All the four theories were used and combined in meta-model to explain the behavioural intention (BI) or actual behaviour (AB) of employees in relation to complying with information security measures in organizations using different causal factors. The research concluded that several behavioural factors should be considered in developing effective security awareness programs.

These factors include the following categorized by their source theory

i. Perceived usefulness (PU), Perceived ease of use (PEOU) from Technology Acceptance Model (TAM),
ii. Subjective norms (SN), perceived Behavioural Control (PCB) from the Theory of Planned Behaviour (TPB)
iii. Perceived severity of sanctions (PSOS), Perceived Certainty of Sanctions (PCOS) from General Deterrence Theory (GDT)
iv. Attitude Towards Information security (ATT), Threat Appraisal (TA), Coping Appraisal (CA), Perceived Vulnerability (PV), Perceived Severity (PSOT) and Response Efficacy (RE) from Protection Motivation Theory (PMT)

The overall goal is to raise the level of information security awareness (ISA) of members, groups and organizations and reduce the gap between behavioural intention (BI) and actual behaviour (AB) with the specific objective to ensure compliance with information security policies and procedures.

7. METHODOLOGY

The goal of this research is to develop a safe and highly efficient biometric-based multimodal authentication system for identity management that takes into consideration Cybersecurity and related risks. The research methodology will be descriptive, analytical and empirical. As a first step, a comparative study of individual biometric traits will be done to determine the strengths, weaknesses and limitations of commonly used biometric traits in identity management systems. Secondly, an assessment of different combinations of biometric multimodal systems and solutions currently in use in identity management systems will be carried out to identify their strengths, weaknesses and limitations.

The results from this analyses would enable the selection of appropriate biometric traits like the face, iris and fingerprints. Fingerprints, palm print and face recognition have been found to be popularly used based on universality, ease of collection and public acceptability.

The following steps will be followed:

i. **Modality** - The biometric traits to be used to build the multimodal model will be selected.
ii. **Level of Fusion** - These traits would then be combined at the matching score fusion level
iii. **Fusion Strategy** – A reliable cryptographic-based algorithm will then be used to further combine the traits

8. EXPECTED RESULTS

The results is to produce give a risk-optimized and secure multimodal identification and authentication system with high accuracy rates and minimal false acceptance and false rejection rates. The research will provide further insights on Cybersecurity risk management challenges related to identity management systems, identify the strengths, weaknesses and limitations of biometric traits.

The results from this will provide data from which an optimal combination of selected biometric traits can be selected and used to develop a reliable biometric-based multimodal authentication system with integrity and that can be relied on by all users and stakeholders with complete confidence. The study will contribute significantly to the body of knowledge in the area of identity management and provide a solution that can be used in different identity management applications and schemes.

REFERENCES

1. Al-Mahafzah, Harbi & Alrawashdeh, Ma'En. (2012). A Survey of Multi-biometric Systems. International Journal of Computer Applications. 43. 10.5120/6182-8612. Retrieved from https://www.researchgate.net/publication/231537573
2. Chate, S, Suhas & Ubale, Pratik & Joshi, Madhuri. (2013). Person Verification using Fusion of Palm Geometry and Palm Print. International Journal of Computer Applications. 73. 42-48. 10.5120/12836-0163.
3. Garg, Suneet & gupta, Renu. (2017). Multimodal Authentication System: An Overview. International Journal of Control Theory and Applications
4. Ibikunle, Francis. (2013). Approach to cybersecurity issues in Nigeria: Challenges and solution. International Journal of Cognitive Research in Science, Engineering and Education
5. Ilugbusi, Abiodun & Adetunmbi, Adebayo. (2017). Development of a multi-intance fingerprint based authentication system. International Conference on Computing Networking and Informatics (ICCNI) 1-9. 10.1109/ICCNI.2017.8123780
6. Kabwe, Felix & Phiri, Jackson. (2019). A Framework for Digital Identity Management. Management .Proceedings of the International Conference In ICT (ICICT2019) - Lusaka, Zambia (20th - 21st November 2019). ISBN: 978-9982-70-985-9. Retrieved from https://www.researchgate.net/publication/337856516
7. Kumar, Munish. (2018). Fingerprint Recognition System: Issues and Challenges. International Journal for Research in Applied Science and Engineering Technology. 6. 556-561. 10.22214/ijraset.2018.2080
8. Latha, L. & Thangasamy, Sangarappan. (2013).Providing multimodal biometric authentication using five competent traits. The Imaging Science Journal. 61. 212-218. 10.1179/1743131X11Y.0000000033.
9. Lebek, Benedikt & Uffen, Jörg & Neumann, Markus & Hohler, Bernd & Breitner, Michael. (2014). Information security awareness and behavior: A theory-based literature review. Management Research Review. 37. 1049-1092. 10.1108/MRR-04-2013-0085. Retrieved from https://www.researchgate.net/publication/280197278

10. Lokeswara Rao Bhogadi,N. Bhagyalaxmi (2018). **Multimodal biometric authentication.** Journal of Wireless Communication Technology. Whioce Publishing. ISSN 2529-766X. Retrieved from http://www.ipindexing.com/article/24536
11. Manivannan, S. & Padma, E.. (2011). Comparative and Analysis of Biometric Systems. International Journal on Computer Science and Engineering. 3. 2156-2162.
12. Manju, R ,A.Rajendran a ,A.Shajin Narguna (2012). International Journal of Engineering Research & Technology (IJERT) Retrieved from https://www.ijert.org/research/performance-analysis-of-multimodal-biometric-based-authentication-system-IJERTV1IS7032.pdf
13. Mohammad Imrana, Ashok Raob , G Hemantha Kumar (2010). Multibiometric Systems: A Comparative Study of Multi-algorithmic andMultimodal Approaches. Retrieved from http://creativecommons.org/licenses/by-nc-nd/3.0/
14. Mwaura, Grace. (2017). Multimodal Biometric System:-Fusion of Face and Fingerprint Biometrics At Match Score Fusion Level. International Journal of Scientific & Technology Research. 6. 41
15. Parkavi, K. R. Chandeesh Babu and J. A. Kumar, "Multimodal Biometrics for user authentication," (*2017) 11th International Conference on Intelligent Systems and Control (ISCO)*, 2017, pp. 501-505, doi: 10.1109/ISCO.2017.7856044
16. Parvathy. J, Dr. Poornima G. Patil. (2018). A Survey on Fingerprint Identification Techniques. International Journal for Research in Applied Science & Engineering Technology (IJRASET**).** *ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887. Volume 6 Issue I, January 2018-*
17. Ramadan Gad, Nawal El-Fishawy, AYMAN EL-SAYED and M. Zorkany, "Multi-Biometric Systems: A State of the Art Survey and Research Directions" International Journal of Advanced Computer Science and Applications (IJACSA), 6(6), (2015). http://dx.doi.org/10.14569/IJACSA.2015.060618Journal on Computer Science and Engineering. 3. 2156-2162. Retrieved from https://www.researchgate.net/publication/272310666
18. Rishabh rajvanshi. 2019. **Cyber-security-ways-to-ensure-identity-protection** Retrieved from https://tecake.in/cyber-security-ways-to-ensure-identity-protection
19. **SAKTHIDEVI, K.R (2019). Cyber Risk Management – A Conceptual framework.** International Journal of Scientific Research and Review. Volume 8, Issue 2, 2019. ISSN No: 2279-543X. Retrieved from http://www.dynamicpublisher.org/gallery/52-ijsrr-d1465.f.pdf
20. Shameem, Z.A., Mohite, J.N., & Sharmin, S (2017). **A Review on** Advance Biometric Fingerprint Based Security Systems. International Journal for Research in Applied Science & Engineering Technology (IJRASET**).** *ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887. Volume 5 Issue X1, November 2017*
21. Sumathi,S, R.***Rani Hema*** Malini (2013). Multimodal Biometrics for Person Authentication using Hand Image. International Journal of Computer Applications (0975 – 8887) Volume 70– No.24, May 2013

Full Research Paper

University Teachers' Use of Twitter as an Instructional Tool and Effective Curriculum Content Implementation in Three Institutions of Higher Learning in Cross River State Nigeria.

Aglazor Genevieve Ph.D
Omoogun Modupe Remi

[1]Dept of Curriculum & Teaching
Dept of Environmental Education
University of Calabar
Calabar-Nigeria

E-maila
aglazorunical@yahoo.com
remiomoogun@gmail.com

Phone
+2348037071236
+2348159556184

ABSTRACT

This study examined University teachers' use of twitter as an instructional tool and effective curriculum content implementation in three higher institutions in Cross River State, Nigeria. One purpose of the study was stated and converted into one research question and statement of hypothesis. Literature review was carried out based on the variable understudy and the survey research design was used in the study.-The stratified random, purposive and accidental sampling techniques were used in the study. The method of data collection was a 20 items four point rating scale questionnaire. A sample of 373 respondents was used in the study and the reliability index of the instrument was .82 using the Cronbach Alpha Reliability method. The statistical tool for data analysis was the Pearson's Product Moment Correlation at .05 level of significance. The result of the study showed that there is a significant relationship between University Teachers' use of Twitter as an instructional tool and effective Curriculum implementation in Universities of Cross River State, Nigeria. Based on the finding of the study, it was recommended that teachers should change the methods and strategies of teaching from traditional methods of chalk and board to communicative strategies like the use of social media like Twitter that are based on the students' real engagement in the teaching-learning process for effective curriculum implementation.

Keywords: Teachers, Twitter, Curriculum implementation, University, Social media

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1. INTRODUCTION

In recent times technology has permeated every facet of life even the classroom is not left out. The use of whatsapp, facebook, Twitter Telegram, Instagram is on the increase. This generation that is deeply involved in social media usage as a means of communication, interaction, entertainment and collaboration and even for business purposes. The Teacher also must adopt this media that has so engaged these students to reach out to them, create educational content and help implement curriculum. Twitter is a social media networking site that offers micro blogging services within the internet and enables users to tweet and retweet messages and information that are currently within 140 words. Devi, Gouthami & Lakshmi (2019), stated that Twitter offers a quick way to post real time information instructional content, provide up to date information and eliminate the need for extensive research.

