-Moghaddam K. has been active in this field for the longest time, with publications in 2010 and 2020. Michels M. and Musshoff O. started their contributions in 2019 and are among the most productive authors. The most recent publication among the top 10 authors is by Shahibi MS, with the peak productivity observed between 2020 and 2022. Table 4 highlights the top 25 most cited studies in this field.

Table 4: Top 25 Most Cited Publications

Publications	Total Citations	Total Citations Per Year
ADNAN N, 2019, TRENDS FOOD SCI TECHNOL	106	17,67
DAXINI A, 2019, LAND USE POL	97	16,17
ZHANG T, 2019, J CLEAN PROD	85	14,17
MOHR S, 2021, PRECIS AGRIC	60	15,00
JUERKENBECK K, 2019, SUSTAINABILITY	55	9,17
CASTIBLANCO JIMENEZ IA, 2021, FUTURE INTERNET	48	12,00
REZAEI-MOGHADDAM K, 2010, AFR J AGRIC RES	44	2,93
NASPETTI S, 2017, SUSTAINABILITY	42	5,25
MORRIS W, 2017, J SMALL BUS ENTERP DEV	39	4,88
ZHENG S, 2019, CHINA AGRIC ECON REV	39	6,50
EVANS KJ, 2017, CRIT REV PLANT SCI	38	4,75
AKYUEZ NC, 2020, SUSTAINABILITY	31	6,20
ULHAQ I, 2022, AQUACULTURE	31	10,33
MICHELS M, 2021, PRECIS AGRIC	29	7,25
REJEB A, 2022, INTERNET THINGS	26	8,67
NIEHM L, 2010, J FAM ECON ISS	26	1,73
TSAUR RC, 2018, SUSTAINABILITY	25	3,57
MARTINI BG, 2021, SENSORS	24	6,00
DIAZ AC, 2021, RESOUR CONSERV RECYCL ADV	24	6,00
FARIDI AA, 2020, LAND USE POL	23	4,60
LANDMANN D, 2021, EUR J DEV RES	22	5,50
KHOZA S, 2021, GEND TECHNOL DEV	21	5,25
HAJI L, 2020, J AGRIC SCI TECHNOL	21	4,20
HASLER K, 2017, SUSTAINABILITY	21	2,63
JAMALUDDIN N, 2013, INT CONF ON ECO AND BUS RES 2013 (ICEBR 2013)	20	1,67

Table 4 reveals that Adnan's 2019 study is the most cited, with 106 total citations and the highest average annual citation rate. Similarly, Daxini's 2019 study has garnered significant attention with 97 citations. The top three most cited publications were all released in 2019. Despite being published in 2010, Rezaei-Moghaddam's study maintains relevance with 44 citations. Conversely, Mohr's 2021 publication, despite being relatively new, has achieved 60 citations. Table 5 presents the top 10 institutions with the highest number of publications.

Table 5: Top 10 Affiliations with the Most Publications

Affiliations	Articles
IOWA STATE UNIVERSITY	9
GEORG AUGUST UNIVERSITY OF GOTTINGEN	8
UNIVERSITY OF GHENT	7
CHUNG HWA UNIVERSITY OF MEDICAL TECHNOLOGY	6
UNIVERSITY OF TEHRAN	6
UNIVERSITY OF VALE DO RIO DOS SINOS	6
KHON KAEN UNIVERSITY	5
MICHIGAN STATE UNIVERSITY	5
SICHUAN AGRICULTURAL UNIVERSITY	5
TEXAS A&M UNIVERSITY	5

Table 5 presents the publication performance of various academic institutions. It includes the names of the institutions, and the number of publications produced by each are provided. Iowa State University ranks first with the highest number of articles (9), indicating its prominent role in academic research in this field. Georg August University Göttingen ranks second with 8 articles, highlighting its notable publication performance. Ghent University ranks third with seven articles. The other universities listed have between 5 and 6 publications, reflecting their active contributions to this research area.

