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USE OF TECHNOLOGY ACCEPTANCE MODELS IN AGRICULTURE: A CITATION NETWORK ANALYSIS

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Abstract:

Agriculture is the backbone of the Indian Economy. For the past few decades, the agriculture sector underwent several metamorphisms and across the globe farmers have adopted a wide variety of farming technologies and farming innovations to improve productivity on as well as the quality of the products. The ultimate aim of all these agricultural technology information management systems are to facilitate the production of quality food items at an affordable cost. Technology adoption and information management in Agriculture may be applied to different levels of farming activities starting from the selection of quality planting materials to harvesting and post harvesting operations. Recent advancements in ICT and mobile applications enables improved usage of precision farming and SMART agriculture practices and brings effective information management. These technological adoptions and information management enable the farmers in producing quality agricultural products and helps to improve their earnings. There are many studies on the acceptance and adoption of Technology by farmers for information management. In this paper we evaluate various Technology Acceptance Models in agriculture using Citation Network Analysis (CNA) to get an understanding about the acceptance and adoption of technology by farmers. Software packages such as Sci2, Gephi and VosViewer were used for CNA analysis. The chronological analysis of data collected from Web of Science database for the period 1989 to 2022 were collected and used for building the network. The main path was identified to understand the evolution of research articles in the subject area of technology acceptance in agriculture. Further we explored the co-citations to trace the extent to which two or more articles are cited together in other research articles. From the main path, we traced the growth of the domain under consideration and identified five different phases of the technology adoption by farmers. Content analysis of major nodes in the main path have been performed to the current trend and future scope of the research area. We performed modularity based clustering algorithm for finding the major research themes in the area. All these analysis provides a clear picture of how the technology adoption in agriculture was evolved over past several years and what are the technologies at different time intervals. The analysis shows that recent research trends in this area is more focussed towards sustainability and majority of scientists have studied and evaluated the technology adoptions using UTAUT model.

Keywords: Agriculture, Information management, Technology acceptance models, UTAUT, Citation Network Analysis, bibliometric analysis

Introduction

Technological adoption in farming are inevitable for profitable agriculture. There are several success stories by farmers by adopting latest trends in technological evasion in agriculture. [Rehman, A, 2017]. Though many of the modern technologies provides a quantum jump in the income of farmers with less human resources, majority of the

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farmers are reluctant in adopting modern technologies mainly due to social and economic factors. [Pignatti, E., (2015]. The extent of farming land, adoption cost and the real benefits of technology are some of the challenging factors for technology adoption. Many social factors such as age, education, gender [Zheng, S. 2019; Adesina, A.A. 2002] etc. are found to have significant influence on farmer's decision to adopt modern agricultural technologies. Speeding up the process of modern technological adoption in agriculture is the need of self-sustainability of each country. To achieve this milestone, first, we have to evaluate the factors which influences the technology acceptance by farmers. There are several methods to evaluate the technology acceptance. In this particular paper we are adopting citation network analysis [Dawson, S, 2014] of literature to evaluate technology acceptance model in farming.

Modernization of technologies is based on the user's acceptance and confidence in existing technologies. Acceptance can be defined as "an antagonism to the term refusal and means the positive decision to use an innovation"[Simon B, 2021]. Development phase of the new technologies should have a clear information regarding the acceptance level of existing one and factors which influenced the acceptance/non-acceptance existing system. There are several theories to model to evaluate the user acceptance and factors which play key role in in the process [Taherdoost H, 2018].

Even though the agriculture sector now overwhelmed with new technologies but the percentage of adoption by farmers is much less compared to other sectors. There are several studies in recent past regarding failures that impede knowledge transfer from experimental stations to farmers [Dirimanova V, 2017]. Agricultural extension workers have significant role in the process of technology diffusion [Rogers EM, 2003]. TAM have been used to analyze aspects such as nutrition, occupational preference by women, patterns in using public transport, education, purchase patterns of class of consumers, and use of computer/internet technologies[Davis FD, 1989]. Many theories has been put forward to introduce factors that have significant effect on user's acceptance such as Social Cognitive Theory [Ratten V, 2015], Theory of Reasoned Action and Interpersonal/planned Behaviour[Armitage C. J., 2001], Theory Diffusion of Innovation Theory[Tuan L, 2021], Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology (UTAUT)[Venkatesh V, 2016], Compatibility UTAUT (C-UTAUT)[Chang A, 2012] etc. Many recent studies used these traditional frame works and uses domains' specific needs to evaluate technology acceptance models.