There are diverse opinions on the use of Twitter as a tool for instruction, that it encourages collaborative learning, academic help seeking and real time information. Many educators believe that social media can be used as effective teaching tools in higher education because of its ease of use, ready availability and individual affordability (Devi, 2019). There has been a lot of research on the challenges of effective curriculum content implementation in higher institutions, some schools of thought have opined that it is due to the dearth of textbooks and obsolete instructional materials in our higher institutions that challenges of effective implementation of curriculum contents keep persisting. Several efforts have been made by the government at all levels over time.

These efforts include the introduction of the Tertiary Education (TETFUND) Intervention programmes with the objective to carry out staff training and development, provision of infrastructures, reading and writing materials, conference attendance and so on. Government has encouraged in-service training and retraining for teachers. Workshops, seminars and other training have also been encouraged. Payments of adequate salaries and so on. But in spite of all these enormous efforts made by the government, there has been no serious improvement as it concerns the effective implementation of curriculum contents in Public tertiary institutions of Cross River State, Nigeria. It is based on these problems that the researchers sought to find answer to whether University Teachers' use of Twitter has any relationship with the effective implementation of curriculum contents in Public tertiary institutions of Cross River State, Nigeria.

1.1 Purpose of the study

The purpose of this study was to investigate the relationship between University Teachers' use of Twitter as an instructional tool and effective Curriculum implementation in three higher institutions of Cross River State, Nigeria.

1.2 Research questions

What is the relationship between University Teachers' use of Twitter as an instructional tool and effective Curriculum implementation in three higher institutions of Cross River State, Nigeria?

1.3 Statement of hypothesis

The hypothesis stated that there is no significant relationship between University Teachers' use of Twitter as an instructional tool and effective Curriculum implementation.

2. LITERATURE REVIEW

Twitter is a powerful social media tool for educators. As more educators contribute, the stronger this community becomes since the users will build a nest of a thriving community of practice. The use of social media has taken over every sector by storm and the educational sector is not left out. This is why Cherwinga (2017), conducted a study on incorporating twitter and blogs into two undergraduate courses offered in the Department of Library Science at Mzuzu University. The study used a sample of 64 students. These students were randomly selected, questionnaire was the instrument used for data collection. Again, Mutekwe (2015), conducted a study on higher education and social media technology.

The study was carried out in four higher institutions in South Africa. The study sought to establish the receptive levels of higher education lecturers in using social media technology and also their perceptions towards integrating it in the classroom. The data for the study were collected through individual interviews with 20 purposively sampled higher institution lecturers from four South African Universities, the analysis the data followed a thematic approach and the study revealed that while quite a good number of the younger higher institution lecturers have embraced social media as part of their modern day social and professional life, that it also enhance the classroom delivery and enhances knowledge creation.

Another study was also conducted by Ross, Mannger, Lapraur and Sallivan (2015) on the use of twitter in the creation of educational professional learning opportunities, the study was carried out using a population of 160 educators – 105 females and 55 males between the ages of 22 and 65 using education related hashtags on twitter. Thirty two educators from the survey population elected to participate in an interview. The study discovered that educators frequently used twitter professionally to collaborate, network and engage in professional and that the integration of technology into life communication, and learning has shifted the ways meaning – making and knowledge occur.

Going forward, Dievi, Gouthami and Lakshmi (2019), stated that social media tools created a platform for the improvement of the educational process, they stated that social media sites offer value in teaching. The researchers noted that the use of twitter and other social media platforms by teachers' in higher institutions offers new opportunities for innovating and modernizing education institutions and for preparing learners for the 21st century. The researchers stated that twitter in higher education creates a social community of learners who share knowledge, values and goals and that twitter brings about "connectedness" which refers to students' feelings of cohesion, spirit, trust and interdependence and also "learning" which refers to the students feeling of the extent to which their learning goals and expectation are satisfied.

A related study was carried out by Edinyang, Effiom, Effiom and Ushie (2020), on teachers' implementation of Social Studies curriculum for effective citizenship in Cross River State, Nigeria. Two research questions were formulated and transformed to statements of hypotheses to guide the study. Literature review was carried out based on the variables under study. Survey research design was utilized. A stratified random sampling technique was used in selecting the 250 respondents sampled for the study. A validated 20 items four point likert scale questionnaire was the instrument used for data collection. Data was analysed using Pearson's Product Moment Correlation statistical tool. The result of the study revealed that there is a significant relationship between availability of instructional materials and curriculum implementation for effective citizenship, and teachers' attitude has a significant relationship with the implementation of Social Studies curriculum for effective citizenship. It was recommended that teachers need to be acquainted with new Social Studies, civic and citizenship developments and how these can be incorporated into diverse aspects of classroom social studies curriculum implementation.

Malik, Hayman-sehrum and Zohri (2019), reviewed literature of 103 peer reviewed scientific studies published from (2009 – 2017) that addressed the use of twitter for educational purposes across formal and informal settings. Most studies used or the literature are descriptive and they are case studies carried out in North American and European Higher Education settings. They found out that based on the literature review and the analysis of the studies, twitter is a useful tool of communication due to high accessibility, novelty and real time formats. The researchers also noted that students, teachers, and other stakeholders use it as a pedagogical tool to gain information.

Chawinger (2016), also conducted a study on the use of twitter in university classrooms in a developing country; the researcher used two university courses offered in the Department of Library and Information Science at Mzuzu University in Malawi. Findings showed that twitter if properly deployed can improve the learning and bring about effective curriculum implementation since twitter is learner centred, that content can be discussed with lecturer anytime anywhere, it was possible for students to have out of class discussion that originally initiated by their lectures, they learn from each other, they were able to generate and share content through creating knowledge and collaborating, however the major challenge posed by the researcher was the limited access to internet and exorbitant internet bundles.

Yarkin and Unmaz (2013), further conducted another study on the use of twitter as an instructional tool. In carrying out the study, 48 students were monitored as they use twitter with their lectures in class, 26 students were females which represent 54% and 24 were male which represent 46%. The lecturers provided instruction with twitter for 14 weeks. The data sources for the study were surveys developed by the researchers. The quantitative survey was administered three times during the course. The questionnaire data for each phase were analyzed using descriptive statistics while the questionnaire items were measured using ANOVA. The result revealed that students' perceived competency level increased in learning and that as they participated, their confidence level increased because they were allowed to share their contribution via twitter and hashtags, they were able to gather more information, collaborate, generate content on their own, the instructor was more of a facilitator.

A related study by Diverniero and Hosek (2013), was carried out on the ways in which instructors used twitter in the classroom and to identify the benefits and downfalls of using twitter as a classroom tool. To carry out the study, the researchers used 44 college instructors within ages 22 – 60 years (M = 41.7, SD = 11.01). The teaching experience of the instructors ranged from 3 to 33 years. The participants represented in the study were a cross-section of teaching job statuses including 18 associate/assistant professors, one full professor, two lecturers and other graduate teaching assistants. Also, a total of 40 college students from ages 18 and above participated in the research.

The research sought to find the importance of twitter for content engagement and for skill development. For content engagement, the researcher found out that instructors used twitter when they believed it would help students and instructors meaningfully engage with course content. On skill development, some instructors used twitter as a medium for skill practice. Most instructors used twitter because it allowed students to engage and augment in-class and out-class discussion, engage students in critical analysis, reflection and application of course content. Both students and instructors agreed that twitter was beneficial for giving shy students a voice in the class and twitter helps form a connection with their professors and instructors.

Researchers contend that relevance can come from effective teaching and increase students' motivation to learn and sense of empowerment towards their own l
earning. These notions suggest connecting students' perception of its relevance but also promoted perception of effective teaching and empowerment. This finding echoes that of Bista (2015) which states that the careful and creative use of twitter can strengthen the educational interest and academic success of students. Twitter is rich in engaging students and teachers across different educational content.

3. METHODOLOGY

The area of the study is Cross River State. Cross River State is located in South-South Geo-political Zone of Nigeria. It comprises of eighteen Local Government Areas. Cross River lies between latitudes 8^0 42^1 23^0 39^1 East of the Greenwich Meridian and longitudes 5^0 57^1 and 23^0 99^1 North of the Equator. The state covers the land mass of approximately 20, 156km^2 square kilometers.

The state has seven public tertiary education institutions. They are University of Calabar in Calabar municipality, Cross River University of Technology (CRUTECH) in Calabar South Local Government Area. College of Health Technology in Calabar Municipality, Cross River College of Education, Awi, in Akamkpa Local Government Area, Institute of Technology and Management in Yakurr Local Government Area, School of Nursing, Itigidi in Abi Local Government Area, Federal College of Education, Obudu. The private tertiary education institutions are Arthur Javis University, Akpabuyo, Nogak Polytechnic Ikom and Owoche College of Education, Bekwarra etc. The population of the study is made up of 7,461 university teachers. The sampling techniques utilized in this study were the stratified random sampling technique, purposive sampling technique and off course the accidental sampling technique. Only three Universities were purposively selected for the study. They are the University of Calabar, University of Cross River and Arthur Jarvis University all in Cross River State.

A sample of 373 respondents representing five percent of the entire population was used in the study with the aid of accidental sampling technique. The instrument for data collection was a questionnaire titled; Use of twitter and curriculum implementation Questionnaire (UTCIQ). The reliability estimate of the instrument was .82 using the split half reliability method. The statistical tool for data analysis was the Pearson's Product Moment Correlation at .05 level of significance with the help of Statistical Package for Social Sciences (SPSS) version 23. The result of the study is as displayed thus;

4. RESULT AND DISCUSSION OF THE STUDY

The hypothesis stated that there is no significant relationship between University Teachers' use of Twitter as an instructional tool and effective Curriculum implementation. The independent variable in this study is use of twitter while the dependent variable for this study is the effective implementation of curriculum contents. Pearson's product moment correlation was used for data analysis. The result is presented in Table 1. The items used in measuring this hypothesis were derived from questionnaire items 1-10 of Section B and items 11-20 of section C of the instrument.

The result of the analysis shown in the table below revealed that use of Twitter produced a mean score of 9.09 with a standard deviation of 2.56 while effective curriculum implementation produced a mean score of 12.47 with a standard deviation of 3.01. The result further revealed that the calculated r-ratio of .028 obtained with a p-value of .000 at 371 degrees of freedom met the condition required for significance at .05 level. Based on this, the null hypothesis which stated that there is no significant relationship between University Teachers' use of Twitter as an instructional tool and effective Curriculum implementation was rejected indicating that there is a significant relationship between University Teachers' use of Twitter as an instructional tool and effective Curriculum implementation in the study area.