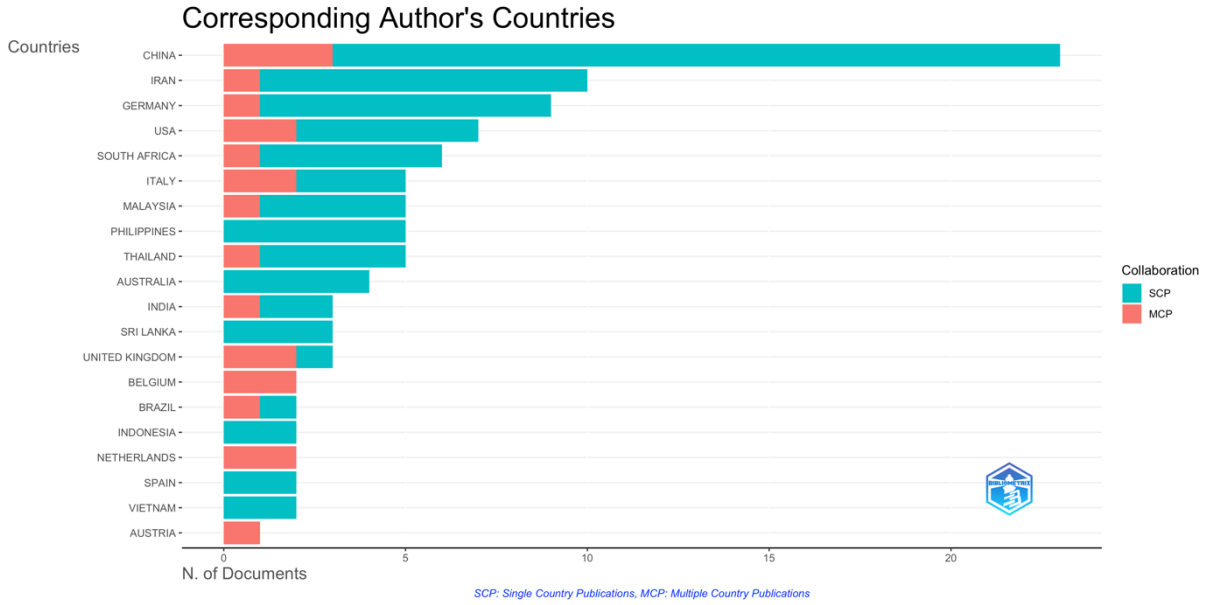
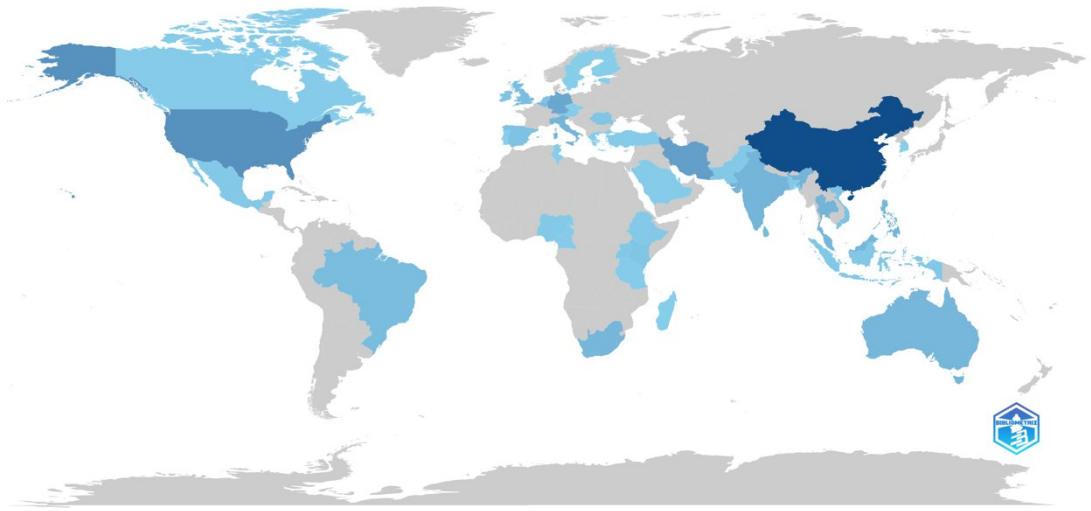


Figure 7: Countries of Corresponding Authors

Figure 7 presents a bibliometric analysis of the countries of the corresponding authors, distinguishing between single-country publications (SCP) and multiple-country publications (MCP). The number of publications is shown on the horizontal axis, while the countries are listed on the vertical axis.

China has the highest number of publications. Most collaborations involve Chinese authors working domestically, while collaborations with authors from other countries (indicated by the orange area) are limited. In contrast, United Kingdom, Belgium, Netherlands, and Austria exhibit stronger international collaborations than domestic ones.