Review Literature on Theory of Technology Acceptance Models

TAM proposed by Davis[Davis FD, 1989] is based on the theoretical framework of Theory of Reasoned Action (TRA) [Ajzen, I, 1985]. TAM highlights the link between a user's beliefs, attitudes, and intentions, as well as their computer usage behaviour. TAM is primarily concerned with two theoretical ideas – "Perceived Usefulness" and "Perceived Ease of Use" to predict the intention to use information systems. "Perceived usefulness (PU)" indicate a measure of confidence of a person in a specific

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system which may enhance the output of a job of that person. “Perceived ease of use” (PEOU) measures a person’s belief in refers to the degree to which a person believes that using a specific method would be comfortable. According to TAM, these two behavioural beliefs lead to behavioural intention and actual behaviour, of which perceived usefulness is the strongest predictor of an individual’s intention to use an information technology[Chao CM, 2019]. TAM doesn’t include subjective norms of TRA [Kamel, R., 2009] in the model to explain behavioural intention. Attitudes are developed by a person's views about how to use a technology or system. The person's attitude toward the use of technology [Lamar, B. 2016], as well as their sense of its utility, define the goal. The effect of perceived utility and perceived ease of use on the intention to employ a particular technology is mediated by attitude. TAM posits that PU is influenced by PEOU. TAM also suggests the inclusion of external variables having an effect on intentions, but mediated by PU and PEOU.[Burton-Jones, A. 2006] TAM is a robust, parsimonious, and powerful method to estimate user adoption of technology that has been widely used in research on information technology and information systems. TAM is one of the most widely tested models of technology acceptance.

Venkatesh et al. [Venkatesh 2016] aimed to bring together the various aspects discussed above and create an unifying framework for explaining technological acceptance. The Unified Theory of Acceptance and Use of Technology (UTAUT) was proposed by merging eight existing models to predict user adoption of information technology/systems. The eight models are the theories of reasoned action (TRA), theory of planned behavior (TPB), Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT), motivational model (MM), model of PC use, and social cognitive theory (SCT).

Materials and Methods

This research mainly focus on the bibliometric information analysis on modelling various Technology adoption by farmers using citation network analysis. We collected data from Web of Science data repository for the period 1989 to 2021 using following keywords “(tehno* OR Mobile*) AND (Adoption OR Acceptance) AND (Model* OR TAM* OR UTAUT*))AND (FARM* OR AGRI*)”. After removing the reviews and book chapters, 2949 articles as on 31st Dec. 2021 found relevant for the analysis and network were created.

Citation Network Analysis of original research articles provides a deep understanding how the origin of the field under consideration, how knowledge flow happened at various levels etc. The CNA analysis can output the trajectory of evolution of knowledge, as well as networks of co-citation or author/co-author[Prabhaa S, 2020; Bindu N, 2019]. We mainly employed software packages such as Sci2, Gephi and VosViwer for CNA analysis. The dynamics of evolution the research related to modelling of adoption or acceptance of technology we first identified the main path. Further we explored the co-citations to trace the extent to which two or more articles are cited together in other research articles. CNA evolved as a technology to get in-

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depth understanding of evolution of the field similar to domain experts. In this paper we performed chronological analysis of data collected from Web of Science database and created the networks. From the main path, we traced the growth of the domain under consideration and identified five different phases of the technology adoption by farmers. Content analysis of major nodes in the main path have been performed to the current trend and future scope of the research area. We performed modularity-based clustering algorithm for finding the major research themes in the area.

Results and Discussion

The figure 1 shows how the number of articles and citations of the articles related to the keywords mentioned in methodology is increasing in recent years. The number of articles in this area was about 50 numbers in 2010 and in 2021 more groups are attracted towards the field. From the analysis it shows that there is about a seven-fold increase in the number of articles for the past 10 years. Number of citations took a steeper increase in these years. For the past 10 years it increased from 50 to 10,000. The figure shows that the field captured the momentum in 2015.

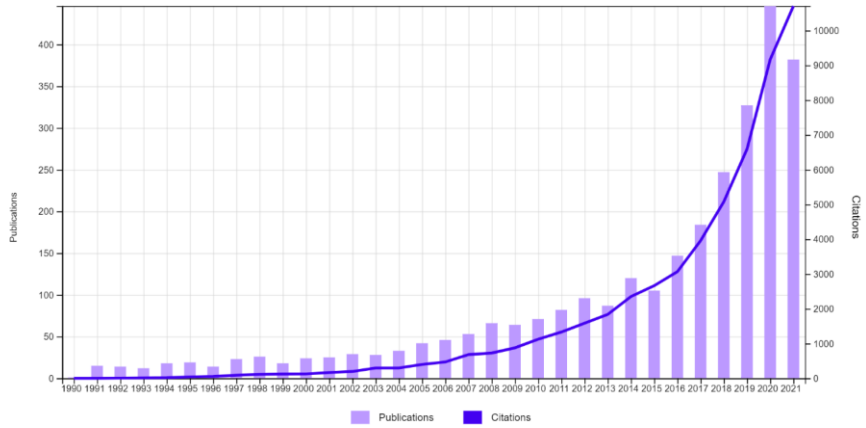

Fig. 1 Total number of articles and citations in the field for the past several years.

We further analyzed the results to find the maximum number of articles appeared in different subject areas. From the analysis it is clear that economics attracted more papers (612 papers), followed by environmental sciences (576 articles). The distribution of the articles in major subject areas is given in Figure 2

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Figure 2: Distribution of articles in major subject areas

Analysis of the results obtained from the keyword search indicate that maximum number of work is happening in CGIAR (which is about 9.93% of the total articles published). This followed by Wageningen University, University of California, University of Gottigen etc which amounts between 3.3 to 2.5. Table 1 shows the Major ten organizations involved in research in the theme area.