The finding of the study is in line with Dievi, Gouthami and Lakshmi (2019) that social media tools created a platform for the improvement of educational process, they stated that social media site offer value in teaching. Furthermore, the use of twitter and other social media platforms by teachers' in higher institutions offers new opportunities for innovating and modernizing education institutions and for preparing learners for the 21st century. Twitter in higher education creates a social community of learners who share knowledge, values and goals and that twitter brings about "connectedness" which refers to students' feelings of cohesion, spirit, trust and interdependence and also "learning" which refers to the students feeling of the extent to which their learning goals and expectation are satisfied.

Pearson's Product Moment Correlation Coefficient Analysis of the relationship between University teachers use of Twitter and effective curriculum content implementation (N=373)

Variables:	x	S.D	r	P-value
Use of Twitter (x):	9.09	2.56		
			028	.000
Effective curriculum Content implementation (y):	12.47	3.01		

*significant at 0.05 level; df= 371

5. CONCLUSION

As technology pervades the global village, the school must be prepared to take the lead. The implementation of the curriculum is the core activity of teaching and learning and its implementation can become more effective with the deployment of Social media. Students are more engaged in learning when they are taught with and use social media.

6. RECOMMENDATIONS

Based on the finding of the study, it was recommended that teachers should change the methods and strategies of teaching from traditional methods of chalk and board to communicative strategies like the use of social media like Twitter that are based on the students' real involvement in the teaching-learning process for effective curriculum implementation.

REFERENCES

1. Bista, K. (2015). Is twitter an effective pedagogical tool in higher education? Perspectives of education graduate students. *Journal of the Scholarship of Teaching and Learning, 15*, 83-102.
2. Chawinga, W. D. (2016). Teaching and learning 24/7 using twitter in a university classroom: Experience from a developing country. *Sage Journal of E-learning and Digital Media, 13(1-2)*, 45-61.
3. Cherwinga, W. D. (2017). Taking social media to a university classroom: Teaching and learning using twitter and blogs. *International Journal of Educational Technology in Higher Education, 14(3)*, 12-23
4. Dievi, K. S., Gouthami, E. & Lakshmi, V. V. (2019). Role of social media in teaching-learning process. *Journal of Emerging Technologies and Innovative Research, 6(1), 34-43*
5. Diverniero, R. & Hosek, A. H (2013). Twitter as a classroom tool: Exploring the use, benefits, and downfalls from the perspectives of instructors and students. *Journal of Social Media in Society, 2(2), 89-97*
6. Edinyang, S. D., Effiom, V. N., Effiom, J. E. & Ushie, D. E. (2020). Assessment of Implementation of Social Studies Curriculum for Effective Citizenship in Upper Basic Education of Cross River State of Nigeria. *European Journal of Social Sciences, 59*(1), 63-77.
7. Malik, A., Heyman-Schrum, & John, A. (2019). Use of twitter across educational setting: A review of the literature. *International Journal of Education Technological Higher Education, 16*, 36.
8. Mutekwe, E. (2015). Higher education and the social media technology: A Dilemma unfolding institutions of higher learning. *Journal of Education and Human Development, 4*, 119-133.
9. Ross, G. R., Marunger, R. M., Laprairie, N. K. & Sallivan, S. (2015). The use of twitter in the creation of educational professional learning opportunities. *Administrative Issues Journal: Connecting Education Practice and Research, 5(1)*, 55-76.
10. Yakin, I. & Tinmaz, H. (2013). Using twitter as an instructional tool: A case study in higher education. *The Turkish Online journal of Educational Technology,12(4), 88-96*

Full Research Paper

Magnetohydrodynamic Flow and Heat Transfer Characteristics in Micropolar-Casson Fluid over a Stretching Surface with Temperature-dependent Material Properties.

Fatunmbi, E.O.
Akanbi, O.O.

Dept. of Maths & Statistics
Federal Polytechnic
Ilaro, Nigeria.

E-mails
ephesus.fatunmbi@federalpolyilaro.edu.ng,
olumuyiwa.akanbi@federalpolyilaro.edu.ng

Phone
+2348034013598;
+2347033549098

ABSTRACT

The current investigation communicates the flow and heat transfer characteristics of an electrically conducting micropolar-Casson fluid over a two-dimensional stretching surface with variable thermal conductivity and viscosity. Thermal radiation, viscous dissipation and heat source effects are also accounted for in the energy equation. The formulated equations of flow and heat transfer are converted from partial to ordinary differential equations using suitable similarity transformations while the dimensionless equations are solved by Runge-Kutta Fehlberg integration scheme. The effects of the physical parameters are publicized through graphs and validated by related published studies in the limiting situations. It is found from the investigation that there is accelerated flow due to the material micropolar term whereas the presence of Casson fluid and magnetic field terms decelerate the velocity. Besides, the surface temperature improves with a rise in the Casson fluid term, Eckert number and thermal conductivity parameter whereas the trend is reversed for micropolarity influence.

Keywords: Micropolar-Casson fluid; Magnetohydrodynamic, Variable viscosity; Variable thermal conductivity; Viscous dissipation

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1. INTRODUCTION

In recent times technology has permeated every facet of life even the classroom is not left out. The use of whatsapp, facebook, Twitter Telegram, Instagram is on the increase. This uction Fluid flow and heat transfer processes can be altered by the imposition of magnetic field in the flow regime. Magnetohydrodynamics (MHD) deals with the interaction of magnetic field and electrically conducting fluids. The application of such flow in diverse fields of applied sciences and engineering are huge. For instance, in metallurgical industries, magnetic field can be applied to heat up, pump, stir, levitate liquid metals and for the purification of molten metals from non-metallic inclusions, It is also useful in plasma, nuclear reactors, MHD generators and accelerators, boundary layer control in aerodynamics (Ibrahim and Makinde, 2015).

The boundary layer flow of MHD over a stretching sheet has been reported by many researchers under different assumptions, configurations and category of fluids (see Qasim, 2013; Ahmad, et al., 2016; Mahanthesh et al., 2018; Ullah et al. 2020; Fatunmbi and Adeniyan, 2020). The simple micro-fluids theory formulated by Eringen (1964) characterizes fluids with micro-constituents. The theory deals with isotropic viscous fluids with micro-elements and micromotion which manifest certain microscopic influences arising from the local structure and micromotion of the fluid parcels. Besides, these fluids have the ability to support stress and body moments with the effects of rotation inertia. For the application of simple micro-fluid concept to the cases of real flow situations, Eringen (1966) simplified further the concept of simple micro-fluids to formulate a subclass of microfluids known as micropolar fluid. Micropolar fluid characterizes fluids with rigid, randomly oriented particles suspended in a viscous medium such as polymeric fluids, liquid crystals, where particles deformation is neglected (Lukaszewicz, 1999).

These rigid particles contained in a small volume can spin about the centroid of the volume element. It also defines a substantial generalization of the Navier-Stokes model and open up a new field of potential applications in extrusion of polymer fluids, the cooling of metallic plate in water bath, synovial lubrication, arterial blood flows, sediment transport in rivers, etc. (Rahman, 2009; Reena and Rana, 2009). Fluids that can be categorized as micropolar fluids are polymeric fluids, fluid suspensions, animal blood, liquid crystals, colloidal fluids, etc (Ahmadi, 1976; Hayat, Mustafa and Obaidat, 2011). The flow and heat transfer of micropolar fluid have been studied by many researchers on different geometries, assumptions and conditions (see Mahmoud, 2007; Salawu and Fatunmbi, 2017; Keimanesh and Aghanajafi, 2017; Fatunmbi and Adeniyan, 2018; Fatunmbi and Okoya, 2020).

The Casson fluid model describes a shear thinning fluid which exhibits yield stress attribute. It posses a property of infinite viscosity at zero rate of shear stress and zero viscosity at infinite rate of shear stress, Das et al. (2018). Whenever the yield stress is greater than the shear stress the fluid characterizes solid nature but when the yield stress is lower than the applied shear stress the fluid begins to flow. This model was invented by Casson (1959) while investigating a flow equation for pigment oil-suspensions of printing ink. Bird et al. (1983) studied the rheology and transport of visco-plastic materials and communicated the fact that the concept of Casson fluid fits a plastic fluid model with shear thinning attributes.

This model has become prominent among other non-Newtonian fluids due to its consequential applications. The suitability of this model to adequately describe the rheological behaviour of various ingredients as paints, lubricants, jelly,tomato sauce, blood, honey, etc has been investigated researchers Casson (1959). For low shear rates, the Casson fluid simulates accurately the flow attributes of blood. Also, the manifestation of protein, fibrinogen as well as globulin in aqueous base plasma, red blood cells portrays human blood as a good example of Casson fluid. These applications have aroused the interest of researchers and scientists to study such a fluid on various configurations and conditions.

Vajravelu et al. (2016) analytically reported a mixed convective motion of Casson fluid configured in a vertically stretched sheet with non-uniform thermal conductivity and prescribed surface temperature condition. Das et al (2018) examined the transport of Casson fluid over an exponentially stretching sheet with the impact of thermal radiation and entropy generation while Krishna et al (2018) analyzed the motion of a reactive Casson fluid in a porous stretching surface. The authors reported that the reactions of Casson parameter and magnetic field term are similar in respect to the velocity profile. Recently, An investigation of hydromagnetic Casson nanofluid in a porous medium was conducted by Fatunmbi and Okoya (2021) with the impact of nonlinear Boussinesq approximation and variable thermal conductivity near a stagnation point. It was pointed out that the Casson fluid material term enhances the thermal field and improved the viscous drag. Likewise, the motion of a radiative Casson fluid over a convectively heated permeable sheet with the impact of Joule heating and wall slip was recently examined by Omotola and Fatunmbi (2021).

The blend of micropolar and Casson fluid properties can be referred to as the micropolar-Casson fluid. Such a composition becomes so crucial in applications particularly in bio-engineering processes, metallurgy, food production, production of pharmaceutical products, paints, synthetic lubricants, biological fluids, e.g. blood flow in human body and drilling operations. Mehmood et al. (2017) numerically investigated such a blend over a convectively heated stretching material with internal heat source whereas the examination of such mixture over a stretching surface characterized by inclined magnetic field and viscous dissipation was done by Iqbal et al. (2017). It was stated by the authors that micropolar material parameter raises the heat transfer and the viscous drag. The aforementioned authors however studied the case of uniform viscosity and thermal conductivity. For better and accurate prediction of the flow behaviour, it is imperative to incorporate temperature-dependent flow properties.