Figure 8 illustrates the publication output of countries in the field, represented on a map with varying shades of color. The number of publications from the top 10 countries with the highest output is also displayed. On the map, countries with publications in the field are shaded from dark blue to light blue, with lighter shades indicating fewer publications.



Country	Articles	Country	Articles
CHINA	73	ITALY	14
USA	34	TAYLAND	14
IRAN	26	AUSTRALIA	13
GERMANY	21	MALAYSIA	13
INDIA	14	PHILLIPPINES	13

Figure 8: Global Distribution of Publications in the Field

According to Figure 8, China ranks first with 73 publications, followed by the United States with 34 and Iran with 26. Germany is in fourth place with 21 publications. Other countries show decreasing output levels. The prominence of China may be attributed to its population density and the critical importance of resource-efficient agricultural practices (english.news.cn, 2023). The United States has invested significantly in agricultural technology, partly due to its aging farming population, making technology adoption increasingly essential (BBC, 2024; USDA, 2023).

Iran's unexpectedly high publication count draws attention compared to other countries. This field's scientific output is concentrated in developed regions, particularly North America, Europe, and East Asia. Notable publication activity is also observed in South America and the Middle East. Turkey, represented in light blue, has produced only two publications: one on using warehouse receipt systems in agriculture and another on adapting sustainable farming practices (Yazar & Secer, 2023; Cakirli Akyüz & Theuvsen, 2020).

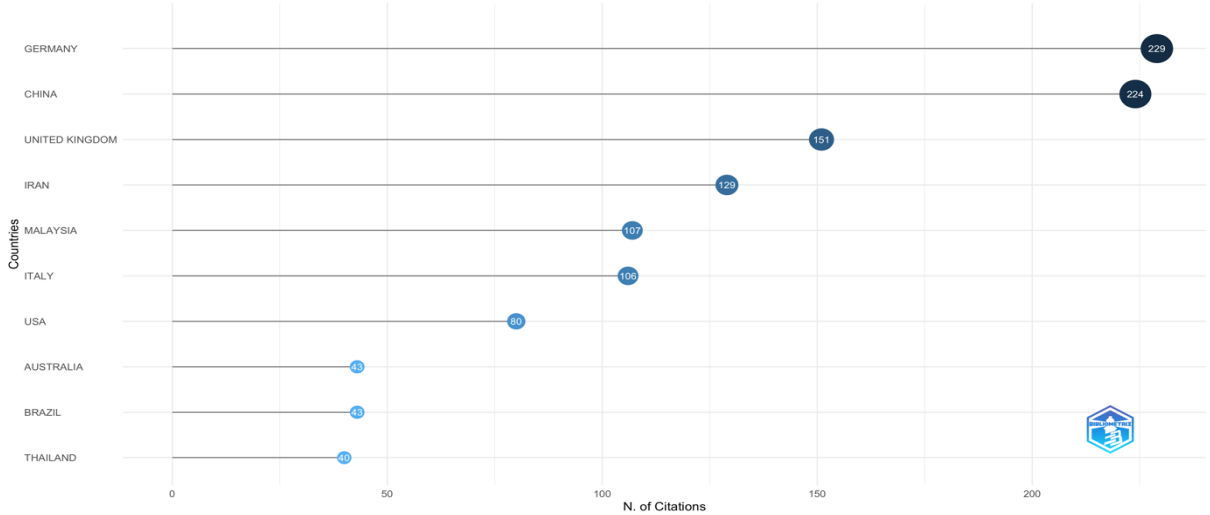


Figure 9: Most Cited Countries

Figure 9 illustrates the total citations of countries on the horizontal axis and the corresponding countries on the vertical axis.

Germany leads with 229 citations, followed by China with 224, the United Kingdom with 151, and Iran with 129. Despite having the highest publication volume (Figure 8), China trails Germany in citation count, indicating that Germany's publications may have a higher impact. Similarly, although the United States ranks second in publication count, it ranks seventh in citations. Figure 10 highlights the most frequently used keywords in the research field.