Table 1: Major research organizations with publications in the subject area

Organization`s Affiliations	**% of Articles**
CGIAR	9.936
WAGENINGEN UNIVERSITY RESEARCH	3.357
UNIVERSITY OF CALIFORNIA SYSTEM	2.543
UNIVERSITY OF GOTTINGEN	2.475
INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE (IFPRI)	2.035
UNITED STATES DEPARTMENT OF AGRICULTURE USDA	2.001
INDIAN COUNCIL OF AGRICULTURAL RESEARCH ICAR	1.899
INTERNATIONAL MAIZE WHEAT IMPROVEMENT CENTER CIMMYT	1.899
COMMONWEALTH SCIENTIFIC INDUSTRIAL RESEARCH ORGANISATION CSIRO	1.729
PURDUE UNIVERSITY	1.458

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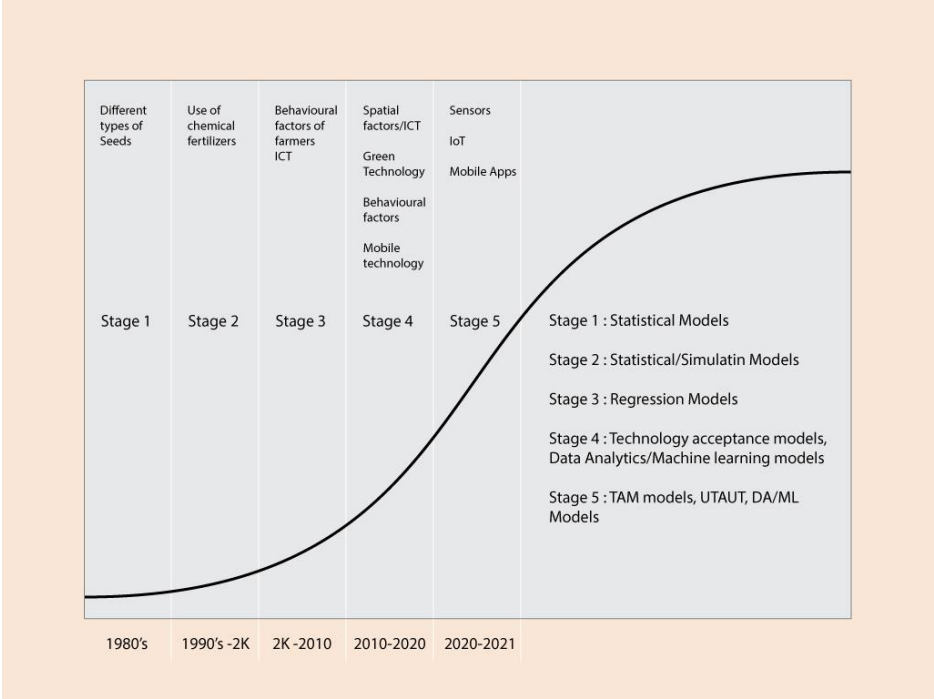

Fig. 3 Literature growth Curve 1980-2021

The research dynamics of the theme is given in Figure 3. Major interdisciplinary subject areas of the cited journal articles, authors, published journals, and major institutions who are contributing to the modelling of agricultural adoption behaviour of farmers were identified from the dataset. Topic analysis was carried out on highly cited publications to obtain a broad picture of the primary research topics and stages of evolution. The area's growth curve is seen above. The major technologies under discussions at different time span starting from 1980's to 2021 were identified and evaluated how it got transformed to areas under the influence of industrial revolution IV. This growth curve shows the maturity of research as well as to get future scope of the research area.

The main technology during 1980's and early 1990's in agriculture was related to development of high yielding plant varieties. During this time the adoption behaviour was tested using conventional statistical methods. Although the use of chemical fertilizer in agriculture was known from decades, in 1990's scientists studied the adoption behaviour of farmers in using the fertilizers. Scientists used statistical or simulation modelling to study the effect. From the beginning of 2000 onwards there was a boom in using Information Communication Technology in Agriculture. Scientists have tested different types of models to explain the behaviour of farmers for the adoption of technology and different regression techniques were used to measure the adoption models. During the period from 2010 – 2010 different research group analysed technology adoption behaviour using different types of technology acceptance models such as Technology Acceptance Model (TAM) . Adoption of Geo Spatial technology, ICT, Green technology, mobile technology etc. in agriculture were

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tested and measured during the period. Early 2020's are witnessing for the adoption of IR IV technologies in agriculture. Scientists are using UTAUT, Data Analytics, Machine learning technologies etc to estimate the adoption behaviour of farmers.

4.1 Main Path Analysis

We created the main path network from the literature and shown in Figure 4. The citation network analysis shows that the major theories in this area started during the period 1975 – 1990. The area starts with articles of Gershon Feder article in 1980. In that manuscript Feder discussed about the adoption of modern technology by farmers when there are uncertainties caused by the extent of farm as well as risk. Feder applied Bayesian models in estimating the acceptance of sequential models [Feder, G. 1985]. In early 1990's people started looking at the adaptability of high yielding variety of seeds. Lin's articles and those articles cited this particular manuscript mainly point towards the adoption of hybrid rice where adoption mainly depends on factors such as behavioural aspects and education[Lin JY, 1991]. Leathers et al studied the attitude towards risk using comparative statistical results. The authors analysed the policies regarding agricultural and environmental sectors. The node mainly reflects the policies and its influence on adoption behaviour by farmers[Leathers HD, 1991a]. Another major paper published by Fafchamps during 1991 in this domain and focused on the preference Cash Crop and food price. [Fafchamps, M. 1992] This paper discuss the model of policy implications and crop choices based on risk under multivariate conditions. The author also indicate that integration of food markets can meet self-sufficiency of food. Leathers and co-workers papers talks about the concept of adoption behaviour farmers and the farmers intention to adopt technology not as a full package but in parts[Leathers HD, 1991b]. This particular set of papers clearly pointed towards the land use policies and it's impact on adoption of new technology by farmers.