The aim of this study therefore is to investigate the flow of an electrically conducting micropolar-Casson fluid over a stretchable material with the effects of temperature-dependent viscosity and thermal conductivity, viscous dissipation and internal heat generation in the presence of isothermal wall condition. The applications of this study to various areas in industries and engineering as mentioned above have induced its investigation. The main equations are solved numerically via Runge-Kutta Fehlberg scheme while the results are presented in tables and graphs with appriopriate discussion..

2. PROBLEM FORMULATION

Consider, an incompressible and steady flow and heat transfer characteristics of an electrically conducting micropolar-Casson nanofluid flow configured in a two-dimensional stretching material in a porous medium. Taking the coordinate as (x, y) having a corresponding velocity components u and v where the flow is directed towards the x axis with y axis being normal to it as shown in Figure. 1. An external magnetic field of uniform strength is applied normal to the flow direction while the impact of the induced magnetic field and electric field is assumed to be negligible on the account of significantly low Reynolds number. It is assumed that the viscosity and thermal conductivity vary linearly with temperature whereas other fluid properties are assumed to be isotropic and uniform. The impact of thermal radiation, viscous dissipation and internal heat generation are incorporated in the heat equation.

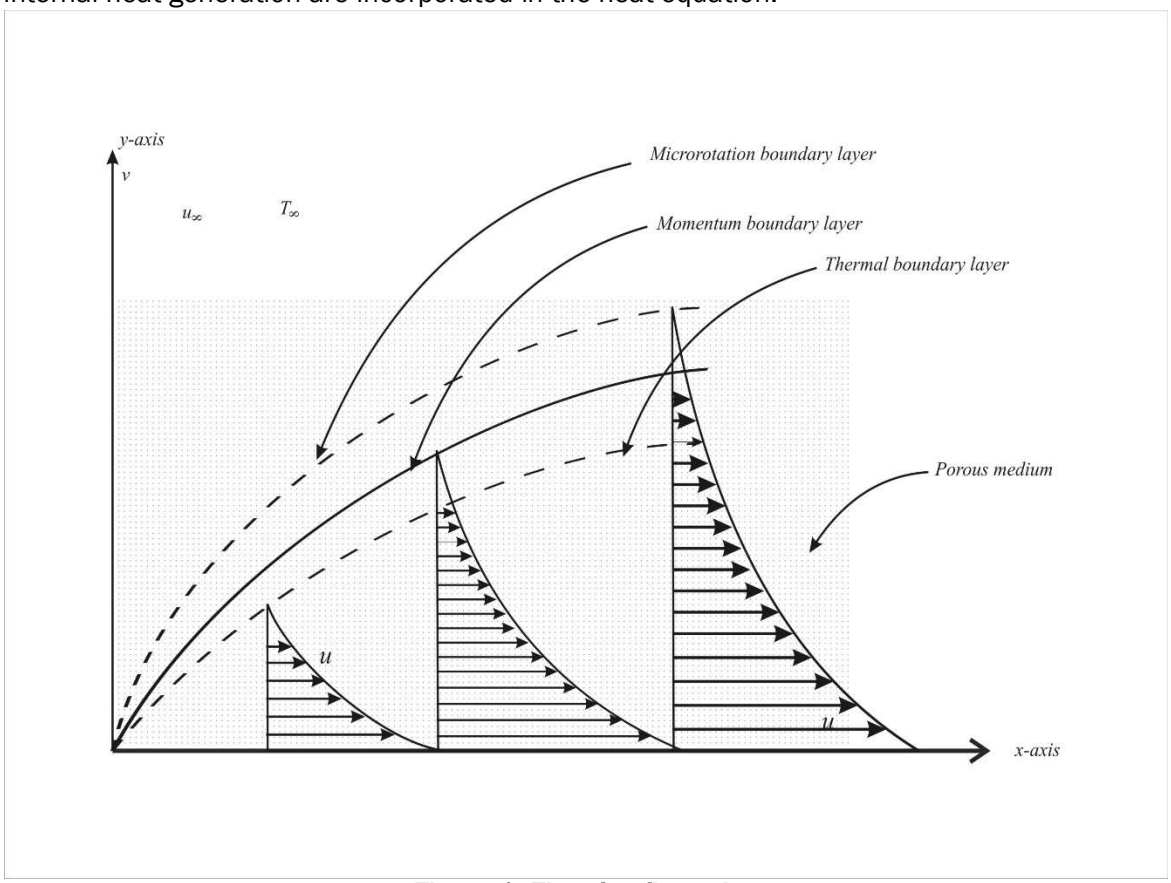

Figure 1. Flow Configuration

The stress tensor and couple stress tensor relations for isotropic micropolar fluid are expressed as (see Eringen, 1966; Lukaszewicz, 1999; Chen *et al.*, 2011):

$$\tau_{ij} = \left(-P + \lambda_r v_{k,k}\right)\delta_{ij} + \mu\left(v_{i,j} + v_{j,i}\right) + \kappa\left(v_{j,i} - v_{i,j}\right) - \kappa\epsilon_{kij}N_k, \quad (1)$$

$$C_{ij} = c_o N_{k,k}\delta_{ij} + c_d\left(N_{i,j} + N_{j,i}\right) + c_a\left(N_{i,j} - N_{j,i}\right). \quad (2)$$

Where $\tau_{ij}^{s} = \left(-P + \lambda_r v_{k,k}\right)\delta_{ij} + \mu\left(v_{i,j} + v_{j,i}\right)$ is the symmetric part of the stress tensor τ_{ij} which denotes the tress tensor for the classical hydrodynamics. Also, τ_{ij} is the Cauchy stress tensor, P is the pressure, λ_r and μ are second viscosity coefficient and dynamic viscosity respectively. κ is the dynamic microrotation viscosity, c_o, c_a and c_d are the coefficients of angular viscosity, v_i, N_k and ϵ_{ijk} are the velocity component, angular velocity component and the alternating/permutation stress tensor, C_{ij} is the couple stress tensor, δ_{ij} is the usual Kronecker delta, $v_{i,j} = \frac{\partial v_i}{\partial x_j}, N_{i,j} = \frac{\partial N_i}{\partial x_j}$ are the partial derivatives with respect to coordinate (x_1, x_2, x_3). The following inequalities must hold for Eq. (1) to remain valid: $\mu \geq 0, 3\lambda + 2\mu \geq 0, \kappa \geq 0$.

Likewise, the rheological equation of an isotropic, incompressible flow of Casson fluid is specified as

$$S_{ij} = \left(\mu_B + \frac{P_y}{\sqrt{2\pi}}\right) 2e_{ij}; \pi > \pi_c, \quad S_{ij} = \left(\mu_B + \frac{P_y}{\sqrt{2\pi_c}}\right) 2e_{ij}; \pi < \pi_c, \tag{3}$$

where S_{ij} denotes the Cauchy stress tensor, P_y stands for the yield stress of the fluid described as

$$P_y = \frac{\mu_B \sqrt{2\pi}}{\beta} \tag{4}$$

Also, μ_B defines the plastic dynamic viscosity of the non-Newtonian fluid while π depicts the product of deformation rate with itself ($\pi = e_{ij}e_{ij}$), π_c denotes the critical value of the product of the component of the deformation rate with itself which is based on the non-Newtonian model. Similarly, one can write

$$\mu = \mu_B + \frac{P_y}{\sqrt{2\pi}}, \tag{5}$$

and on substituting Eq.(4) into (5) results to

$$\mu = \mu_B \left(1 + \frac{1}{\beta}\right) \Rightarrow \vartheta = \frac{\mu_B}{\rho}\left(1 + \frac{1}{\beta}\right), \tag{6}$$

where ϑ is the kinematic viscosity and $\beta = \mu_B \frac{\sqrt{2\pi}}{P_y}$ describes the Casson fluid parameter. Now, on the assumption that the viscosity and thermal conductivity are temperature-dependent and that the medium is porous, the partial differential equations governing the flow and heat transfer of Micropolar-Casson fluid model can be written as

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0, \tag{7}$$

$$\bar{u}\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \frac{1}{\rho_\infty}\left[\left(1 + \frac{1}{\beta}\right)\frac{\partial}{\partial y}\left(\mu_{B_\infty}\frac{\partial u}{\partial y}\right)\right] + \frac{\kappa}{\rho_\infty}\frac{\partial^2 u}{\partial y^2} + \frac{\kappa}{\rho}\frac{\partial N}{\partial y} - \frac{1}{\rho_\infty}\left[\frac{\mu_{B_\infty}}{K_p}\left(1 + \frac{1}{\beta}\right) + \kappa\right]u - \frac{\sigma B_o^2}{\rho_\infty}u, \tag{8}$$

$$u\frac{\partial N}{\partial x}+v\frac{\partial N}{\partial y}=\frac{\gamma}{\rho_\infty j}\frac{\partial^2 N}{\partial y^2}-\frac{\kappa}{\rho_\infty j}\left(2N+\frac{\partial u}{\partial y}\right), \tag{9}$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial \bar{y}}=\frac{1}{\rho_\infty C_p}\frac{\partial}{\partial y}\left[\left(k(T)+\frac{16T_\infty^3\sigma^\star}{3k^\star}\right)\frac{\partial T}{\partial y}\right]+\frac{1}{\rho_\infty C_p}\left[\mu_{B_\infty}(T)\left(1+\frac{1}{\beta}\right)+\kappa\right]\left(\frac{\partial u}{\partial y}\right)^2+\frac{Q^\star(T-T_\infty)}{\rho_\infty C_p}. \tag{10}$$

The associated boundary conditions are:

$$\begin{aligned} &y=0: u=u_w=ax, v=0, N=-n\frac{\partial u}{\partial y}, T=T_w \\ &y\longrightarrow\infty: u\longrightarrow 0, N\longrightarrow 0, T\longrightarrow T_\infty, \end{aligned} \tag{11}$$

where u and v are the velocity components in x and y directions respectively, a is constant >0. Also, ρ is the fluid density, κ is the vortex or microrotation viscosity, T is the fluid temperature, N is the component of microrotation whose direction of rotation is in xy plane, B_o is the magnetic field intensity, j indicates the microinertia density, C_p is the specific heat at constant pressure, T_w is the temperature of the stretching sheet, T_∞ is the free stream temperature, q_r radiative heat flux, $Q^\star$ is the volumetric rate of heat generation/absorption and K_p is the permeability of the porous medium. Similarly, n is a surface boundary parameter with $0\le n\le 1$. The case when $n=0$ corresponds to $N=0$, this represents no-spin condition i.e. strong concentration such that the micro-particles close to the wall are unable to rotate.