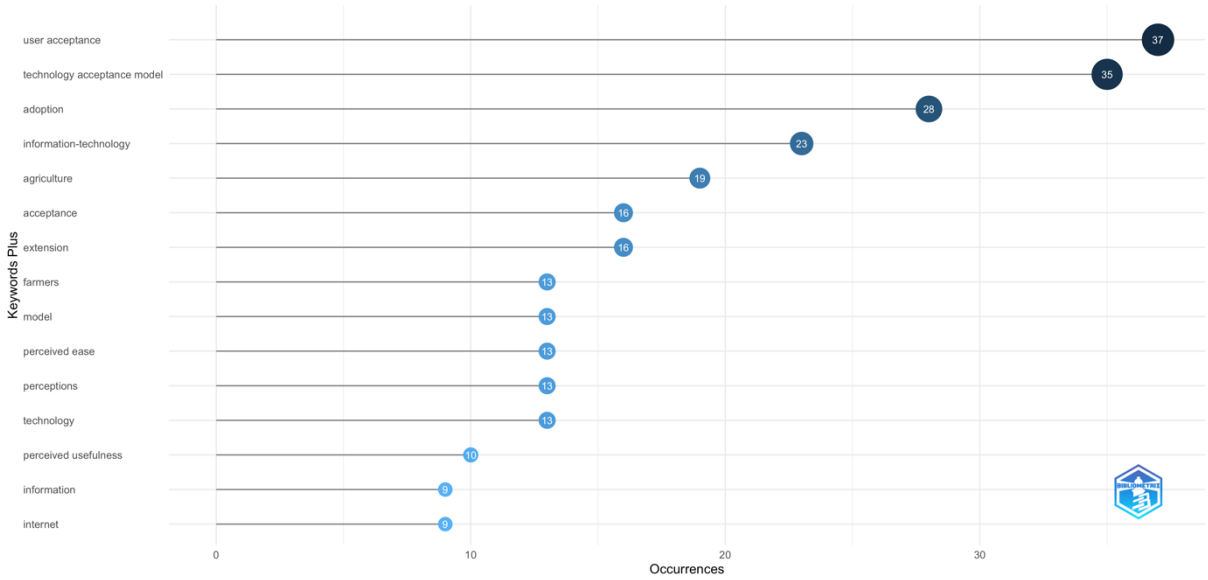


Figure 10: Most Relevant Keywords

Figure 10 displays the frequency of keywords on the horizontal axis and the keywords on the vertical axis.

The most frequently used keyword is "user acceptance" with 37 occurrences. Other common keywords include "technology acceptance model," "adoption," "information technology," and "agriculture," with decreasing frequencies. These keywords reflect the main focus areas in studies examining technology acceptance in agriculture.

Figure 11 presents the Co-occurrence analysis, which shows the words frequently used together in the publications.

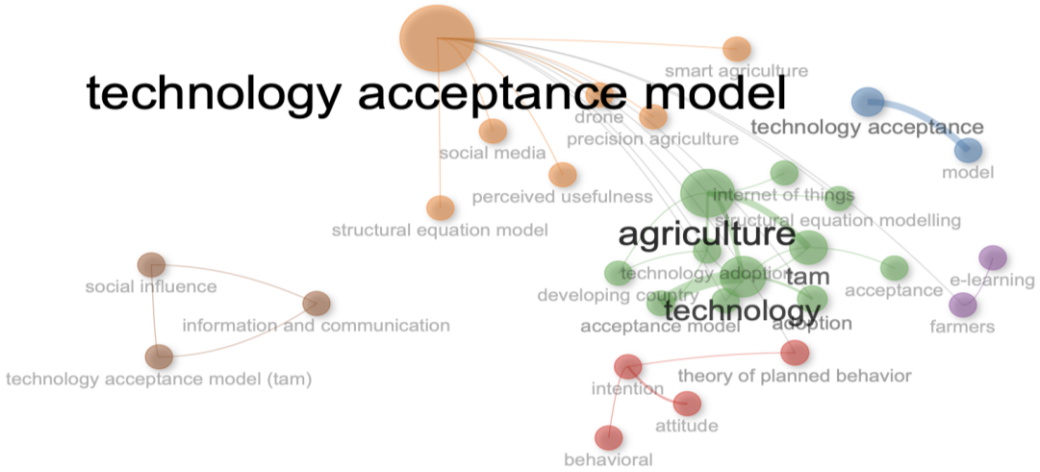


Figure 11: Co-occurrence Analysis (Keyword Connections)

Figure 11 presents the co-occurrence analysis, showing which keywords are most frequently used together. The size of the circles represents the frequency of keyword usage, while the thickness of the lines indicates the strength of the connection between co-occurring keywords.