The findings of Lin's, Leathers's together with Fafchamps and Lin's observations initiated further research in this area and Smale came up with a model which talks about the utilization of land allocation for high yielding variety seeds[Smale, M, 1994]. Nkonya et al. in their findings talk about factors influences of socio-economic factors that may influence adoption behavior of farmers especially land use. They studied the usage of high yield seed variety and chemical fertilizer by farmers to improve the crop yield [Nkonya E, 1997].

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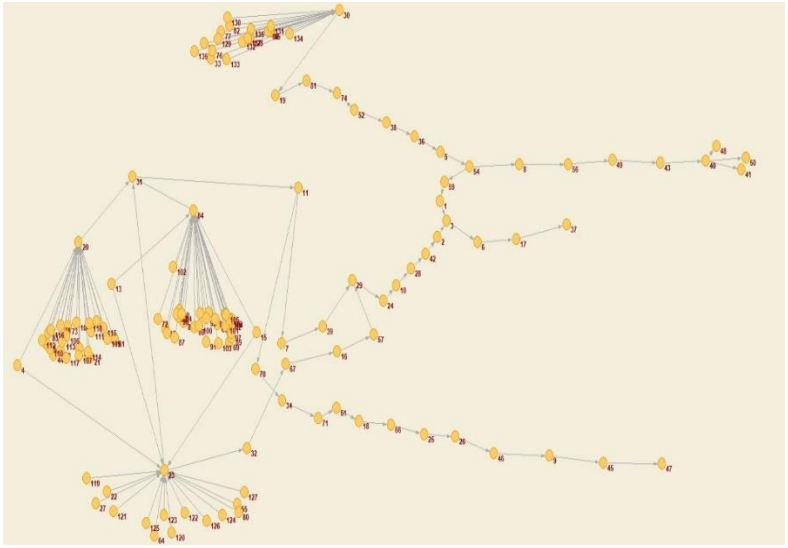

Figure 4: Main Path Network

In another development Polson and co-workers worked on technology adoption by cassava and found that younger generation of farmers are more adaptable for new technologies and they are getting a considerable high yield compared to traditional farming[Polson AR, 1991]. This node was originated from the set of papers which deals with factors recommending best farm practices in different parts of the world. This further initiated a series of study relating the farmers perception about adoption of technology at different levels[[Polson AR, 1991].

From the year 2018 onwards more and more Information Communication Technology especially mobile technologies were developed for agricultural systems. Therefore, the recent developments in this area is mainly about adoption of mobile technologies and there a few literature published in this area and papers by Verma eta al[Verma, P, 2018], Zhang et al. [Zheng, S 2019] etc are a few examples. In one of the major article published in this line discussed about “mobile based agricultural extension services” that may result in comprehensive growth of farming in rural area. The study summarized the major influential factors for the acceptance of mobile technology using technology acceptance model(TAM). The authors employed the structural equation modelling (SEM) to identify the intricate association of perceived usefulness(PU), perceived ease of use(PEOU), social influence, attitude, perceived economic wellbeing(PEWB) and behavioral intention in technology acceptance. Authors found that social influence do have a major impact on attitude, PEOU, PEWB and PU etc. but not on behavioral intention. The major finding is that PEWB is a precursor to PU. The paper also revealed that mobile based agricultural extension services are more effective that traditional ones mainly because farmers do trust each other and they assume that adoption of information communication technology adopted by the others may benefit them also.

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These finding further developed the branch and Rajasekharan et al. studied the pattern of decision by farmers in selecting intercropping and reported that the perception of profitability have a significant influence in decision making[Rajasekharan, P, 2002]. This study further invoked a series of studies in which scientists analysed the profit and adoption at different countries and in different crops. Nkonya studies also triggered the work by Merra M et al. who studied the about the risk as well as uncertainty involved in adoption of new technologies. They also examined the learning curve in adoption of new technologies by farmers[Merra M, 2003]. These set of papers further triggered the research in land use policies and green agricultural practices[Huifang, S, 2021]. Marra et al. pointed towards a set of publications in which researchers are more concentrating on the adoption behaviour due to physical characteristics such as connectivity between farmers, extent of land, type of seed etc. This further lead to discussion about the attitude of farmers in adoption of technology [Veltheim Rv, 2021]

Nkoya's study further triggered one of the highly informative research article originated from Matuschke et al.[Matuschke I, 2008] in which they talk about impacts of privatisation technology on farmers' trend towards acceptance of technology. This work along with the work of originated from Marras's work especially Gadhim's [Gadhim AKA, 2005] work on acceptance of technology by farmers based on risk and uncertainty framed the next important article in this area which talks about importance of social network on hybrid seed adoption[Matuschke, I, 2009]. These article along with the article of Abdulai [Abdulai , AN, 2016] converged and a new set of articles which inspired scientist to do research on importance of technology acceptance based on water and soil conservation management. In this set Faridi's paper reports that integration of UTAUT and ITM will provide comprehensive conceptual model for explaining the acceptance of modern technologies in agriculture [Faridi AA, 2020].