The case $n=\frac{1}{2}$, indicates weak concentration of micro-particles and the vanishing of anti-symmetric part of the stress tensor and the case $n=1$ represents turbulent boundary layer flows. Following previous authors, it is reasonable to consider the temperature-dependent viscosity and thermal conductivity model as considered by Layek et al. (2005); Salem and Fathy (2012); Fatunmbi et al (2020). Hence, the plastic dynamic viscosity and thermal conductivity variation with temperature are expressed respectively given in Eq. (12) as

$$\mu_B(T)=\mu_{B_\infty}[1+\zeta(T_w-T)],\ k(T)=k_\infty[1+\epsilon(T-T_\infty)] \tag{12}$$

Here μ_{B_∞} is the fluid viscosity at reference temperature, k_∞ is the thermal conductivity of the fluid far away from the surface sheet, ζ and ϵ are constants. Introducing the similarity transformations variables and stream functions (11) into the governing equations.

$$\eta=y\left(\frac{a}{\nu_\infty}\right)^{1/2}, \psi=f(\eta)x(a\nu)^{1/2}, N=axg(\eta)\left(\frac{a}{\nu}\right)^{\frac{1}{2}}, \theta=\frac{T-T_\infty}{T_w-T_\infty}, u=\frac{\partial\psi}{\partial y}, v=-\frac{\partial\psi}{\partial x} \tag{13}$$

Then, the continuity equation (7) is satisfied in view of Eq. (13) while Eqs. (8-10) taking cognizance of Eq. (10) transform to ordinary differential equations as listed below.

2.1 The Transformed Equations

$$\left(1+\frac{1}{\beta}\right)[(1+\xi-\xi\theta+K)f'''-\xi\theta'f''-Da(1+\xi-\xi\theta)f'-Mf']-f'^2+ff''+Kg'=0, \quad (14)$$

$$(1+K/2)g''+fg'-f'g-K(2g+f'')=0, \quad (15)$$

$$\frac{1}{Pr}(1+h\theta+R)\theta''+h\theta'^2+f\theta'+\left(1+\frac{1}{\beta}\right)(1+\xi-\xi\theta+K)f''^2Ec+B\theta. \quad (16$$

The conditions at the boundary transmute to

$$\begin{aligned} &f'(0)=1, f(0)=0, g=nf''(0), \theta(0)=1 \\ &f'(\infty)=0, \theta(\infty)=0, g(\infty)\to 0. \end{aligned} \quad (17)$$

Where $\xi=\zeta(T_w-T_\infty)$ defines the viscosity parameter, $h=\epsilon(T_w-T_\infty)$ describes the thermal conductivity term, $K=\kappa/\mu_{B_\infty}$ indicates the micropolar material parameter, $Da=\frac{\vartheta}{aK_p}$ denotes the Darcy parameter, $M=\frac{\sigma B_0^2}{a\rho_\infty}$ defines the magnetic field term, $Pr=\frac{\mu_\infty C_p}{k_\infty}$ is the Prandtl number, $Ec=\frac{u_w^2}{C_p(Tw-T_\infty)}$ indicates the Eckert number and $B=\frac{Q^\star}{aC_p}$ describes the heat source parameter. The following quantities namely; the skin friction coefficient and the local Nusselt number draw the attention of the engineering community . These quantities are respectively described as:

$$C_{fx}=\frac{\tau_w}{\rho_\infty U_w^2}, Nu_x=\frac{xq_w}{k(T_w-T_\infty)}, \quad (18)$$

where τ_w indicates the shear stress while q_w defines the heat flux at the surface. Here,

$$\tau_w=\left(\mu+\frac{P_y}{\sqrt{2\pi_c}}\right)\frac{\partial u}{\partial y}+\kappa N\Big|_{y=0}, q_w=-\left(k_\infty+\frac{16T^3\sigma^\star}{3k^\star}\right)\frac{\partial T}{\partial y}\Big|_{y=0}, \quad (19)$$

in view of equations (13) and (19), the quantities in (18) orderly yields (20-21)

$$C_{fx}=\left((1+\frac{1}{\beta})(1+(1-g)K)\right)Re_x^{-1/2}f''(0), \quad (20)$$

$$Nu_x=-[1+R(1+\theta(0))]Re_x^{1/2}\theta'(0), \quad (21)$$

3 NUMERICAL METHOD WITH VALIDATION

The system of Eqs. (14-17) constitutes a nonlinear boundary value problem which the solution has been sought numerically using the shooting technique alongside with Runge-Kutta-Fehlberg scheme. Due to its popularity in the open literature, we do communicate the detail description in this study. The details can be found in the work of (see Ali, 1994, Attili and Syam, 2008; Xu and Lee, 2013; Mabood and Das, 2016; Mahanthesh et al., 2018;).

The default values used in this study are listed as $K = M = Da = 0.5, R = h = \xi = B = 0.2, Ec = 0.1, n = 0.5$ and $Pr = 0.72$ unless otherwise specified in the graphs. To authenticate the accuracy of our numerical solution a comparison is carried out in Table 1 with some existing results in literature in the limiting condition and both solutions are found in good harmony. The comparison is carried out with the work of Chen (1998) and Qasim et al. (2013) for different values of Prandtl number Pr when $K = Ec = R = Da = M = h = \xi = B = 0$ and $\beta \to \infty$. The highest percentage relative difference is found to be 0.42%.

Table .1: Comparison of the values of the Nusselt number Nu_x with existing studies for various values of Pr

Pr	Chen (1998)	Present study	$\lvert\%RD\rvert$	Qasim e al. (2013)	Present study	$\lvert\%RD\rvert$
0.72	0.46170	0.46368	0.42	0.46360	0.46368	0.02
1.00	0.58010	0.58211	0.35	0.58202	0.58211	0.01
3.00	1.16525	1.16535	0.01	1.16525	1.16535	0.01
5.00	1.56805	1.56816	0.01	1.56805	1.56816	0.01
7.00	1.89540	1.89551	0.01	1.89542	1.89551	0.00
10.00	2.30800	2.30811	0.00	2.30800	2.30811	0.00
100.00	7.76565	7.76576	0.00	7.75826	7.76576	0.10

Table 2: Computational values of the values of C_{fx} with variation in K, β, ξ, Da and M

K	β	ξ	Da	M	C_{fx}
0.1	0.1	0.2	0.4	0.5	0.6244414
0.3					0.5454724
0.5					0.4907923
0.3	0.1	0.2	0.4	0.5	0.6675712
	0.3				0.7892711
	0.5				0.8686437
		0.1			0.6574750
		0.3			0.6772104
		0.5			0.6952372
		0.2	0.1		0.4484146
			0.3		0.6046815
			0.7		0.8249991
			0.4	0.3	0.6571026
				0.6	0.6727449
				0.8	0.6829753
0.0	∞	0.1		0.5	1.3827854
		0.3			1.3926768
		0.5			1.4026076
		0.2	0.1		1.2739253
			0.3		1.2572062
			0.7		1.4920829
			0.4	0.3	1.3144136
				0.6	1.3219056
				0.8	1.4909093

4.RESULTS AND DISCUSSION

This section presents the graphical illustrations and the discussion of the effects of various physical parameters on the non-dimensional quantities namely: velocity, microrotation and temperature profiles.. Besides, the reaction of the skin friction coefficient C_{fx} to variations in some selected parameters, namely, micropolar parameter, Casson fluid parameter β, viscosity term ξ, Darcy number Da and magnetic field parameter M are recorded in Table 2. From this table, it is clearly noticed that an increase in K facilitates the reduction in the viscous drag such that C_{fx} is drastically reduced. However, there is a spontaneous increase in the skin friction coefficient C_{fx} as the value of β, ξ Da and M improves. In the absence of the non-Newtonian fluids (K=0, $\beta \to \infty$), the fluid becomes Newtonian. In this case, the skin friction coefficient is

examined and it is observed that the skin friction coefficient is higher for growth in ξ, Da and M as compared to the case of non-Newtonian fluid as noticed from the table..

Figure 2 portrays the reaction of the velocity profile for variations in the viscosity parameter ξ in the presence of the Casson fluid parameter β.. Increasing the magnitude of ξ makes the fluid to be more viscous and thereby creates higher resistance to the fluid motion and thereby decelerates the flow as seen in this figure. Similarly, there is a reduction in the fluid flow owing to a rise in β. This trend indicates that growth in β dictates a fall in the velocity field due to a reduction in the yield stress as β rises which in turn decelerates the motion of the fluid. In addition, a rise in β empowers the plastic dynamic viscosity over the Casson fluid viscosity and at such, the flow is resisted. However, the temperature field reacts conversely with a rise in the viscosity parameter ξ and β as displayed in Fig. 3. The thermal boundary layer thickens with an increase in ξ and in consequence, the temperature is raised. The resistance created due to fluid viscosity develops a frictional heating in the flow regime and thus provides additional heating leading to a rise in temperature. The microrotation of the fluid parcels also enhances due to a rise in ξ as found in Fig. 4.