The analysis reveals six clusters of keywords, each represented by a distinct color, generated by the Biblioshiny program. The yellow cluster stands out, featuring the central keyword “technology acceptance model.” This cluster is closely linked to terms such as “social media,” “drone,” and “precision agriculture.”
The green cluster highlights the co-occurrence of “agriculture” and “technology,” along with other terms like “internet of things” and “developing country.” The red cluster focuses on the Theory of Planned Behavior and its components, while the blue cluster centers around “technology acceptance” and “model.” The purple cluster explores connections between farmers and e-learning, while the brown cluster links social influence, information, communication, and TAM. Figure 12 presents the thematic analysis provided by the Biblioshiny program.

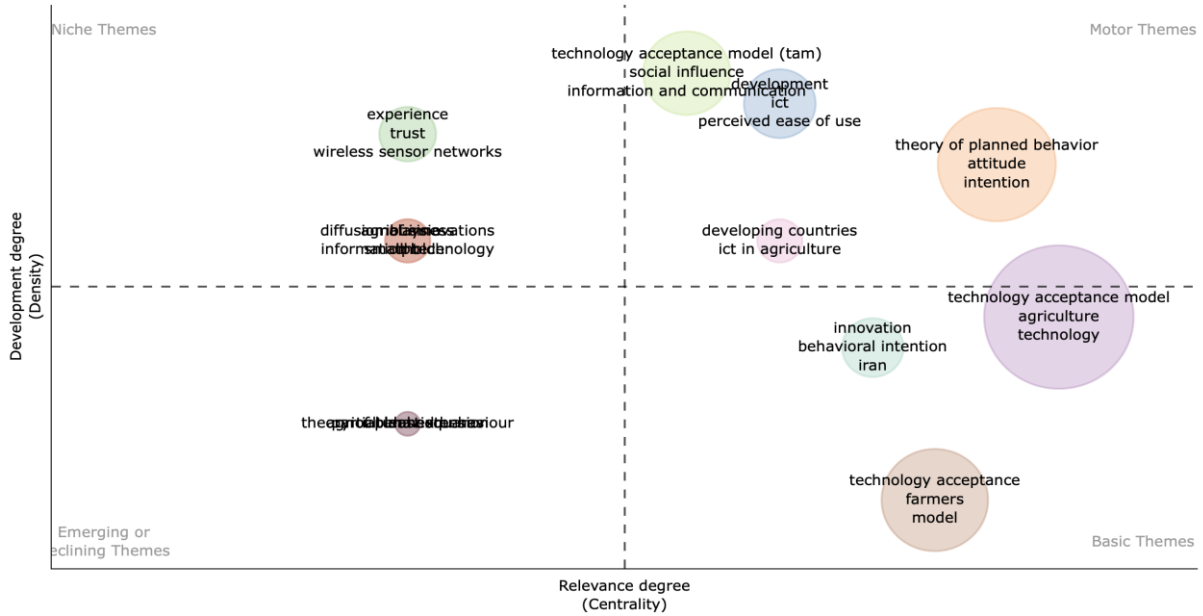


Figure 12: Thematic Analysis

The thematic analysis in Figure 12 categorizes keywords into four regions based on their centrality and density. These regions correspond to four distinct themes: motor themes in the upper right, niche themes in the upper left, emerging or declining themes in the lower left, and basic themes in the lower right. Motor themes, which are both highly central and widely prevalent, include notable keywords such as the use of information and communication technologies in connection with development, developing countries, and social impact. Niche themes focus on the interplay of experience, trust, wireless sensor networks, and the combination of innovation diffusion and information technologies. Agricultural extension emerges as an example of either newly developing or fading themes. Among the basic themes, which are central but less prevalent, innovation, Iran, and behavioral intention stand out, apart from those closely related to motor themes. Figure 13 presents the co-citation analysis.