The work by Polson initiated a series of papers and one of the paper in that line is the paper by Abdulai which talks about farmers' educational status social networks, access to bank credits, agricultural extension services, available machines for farming and especially the soil quality positively influence adoption of conservation of agricultural technology. Faridi's paper further inspired scientist to work on modern technologies and gadgets for to improve the quality and quantity of crops. During the past few years farmers where practicing smart farming where Internet of Things technology got a prominent role. The authors used UTAUT model for analyzing the observations.

The paper shows that "performance expectancy", "effort expectancy", "social influence" , "individual factors" and "Facilitating conditions" got a positive influence on adoption of IoT technology[Ronaghi MH, 2020] . This sub tree ends with a very recent paper [Sarkar A, 2022] which uses PLS-SEM to study which indicates that cooperativeness in participation is crucial in adoption of technologies Another important citation network started from Abdulai's paper is mainly talking about wheat farming and factors affecting technology adoption specifically in china such as cooperativity, yield, farm size etc[Zheng H, 2021]. These set of papers leads to a set

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of papers which talks about the sustainability and household livelihood capitals by adoption of technology[Huifang S, 2021]. The main path indicate that recent trends in this area is more focussed towards sustainability and majority of scientists are evaluating technology adoption using UTAUT.

4.2 Analysis of Network's Giant Component

Using Gephi Software, we investigated the network's large component further. The cluster we got from the above analysis is given below. There are totally 5 clusters in the giant component. The cluster 1 and II is almost similar with 32% of the total population. The third cluster (Zeroth one in the figure) is about 22.3%. The figure is given in Figure 5.

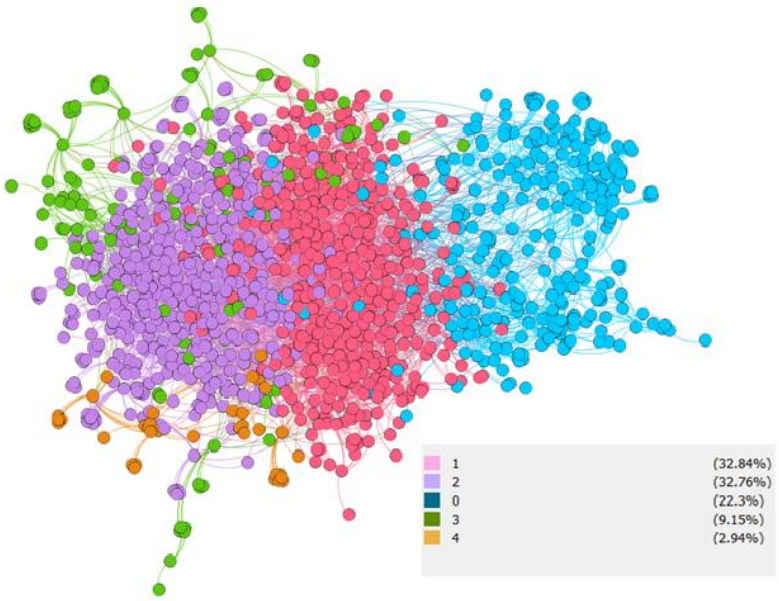

Figure 5: Clusters formed from the giant component of the network

We created the word cloud for the clusters to find out which is the most relevant field in the cluster. For this analysis the title, abstract and stop words were removed (this includes adoption, farmer etc). The word cloud got from the first cluster (Modularity cluster 1) is given below.

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Figure 6: Word cloud from the first cluster (Modularity 1)

The cluster mainly talks about the adoption behaviour with major attention towards irrigation and micro-irrigation technology. The effect on farming on climate is a major factor for adoption and farmers are concerned with economic benefits due to adoption.

Figure 7: Word cloud from the second cluster (Modularity 2)

The second major cluster talks about the climate condition in adoption. The cluster also deals with effectiveness of extension service and importance of the quantity of production in adoption of new technologies. The cluster also looks at the importance of water, land and soil utilization using technology adoption.

Figure 8: Word cloud from the third cluster (Modularity 0)

The third cluster is about 22.3% of the total of giant cluster. We further created the word cloud and shown in the Figure given above. From the figure it is clear that this cluster belongs to adoption behaviour which are suitable for environmental factors and precision farming. Most of the studies were conducted in the country of Malaysia and

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are pointing towards how organic methods can be applied in farms and for crop management. The farmer's perception regarding agri-environmental measures are well discussed in articles. The second major cluster formed also shares about 32% of the total in the giant cluster.

4.3. Co-citation Network Analysis

The Co-citation networks analysis were created with more than 25 co-citations of articles. to analyse the bibliometric of research. Figure 9 depicts the co-citation networks of articles and journals. Table 2 shows the top 20 articles with the most co-citations. The paper published by Feder is cited maximum times (323 times). The article published by Kisse M got maximum attention with in the shortest span of time.