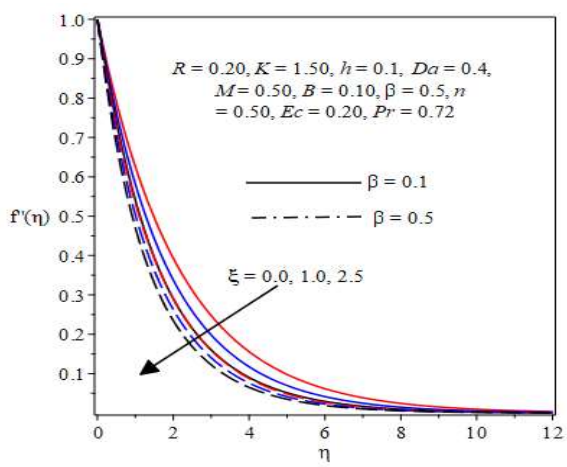

Fig. 2 Effect ξ and β on velocity profile

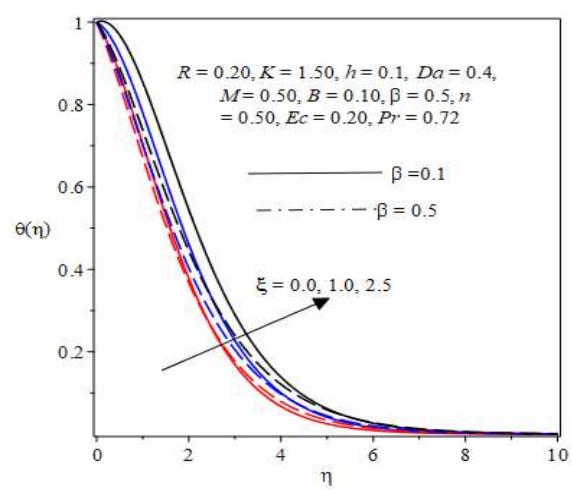

Fig. 3 Effect of ξ and β on temperature

Figure 5 depicts the influence of material micropolar parameter K on the velocity profile in the existence of the magnetic field term M. Clearly, the hydrodynamic boundary layer grows with rising K. A rise in K depicts a fall in the in the dynamic viscosity and a rise in the microrotation viscosity κ and thus, the viscous force is reduced and the flow increases. On the hand, a rise in M decelerates the motion of the fluid due to the drag created by the Lorentz force by the imposition transverse magnetic field to an electrically conducting micropolar-Casson. The Lorentz force offers a drag in the fluid motion with the corresponding increase in M and hence, the fluid velocity reduces. The temperature profiles fall for a rise in K but develops with growth in M due to friction in the fluid particles as a result of resistance created by the Lorentz force as seen in Fig. 6. The microrotation field shrinks with an increase in K but grows with a ruse in the magnitude of M as shown in Fig. 7. The microrotation field is augmented due to magnetic field influence.

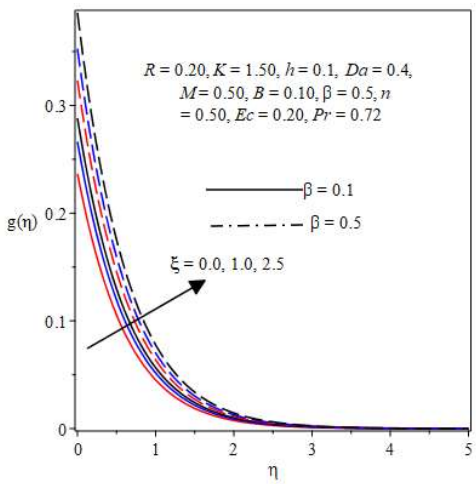

Fig. 4 Effects ξ and β on microrotation

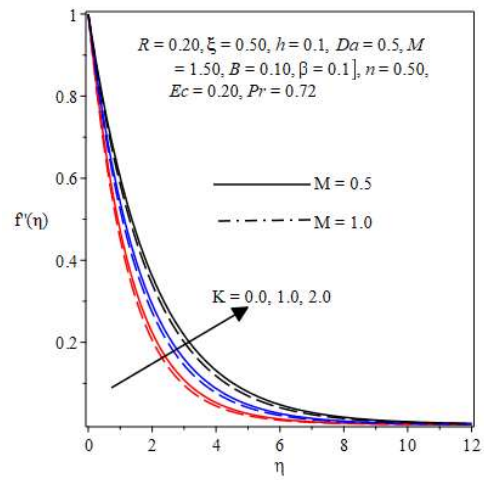

Fig. 5 Graph of K and M on velocity

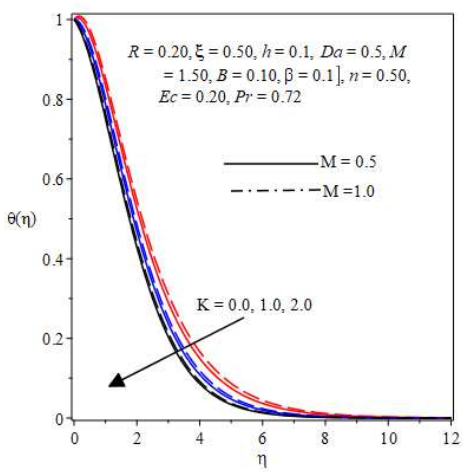

Fig. 6 Graph of K and M on temperature

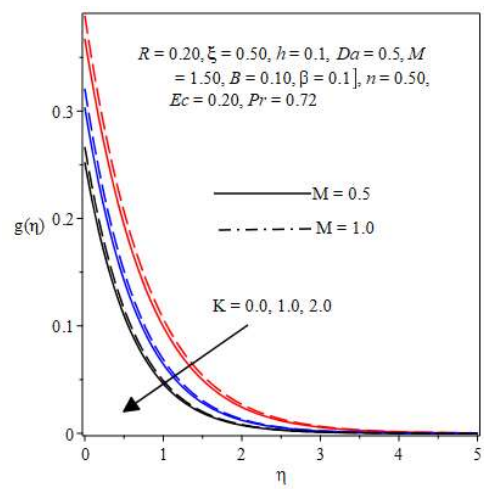

Fig. 7 Plot of K and M on microrotation

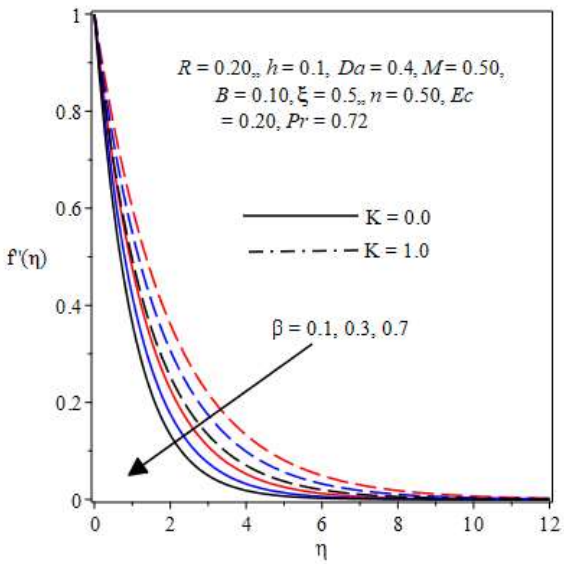

Fig. 8 Impact β and K on velocity

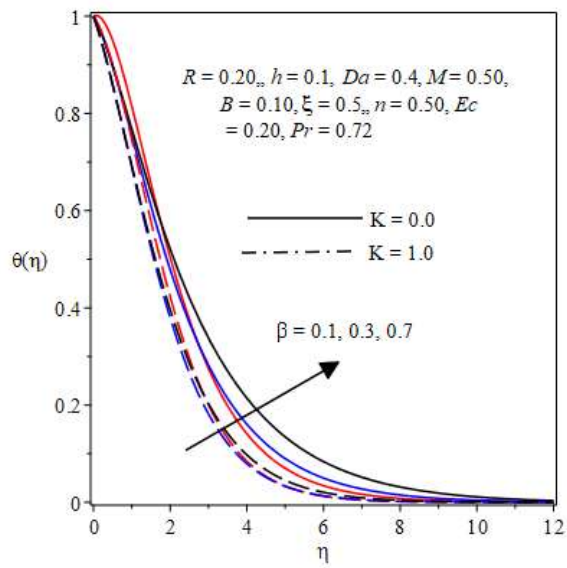

Fig. 9 Plot of β and K on temperature

The combined effects of micropolar-casson fluid on the velocity and temperature profiles are described in Figs. 8 and 9 respectively. Fig. 8 reveals the shrinking nature of the momentum boundary layer structure with a raise in the magnitude of β in the presence or absence of the micropolar fluid influence. However, the micropolar fluid influence boosts the velocity profile. The heat distribution appreciates as β grows as noted in Fig. 9. Meanwhile, the heat energy is lower in the presence of micropolar fluid material term K as compares to its presence.