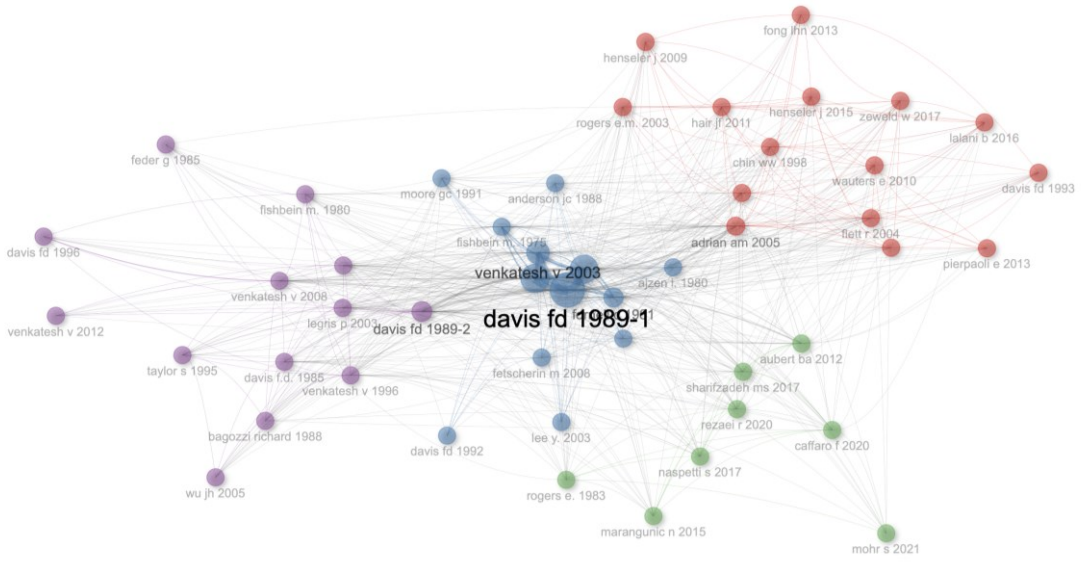


Figure 13: Co-citation analysis

Figure 13 displays the most frequently co-cited publications. This analysis identifies clusters of studies often cited together. The analysis reveals four distinct clusters, with the most prominent circles representing the most co-cited works. Studies by Davis and Venkatesh emerge as the most frequently co-cited, reflecting their foundational contributions to the development of TAM. These authors are pivotal figures in shaping the theoretical framework of technology acceptance.

4. Discussion and Conclusion

The findings indicate a significant increase in recent academic studies focusing on TAM in the agricultural sector. Starting from 2009, there has been a marked rise in publications, particularly after 2016. The trend peaked in 2021 and 2022, with 19 and 20 publications, respectively, before experiencing a slight decline in 2023. Nonetheless, an annual growth rate of 9.68% suggests a sustained and growing interest in the field.

Examining the most frequently published sources reveals that *Sustainability* leads in the number of publications and citation impacts. Other significant journals include *Land Use Policy* and the *Journal of Cleaner Production*. These journals are highly influential within the domain, as evidenced by their high H-index values.

Michels and Musshoff are among the most prolific authors; their publication volume is remarkable. Rezaei-Moghaddam, Marcolin, and Vezzetti demonstrate high citation impact. Adnan's 2019 study is the most cited work, underlining its substantial influence on subsequent research. Furthermore, Iowa State University emerges as the leading institution in this field. Researchers seeking to contribute to this domain may benefit from reviewing works published in these prominent sources and institutions.

Geographically, China leads in publication volume, while Germany ranks highest in citation impact. Other key contributors include the United States, Iran, and the United Kingdom. While scientific output is concentrated in developed regions, notable activity is also observed in South America and the Middle East. Turkey, however, has only contributed two studies in this field, indicating room for growth.

Keyword analysis highlights "user acceptance," "technology acceptance model," and "adoption" as central themes. The frequent occurrence of "precision agriculture" emphasizes the focus on technologies that enhance agricultural efficiency and environmental sustainability.

This study examined research utilizing TAM to explore technology acceptance in agriculture. Future studies could expand the analysis by incorporating other models, such as the Unified Theory of Acceptance and Use of Technology (UTAUT) or the Theory of Planned Behavior (TPB). Additionally, variables influencing technology acceptance could be investigated to refine TAM for the agricultural context. As the body of research grows, new variables may emerge to address sector-specific challenges.

In conclusion, the use of TAM in the agricultural sector is rapidly expanding, with significant contributions from various countries, institutions, and authors. This bibliometric analysis underscores the importance of TAM in understanding agricultural technology adoption and serves as a foundation for future research in this area.,

Acknowledgments

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