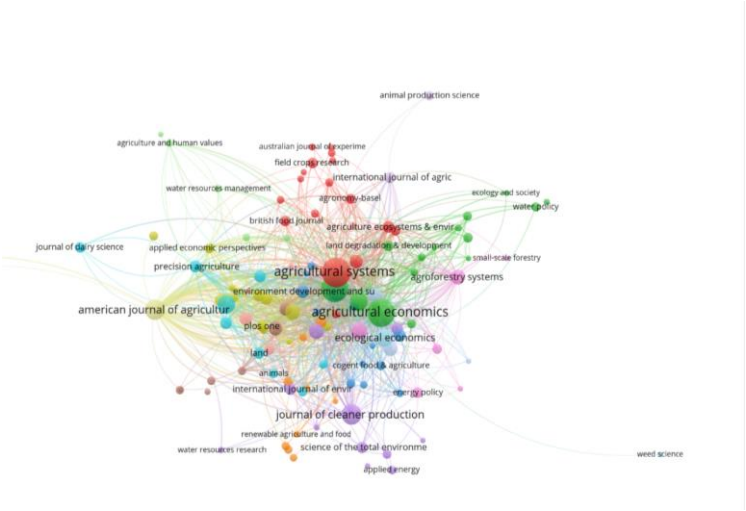

Figure 9. Journals' co-citation network

We investigated major journals which publish the adoption of new technologies by farmers. The investigation shows that the journal "Agricultural Systems" has published maximum number of papers followed by "Sustainability and Agricultural Economics". The journal "Land Use Policy" also attracted quite a good number of publications in this area.

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Table 2: Major co-cited articles

AUTHOR	JOURNAL	DOI	Citations
FEDER G	Economic Development and Cultural Change	doi 10.1086/451461	323
KNOWLER D	Food Policy	doi 10.1016/j.foodpol.2006.01.003	125
AJZEN I	Organizational Behavior and Human Decision Processes	doi 10.1016/0749-5978(91)90020-t	113
FEDER G	Technological Forecasting and Social Change	doi 10.1016/0040-1625(93)90053-a	110
DAVIS FD	MIS Quarterly	doi 10.2307/249008	101
FOSTER AD	Journal of Political Economy	doi 10.1086/601447	95
ADESINA AA	Agricultural Economics	doi 10.1016/0169-5150(93)90019-9	90
GRILICHES Z	Econometrica	doi 10.2307/1905380	90
ADESINA AA	Agricultural Economics	doi 10.1016/0169-5150(95)01142-8	84
BANDIERA O	The Economic Journal	doi 10.1111/j.1468-0297.2006.01115.x	83
KASSIE M	Technological Forecasting and Social Change	doi 10.1016/j.techfore.2012.08.007	83
GREENE WILLIAM. H.	Econometric Analysis		81
VENKATESH V	MIS Quarterly	doi 10.2307/30036540	77
FOSTER AD	Annual Review of Economics	doi 10.1146/annurev.economics.102308.124433	76
CONLEY TG	American Economic review	doi 10.1257/aer.100.1.35	75
ABDULAI A	Land Economics	doi 10.3368/le.90.1.26	70
DI FALCO S	American Journal of Agricultural Economics	doi 10.1093/ajae/aar006	70
RAHM MR	American Journal of Agricultural Economics	doi 10.2307/1240918	68
DOSS CR	Agricultural Economics - BLACKWELL	doi 10.1111/j.1574-0864.2006.00119.x	67

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Table 3: Journals with highest citations in the co-citation network

JOURNAL SOURCE	CITATIONS
AGRICULTURAL SYSTEMS	113
SUSTAINABILITY	103
AGRICULTURAL ECONOMICS	102
LAND USE POLICY	57
AMERICAN JOURNAL OF AGRICULTURAL ECONOMICS	54
JOURNAL OF CLEANER PRODUCTION	53
COMPUTERS AND ELECTRONICS IN AGRICULTURE	44
AGRICULTURAL WATER MANAGEMENT	42
ECOLOGICAL ECONOMICS	39
JOURNAL OF AGRICULTURAL ECONOMICS	35
FOOD POLICY	31
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	30
AGROFORESTRY SYSTEMS	28
FOOD SECURITY	28
WORLD DEVELOPMENT	28
JOURNAL OF ENVIRONMENTAL MANAGEMENT	26
TECHNOLOGY IN SOCIETY	26
JOURNAL OF AGRICULTURAL AND RESOURCE ECONOMICS	24
AGREKON	23
AGRICULTURE-BASEL	21
ENVIRONMENT DEVELOPMENT AND SUSTAINABILITY	21
JOURNAL OF FOOD AGRICULTURE & ENVIRONMENT	21
AUSTRALIAN JOURNAL OF AGRICULTURAL AND RESOURCE ECONOMICS	20
ENVIRONMENTAL SCIENCE AND POLLUTION RESEARCH	20

Conclusion

In the present study we analyzed the research trends and analysed the cutting edge areas of research dynamics from different view points. Initially we looked into the growth curve to identify the major technology areas evolved during past several years. The main path network were created and found that how the subject was evolved

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during the past several years. Then co-citation analysis of the articles and authors were analysed. All these analysis provides a clear picture of how the technology adoption in agriculture was evolved over past several years with different technologies at various time periods. The major path revealed that the area began with research into the adoption of high yielding seed varieties, followed by research into the effects of various fertilisers on production. Scientists found that land use policies and importance of government interventions through policies or as extension services also got significant influences in technology adoption. The main path indicates that recent trends in this area is more focussed towards sustainability and majority of scientists have studied and evaluated the technology adoption using UTAUT framework. This research gives useful information source for the scientists and researchers who are involved in the development of new technologies in Agriculture and allied field. Institutions and authors can track down and identify appropriate themes, as well as research groups of co-authors, from around the world for future research collaborations in this field. The report highlighted current issues and provided an outline of global research trends.