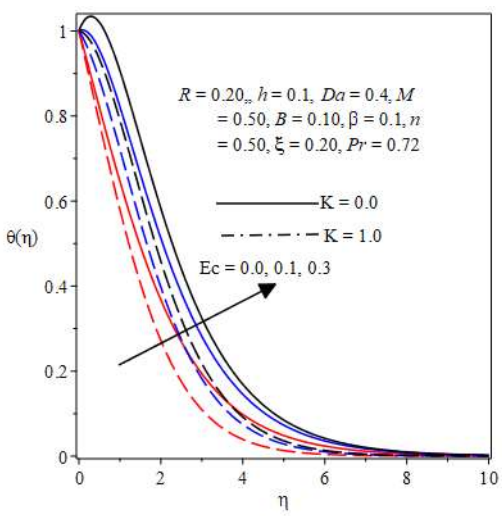

Fig. 10 Effects Ec and K on temperature

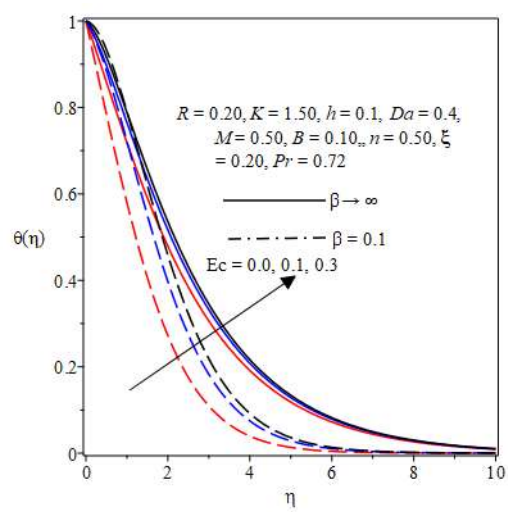

Fig. 11 Effect of Ec and β on temperature

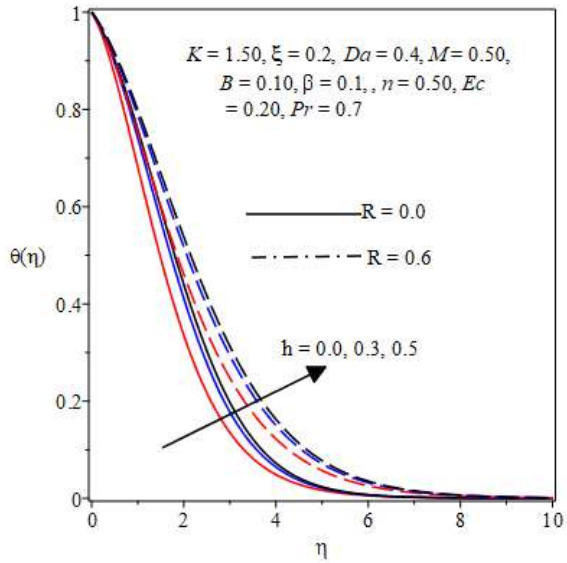

Fig. 12 Effects h and R on temperature

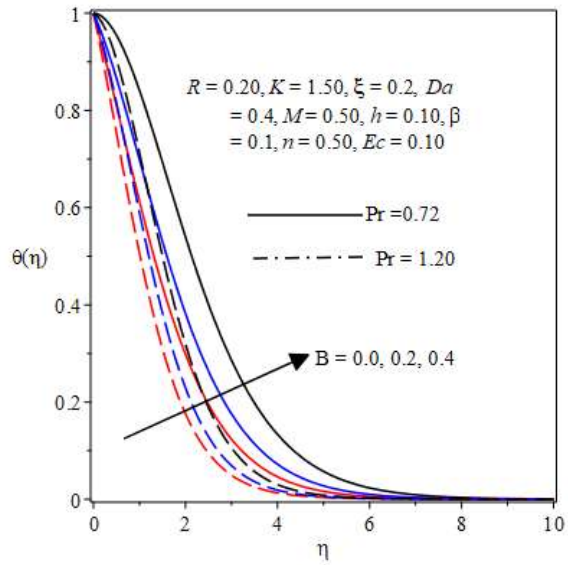

Fig. 13 Effects B and Pr on temperature

Figures 10-11 respectively reveals the reaction of temperature profile to variation in the Eckert number Ec in the presence of material micropolar term K and in the presence of Casson fluid term β. Clearly, the thermal field soars in both cases as Ec rises in magnitude. This is due to the frictional heating on the account of friction between the fluid particles and the stretching sheet. However, the impact of K and β are opposite each other as shown in these figures. Similarly, the thermal field appreciates due to growth in the thermal conductivity h and radiation R terms as illustrated in Fig. 12. The heat source term B also boost the temperature profile due to additional heating as displayed in Fig. 13. However, a rise in the Prandtl number Pr shrinks the thermal boundary layer and lowers the average temperature as portrayed in Fig. 13.

5. CONCLUSION

A numerical investigation has been carried out on the flow and heat transfer characteristics of magnetohydrodynamic micropolar-Casson fluid over a two-dimensional stretching sheet in a porous medium. The main equations of flow and heat dissipation are characterized by variable viscosity and thermal conductivity, thermal radiation, viscous dissipation and internal heat source. Similarity transformations variables are used to re-modelled the governing equations which are then solved by shooting technique associated with Runge-Kutta Fehlberg integration scheme. The obtained results strongly agree with published works in the related studies in literature as special cases of the present study. The impact of the physical parameters are shown in the various graphs and deliberated. Conclusively, it is revealed from the study that:

- There is a decelerated flow in the presence of Casson fluid β, viscosity parameter ξ. Growth in the Casson fluid parameter compels a rise in the viscous force due to a decrease in the yield stress as β grow leading to a resistance in the fluid motion.
- The micropolar material parameter K enhances the fluid motion by the reduction in the strength of the dynamic plastic viscosity and a rise in the vortex viscosity. Conversely, the thermal field falls with growing values of K leading to a cool surface.
- The thermal boundary layer expands with growth in the viscosity parameter ξ and Casson fluid material parameter β and thus, the surface temperature improves as ξ uplifts, a frictional heating is developed in the flow regime which offers extra heating in the thermal field.
- The surface temperature rises by a rise in Ec, radiation term R and internal heat source B but an increase in the Prandtl number Pr behaves contrary on the thermal field. The temperature can be cooled in the presence of Pr.

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REFERENCES

1. Ahmad, K., Hanouf, Z. and Ishak, A. (2016). Mixed convection Jeffrey fluid flow over an exponentially stretching sheet with magnetohydrodynamic effect, AIP ADVANCES 6, 1-8, 035024.
2. Alkasasbeh, H. T. (2018). Numerical Solution of Micropolar Casson Fluid Behaviour on Steady MHD Natural Convective Flow about A Solid Sphere. Journal of Advanced Research in Fluid Mechanics and Thermal Sciences 50(1), 55-66.
3. Ali, M. E. (1994). Heat transfer characteristics of a continuous stretching surface, Warme-und Stoffubertragung, 29(4), 227-234.
4. Animasaun I.L and Aluko O.B. (2014). Analysis on variable fluid viscosity of non-Darcian flow over a moving vertical plate in a porous medium with suction and viscous Dissipation. International Organization of Scientific Research (Journal of Engineering), 2014, 18–32.
5. Animasaun, I. L. (2014). Effects of thermophoresis, variable viscosity and thermal conductivity on free convective heat and mass transfer of non-Darcian MHD dissipative Casson fluid flow with suction and nth order of chemical reaction, Journal of Nigeria Mathematical Society, 2014, 1-21.
6. Attili, B. S. and Syam, M. L. Efficient shooting method for solving two point boundary value problems, Chaos, Solitons and Fractals, 35(5), 895-903, (2008).
7. Bird, R.B., Dai, G.C., Yarusso, B.J. (1983). The rheology and flow of viscoplastic materials. Rev Chem Eng, 1, 1–83.
8. Casson, N. (1959). Rheology of Disperse Systems in Flow Equation for Pigment Oil Suspensions of the Printing Ink Type, Rheology of disperse systems, C. C. Mill, Ed., 84–102, Pergamon Press, London, U. K. (1959).
9. Chen, J., Liang, C. and Lee J. D. (2011). Theory and simulation of micropolar fluid dynamics. J. Nanoengineering and Nanosystems, 224, 31-39.
10. Das, S., Mondal, H., Kundu, P. K. and Sibanda, P. (2018). Spectral quasilinearization method for Casson fluid with homogeneous heterogeneous reaction in presence of nonlinear thermal radiation over an exponential stretching sheet, Multidiscipline Modeling in Materials and Structures, https://doi.org/10.1108/MMMS-04-2018-0073

11. Eringen, A. C. (1964). Simple microfluids. {International Journal of Engineering Science, 2(2), 205-217.
12. Eringen, A. C. (1966). Theory of micropolar fluids. J. Math. Anal. Appl., {16}, 1-18.
13. Fatunmbi, E. O. and Adeniyan, A. (2018). MHD stagnation point-flow of micropolar fluid past a permeable stretching plate in porous media with thermal radiation, chemical reaction and viscous dissipation. Journal of Advances in Mathematics and Comp Science, {26}(1), 1-19.
14. Fatunmbi, E. O. and Fenuga, O. J. (2017). MHD micropolar fluid flow over a permeable stretching sheet in the presence of variable viscosity and thermal conductivity with Soret and Dufour effects. International Journal of Mathematical Analysis and Optimization: Theory and Applications, {2017}}, 211- 232.
15. Fatunmbi, E. O. and Adeniyan, A. (2020). Nonlinear thermal radiation and entropy generation on steady flow of magneto-micropolar fluid passing a stretchable sheet with variable properties, Results in Engineering, 6, 100142, 1-10.
16. Fatunmbi, E. O. and Okoya, S. S. (2020). Heat transfer in boundary layer magneto-micropolar fluids with temperature-dependent material properties over a stretching sheet, Advances in Materials Science and Engineering, 2020, 1-11.
17. Fatunmbi, E. O. and Okoya, S. S. (2020). Heat transfer in boundary layer magneto-micropolar fluids with temperature-dependent material properties over a stretching sheet, Advances in Materials Science and Engineering, 2020, 1-11. Diffusion Foundations. 26, 63-77.
18. Fatunmbi, E. O. and Okoya, S. S. (2021). Quadratic Mixed Convection Stagnation-Point Flow in Hydromagnetic Casson Nanofluid over a Nonlinear Stretching Sheet with Variable Thermal Conductivity, Defect and Diffusion, 409, 95-109.
19. Gbadeyan, J. A., Titiloye, E. O., Adeosun, A. T. (2020). Effect of variable thermal conductivity and viscosity on Casson nanofluid flow with convective heating and velocity slip, Heliyon, 6, 1-10, e03076.
20. Ibrahim, W. and Makinde, O. D. (2015). Magnetohydrodynamic Stagnation Point Flow and Heat transfer of Casson nanofluid past a stretching sheet with slip and convective boundary condition, Journal of Aerospace Engineering, 1-11.
21. Iqbal, Z., Mehmood, R. Azhara, R. and Mehmood, Z. (2017). Impact of inclined magnetic field on micropolar Casson fluid using Keller box algorithm. Eur. Phys. J. Plus, 132, 1-13.
22. Krishna, V. H., Reddy, G. V. R. and Makinde, O. D. Chemical Reaction Effect on MHD Flow of Casson Fluid with Porous Stretching Sheet, Defect and Diffusion, 389, 100-109.
23. Layek, G.C, Mukhopadhyay, S, Samad, S.K. (2007). Heat and mass transfer analysis for boundary layer stagnation point flow towards a heated porous stretching sheet with heat absorption/generation and suction/blowing. Int Commun Heat Mass Transfer, ;34, 347–56
24. Lukaszewicz, G. (1999). {\it Micropolar fluids: Theory and Applications} (1st Ed.). Birkhauser, Boston.
25. Mabood, F. and Das, K. (2016). Melting heat transfer on hydromagnetic flow of a nanofluid over a stretching sheet with radiation and second order slip, Eur. Phys. J. Plus 131(3).