Reference

1. Abdulai, A.N. (2016), Impact of conservation agriculture technology on household welfare in Zambia. Agricultural Economics, 47, 729-741. https://doi.org/10.1111/agec.12269

2. Adesina, A.A. & Chianu, (2002) J. Determinants of farmers' adoption and adaptation of alley farming technology in Nigeria. *Agroforestry Systems 55***,** 99–112.

3. Ajzen, I. (1985). From intention to actions: A theory of planned behavior. In J. Kuhl, & J. Beckman (Eds.), *Action control: From cognition to behaviour,* 11-39. New York: Springer-Verlag.

4. Armitage C. J. & Conner M. (2001) Efficacy of the theory of planned behaviour: A meta analytic review. *Brit J Soc Psychol. 40*(4), 471–499

5. Bindu, N., et al. (2019). From conventional governance to e-democracy: Tracing the evolution of e-governance research trends using network analysis tools. *Gov. Inf. Q., 36*, 385-399.

6. Burton-Jones, A. & Hubona, G.S., (2006) The mediation of external variables in the technology acceptance model, *Information & Management,43*(6) DOI:10.1016/j.im.2006.03.007

7. Chang, A. (2012). "UTAUT and UTAUT 2: A Review and Agenda for Future Research" *The Winners*. *13*(2), 106-114. 10. 10.21512/tw.v13i2.656.

8. Chao C. M. (2019). Factors Determining the Behavioral Intention to Use Mobile Learning: An Application and Extension of the UTAUT Model. *Frontiers in psychology*, *10*, 1652. https://doi.org/10.3389/fpsyg.2019.01652

9. Davis, F. D. (1989). "Perceived usefulness, perceived ease of use, and user acceptance of information technology" *Management Information Systems Quarterly, 13*(3), 319–340. doi:10.2307/249008

ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 05| 2022
DOI 10.17605/OSF.IO/RQHN8

10. Dawson, S et al. (2014) “Current state and future trends: a citation network analysis of the learning analytics field” *LAK '14: Proceedings of the Fourth International Conference on Learning Analytics And Knowledge*, 231–240, https://doi.org/10.1145/2567574.2567585

11. Dirimanova, V. & Radev, T.. (2017). The knowledge transfer in the agricultural sector in south-central region of Bulgaria. *Bulgarian Journal of Agricultural Science*, 23, 505-511.

12. Fafchamps, M. (1992), Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World. *American Journal of Agricultural Economics, 74*, 90-99. https://doi.org/10.2307/1242993

13. Faridi, A. A. et. al., (2020) Attitude components affecting adoption of soil and water conservation measures by paddy farmers in Rasht County, Northern Iran, *Land Use Policy*, *99*, 104885, https://doi.org/10.1016/j.landusepol.2020.104885.
14. Feder, G. et al. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change*, 33(2), 255–298. https://doi.org/10.1086/451461
15. Ghadim, A.K.A. et al. (2005), Risk, uncertainty, and learning in adoption of a crop innovation. Agricultural Economics, 33, 1-9. https://doi.org/10.1111/j.1574-0862.2005.00433.x

16. Huifang, S., et al. (2021) "How Does the Stability of Land Management Right (SLMR) Affect Family Farms’ Cultivated Land Protection and Quality Improvement Behavior (CLPQIB) in China?" *Land 10*(10) 1052. https://doi.org/10.3390/land10101052

17. Kamel, R., et al. (2009). User Acceptance of Internet Banking In Malaysia: Test of Three Competing Models. *IJEA, 1*, 1-19. 10.4018/jea.2009010101.

18. Lamar, B. et al. (2016). "Technology Acceptance in a Sample of College Sudents." *International Journal of Education Research 11*(1), 89-104.

19. Leathers, H.D. & Quiggin, J.C. (1991a), Interactions between Agricultural and Resource Policy: The Importance of Attitudes toward Risk. *American Journal of Agricultural Economics*, *73*, 757-764. https://doi.org/10.2307/1242828

20. Leathers, H. D., & Smale, M. (1991b). A Bayesian Approach to Explaining Sequential Adoption of Components of a Technological Package. *American Journal of Agricultural Economics*, *73*(3), 734–742. https://doi.org/10.2307/1242825

21. Lin, J.Y. (1991), Education and Innovation Adoption in Agriculture: Evidence from Hybrid Rice in China. *American Journal of Agricultural Economics, 73*,713-723. https://doi.org/10.2307/1242823

22. Marra, M. et al. (2003) "The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve?," *Agricultural Systems*, *75*(2-3), 215-234.
23. Matuschke, I. & Qaim, M. (2008), Seed Market Privatisation and Farmers’ Access to Crop Technologies: The Case of Hybrid Pearl Millet Adoption in India. Journal of Agricultural Economics, *59*, 498-515. https://doi.org/10.1111/j.1477-9552.2008.00159.x

24. Matuschke, I. & Qaim, M. (2009), The impact of social networks on hybrid seed adoption in India. Agricultural Economics, 40, 493-505. https://doi.org/10.1111/j.1574-0862.2009.00393.x

ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 05| 2022
DOI 10.17605/OSF.IO/RQHN8

25. Nkonya, E., Schroeder, T. and Norman, D. (1997), Factors Affecting Adoption of Improved Maize Seed And Fertiliser In Northern Tanzania. Journal of Agricultural Economics, 48, 1-12. https://doi.org/10.1111/j.1477-9552.1997.tb01126.x

26. Pignatti, E. et. al. (2015). "What really matters? A qualitative analysis on the adoption of innovations in agriculture" Journal of Agricultural Informatics. *6*(4), 73-84. 10.17700/jai.2015.6.4.212.

27. Polson, A. R. & Spencer, D. S. C. (1991) The technology adoption process in subsistence agriculture: The case of cassava in Southwestern Nigeria, *Agricultural Systems*, *36*(1) 1991, 65-78, https://doi.org/10.1016/0308-521X(91)90108-M.
28. Prabhaa, S., et al. (2020). Citation network analysis of plastic electronics: Tracing the evolution and emerging research fronts. Materials Today: Proceedings. 33, 1345-135010.1016/j.matpr.2020.04.236.

29. Rajasekharan, P. & Veeraputhran, S. (2002) Adoption of intercropping in rubber smallholdings in Kerala, India: a tobit analysis. *Agroforestry Systems 56***,** 1–11. https://doi.org/10.1023/A:1021199928069

30. Ratten V. (2015) "Social Cognitive Theory and the Technology Acceptance Model in the Cloud Computing Context: The Role of Social Networks, Privacy Concerns and Behavioural Advertising. In: Brem A., Viardot É. (eds) *Adoption of Innovation*. Springer, Cham. https://doi.org/10.1007/978-3-319-14523-5_4

31. Rehman, A. et al (2017). "Modern Agricultural Technology Adoption its Importance, Role and Usage for the Improvement of Agriculture" *Life Science Journal*. 14(2), 70-74. 10.7537/marslsj140217.10.

32. Rogers, E. M. (2003). Diffusion of innovations (5th ed.). New York: Free Press

33. Ronaghi, M. H. & Forouharfar, A., (2020) A contextualized study of the usage of the Internet of things (IoTs) in smart farming in a typical Middle Eastern country within the context of Unified Theory of Acceptance and Use of Technology model (UTAUT), *Technology in Society*, *63*,101415, https://doi.org/10.1016/j.landusepol.2020.104885

34. Sarkar, A., Wang, H., Rahman, A., Qian, L., & Memon, W. H. (2022). Evaluating the roles of the farmer's cooperative for fostering environmentally friendly production technologies-a case of kiwi-fruit farmers in Meixian, China. *Journal of environmental management*, *301*, 113858. https://doi.org/10.1016/j.jenvman.2021.113858

35. Simon, B. et al (2001) "Knowledge media in the education system: acceptance research in universities" *WU Vienna University of Economics and Business: Wien, Austria*, 179.

36. Smale, M et al. (1994). Land Allocation in HYV Adoption Models: An Investigation of Alternative Explanations. *American Journal of Agricultural Economics*, *76*(3), 535–546. https://doi.org/10.2307/1243664

37. Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia Manufacturing.* 22, 960-967. 10.1016/j.promfg.2018.03.137.

38. Tuan L. et. al. (2021). "One must do, five reductions" qualitative analysis of the diffusion and adoption constraints in Vietnam. Development in Practice." 1-13. 10.1080/09614524.2021.1937556.

ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 05| 2022
DOI 10.17605/OSF.IO/RQHN8

39. Veltheim, R.v., et al. (2021) "German Farmers' Attitudes on Adopting Autonomous Field Robots: An Empirical Survey" *Agriculture* 11(3)216. https://doi.org/10.3390/agriculture11030216

40. Venkatesh, V. et al. (2016). Unified Theory of Acceptance and Use of Technology: A Synthesis and the Road Ahead. Journal of the Association for Information Systems. 17. 328–376. 10.17705/1jais.00428.

41. Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS quarterly*, *36*(1), 157-178.

42. Verma, P., Sinha, N., (2018) Integrating perceived economic wellbeing to technology acceptance model: The case of mobile based agricultural extension service, *Technological Forecasting and Social Change*, *126*, 207-216, DOI 10.1016/j.techfore.2017.08.013

43. Zheng, H., et al. (2021), Adoption of organic soil amendments and its impact on farm performance: evidence from wheat farmers in China. *Aust J Agric Resour Econ*, *65*, 367-390. https://doi.org/10.1111/1467-8489.12406
44. Zheng, S et al. (2019), "Technology adoption among farmers in Jilin Province, China: The case of aerial pesticide application", China Agricultural Economic Review, *11*(1), 206-216. https://doi.org/10.1108/CAER-11-2017-0216