26. Mahanthesh, B., Gireesha, B. J., Gorla, R. S. R. and Makinde, O. D. (2018). Magnetohydrodynamic three-dimensional flow of nanofluids with slip and thermal radiation over a nonlinear stretching sheet: a numerical study, Neural Comput & Applic, 30, 1557–1567.
27. Megahed, A. M. (2015). Effect of slip velocity on Casson thin film flow and heat transfer due to unsteady stretching sheet in presence
28. Mahmoud, M. A. A. (2007). Thermal radiation effects on MHD flow of a micropolar fluid over a stretching surface with variable thermal conductivity Physica A , {375, 401-410.
29. Mehmood, Z. Mehmood, R., and Z. Iqbal (2017). Numerical investigation of micropolar Casson fluid over a stretching sheet with internal heating, Communications in Theoretical Physics, 67(4), 443–448.
30. Mitsoulis, E.(2007). Flows of viscoplastic materials: Models and computations. The British society of rheology, 2007, 135–78
31. Omotola, O. E. and Fatunmbi, E. O. (2021). Magnetohydrodynamic radiative Casson fluid motion past a convectively heated and slippery non-linear permeable stretching plate, Fepi-Jopas, 3(1), 45-55.
32. Qasim, M., Khan, I. and Shafle, S. (2013). Heat transfer in a micropolar fluid over a stretching sheet with Newtonian heating. Plos One, 8(4), 1-6.
33. Salem, A. M, Fathy, R. (2012). Effects of variable properties on MHD heat and mass transfer flow near a stagnation point towards a stretching sheet in
34. SallehMZ, Nazar R, Pop I. (2010) Boundary layer flow and heat transfer over a stretching sheet with Newtonian heating. J Taiwan Inst Chem Eng, 41, 651–655.
35. Ullah, Z, Zamana, G. and Ishak, A. (2020). Magnetohydrodynamic tangent hyperbolic fluid flow past a stretching sheet, Chinese Journal of Physics, 66 258–268.
36. Vajravelu, K., Prasad, K. V., Vaidya, H., Basha, N. Z. and Chiu-On Ng. (2016). Mixed Convective Flow of a Casson Fluid over a Vertical Stretching Sheet, Int. J. Appl. Comput. Math, 1-20. DOI 10.1007/s40819-016-0203-6
37. Xu, L. and Lee, E.W.M. Variational iteration method for the magnetohydrodynamic flow over a nonlinear stretching sheet. Abst Appl Anal 5 pages (2013).

Conceptual Research Paper

An Evaluation of Blockchain-Based Technologies In The Food Supply Chain

[1]Adegbenro, D.R.
[2]Longe Olumide Babatope
[3]Dawodu, A.A.
[4]Omonayin, E.T
[5]Abdulrahman, M

[1]PhD Candidate
ACETEL -Nat. Open University of Nigeria, Abuja, Nigeria

[2]Academic City University College, Accra, Ghana

[3]DS Adegbenro Polytechnic Itori-Ewekoro, Nigeria

[4]Baze University, Abuja Nigeria

[5]American University of Nigeria Yola, Nigeria

Corresponding E-mail
adegbenrodimeji@yahoo.com

Phone
+2348164274303

ABSTRACT

Beyond the financial sector, the use of blockchain in supply chain traceability is extremely important, although the trade-offs between implementation difficulties and attainable effect are uncertain. Six components of blockchain-based technologies in the food supply chain were examined in this research using a technology elvaluation methodology that differentiates between six distinct components of a technology: technique, knowledge, organization, innovation, environment and product. The research aims to offer fresh crucial insights into how blockchain-based technologies may be applied in the food supply chain, as well as to further the debate on blockchain-based technologies' social and environmental implications. The findings show that blockchain is not a stand-alone technology, but rather one component in a larger system of technologies. While blockchain-based technologies are anticipated to have a wide range of effects, only a few are directly related to the blockchain: Change management and external pressure, Complexity of integrating different systems, Lack of knowledge and expertise, high investment are the impediment and constraints affecting full adoption of block chain based technologies. More study is required to establish if blockchain-based technologies enhance the sustainability of agricultural supply chains as anticipated.

Keywords: Micropolar-Casson fluid; Magnetohydrodynamic, Variable viscosity; Variable thermal conductivity; Viscous dissipation

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1. INTRODUCTION

Many contemporary supply chains span several countries and include a number of different actors, making it more difficult to identify where a product originated and how it was produced from its inception. It is common for companies to have little or no awareness about their second and third-tier vendors. When it comes to exchanging information with consumers and verifying the authenticity of a product, this may be an issue for certain businesses. As supply chains get more complex, consumers are expecting more information on product safety, quality, and long-term sustainability from manufacturers.

This is true in particular for the food industry. This is true in particular for the food industry. According to a 2016 survey, 94 percent of consumers want to know how their food is produced and where it comes from. Food adulteration and mislabeling, which can include anything from purposeful substitution, dilution, counterfeiting, misrepresentation of food, ingredients, or packaging to incorrect or misleading comments about the product, has eroded consumer confidence in food labels and weakened consumer confidence in the food industry. It is estimated that this will cost $30 to $40 billion each year (World Economic Forum, 2019).

Today's customers want products that are healthy, safe, and of consistently high quality. They want guarantees about the quality of the food they're buying, as well as openness about any problems that may arise. Consider the recent EHEC-bacteria outbreak in Germany as evidence for this claim. Customer demands also include a year-round supply of a broad variety of products in an affordable price range. National and international food quality and safety regulations and legislation, as well as trade law reforms (WTO) that have led to more open markets, all contribute to these needs. With increasing levels of uncertainty, supply chains become more vulnerable.

Figure 1: Supply Chain Management Components
Source: https://www.michiganstateuniversityonline.com/resources/supply-chain/what-is-supply-chain-management/

This vulnerability is exacerbated even more if businesses have grown dependent on other organizations as a consequence of the practice of outsourcing. Increased supply and demand uncertainty, globalization of the market, shorter product and technology life cycles, and increased use of manufacturing, distribution, and logistics partners, resulting in complex international supply network relationships, have all contributed to increased supply chain risk exposure in the past decade or more.

As the food trade has grown more international, the food supply chain has gotten more complex, increasing the possibility of food fraud. As a consequence, trust between supply chain partners has been eroded, and consumer worries about food safety have increased significantly (Tahir et al., 2020). The global food safety issues of recent years include the 2013 horse meat scandal in Europe, which was caused by food labeling fraud (Bechtsis, Tsolakis, Bizakis, & Vlachos, 2019), the 2017 multi-state Salmonella outbreak in the United States, which was caused by Maradol papayas (Menson 2018), and the 2017 contaminated egg scandal in Switzerland, Hong Kong, and 15 EU member states (Saurabh & Dey, 2021a). These food safety concerns not only threaten people's health, but they also have an impact on customers' perceptions of the food industry as a whole.

In order to overcome the existing constraints of food supply chain management, blockchain technologies, which enhance transparency, security, and durability of supply chains, have the potential to become more widely used (Antonucci et al., 2019). Blockchain technology allows all parties in a supply chain network to permanently store and retain data, which improves transparency and trust in complicated supply chains (Stoyanova, Nikoloudakis, Panagiotakis, Pallis, & Markakis, 2020). By linking foodborne outbreaks to their causative food vehicle, blockchains make it feasible to reduce the number of disease outbreaks and casualties in catastrophe situations. Also beneficial is the fact that blockchain allows for a more thorough investigation into the underlying reason of an out-break, which is beneficial for future preventive efforts (Papa, 2017).

Fig 2: Components of Blockchain Technologies
Source: https://www.inc.com/drew-hendricks/blockchain-the-new-technology-of-trust.html

Blockchain technology may be used by governments to enable multi-party control of food markets, according to the World Bank. Using a system that collects information about food market transactions, food supervision issues may be more effectively addressed and addressed more effectively (Helo & Hao, 2019).The use of blockchain technology will make it simpler for businesses to verify the origins, manufacturing times, and production locations of raw materials in order to ensure that they are of high quality.

2. REVIEW OF RELEVANT LITERATURES

Agri-food companies may utilize blockchain technology to improve process transparency and efficiency, promote trustworthiness, and remove unnecessary middlemen from the supply chain. This can also raise consumer confidence in traceable food products, according to (Papa, 2017). Despite the potential role of blockchain technology integrated information and communication technologies (ICTs) in the agri-food supply chain, there is a significant knowledge gap between blockchain adoption and new ICTs that may be used. It is still unclear how actors evaluate the relative significance of different factors for technology adoption, or to what degree such elements affect their decision-making processes when deciding whether or not to embrace a technology. Many individuals nowadays think that the blockchain was created only for the purpose of storing financial information. However, by using a decentralized approach, operating structure, it can be applied to various domains. In this context, we chose to investigate the possibilities of blockchain in food chain supply.

However, it has not yet been determined how actors assess the relative significance of various variables for technology adoption, or to what degree such aspects affect their decision-making processes regarding technology adoption intentions. Aspects of the current study that are particularly noteworthy are the feasible design and processes of blockchain technology architecture in the context of agri-food supply-chain management (Kouhizadeh & Sarkis, 2018). Despite this, it has not given much attention to the desires of supply chain actors when it comes to blockchain adoption. It is necessary to determine the most essential characteristics of the agri-based supply chain, as well as the optimum mix of this restricted number of attributes that are the most authoritative on supply chain users' choice or decision-making.

By investigating determinants or factors of technology adoption and proposing scalable, traceable, trackable, interoperable, and resilient blockchain architecture for sustainable agricultural and food supply chain practices, we hope to make a contribution to this potential research gap in the literature. In addition to contributing to the economic and environmental dimensions of sustainability (Malik, Kanhere, & Jurdak, 2018) blockchain technology can help to achieve an inclusive agri-food supply chain by embracing collaborative networks (Antonucci et al., 2019), community-based ownership of resources, democratic governance, and a decentralized digital technology platform. With the use of the Interpretative Structural Modeling (ISM) and Decision-making Trial and Evaluation Laboratory, (Management & Journal, 2019) identified and assessed thirteen enablers (DEMATEL). They discovered the most important enablers, which were traceability, auditability, immutability, and provenance, among other things. These enablers are divided into groups depending on their driving power and their reliance on certain power levels (or values).

The findings of the research are limited to the interrelationships between blockchain characteristics in the agricultural supply chain. However, determining the appropriate amount of each parameter as well as the optimal supply chain design is essential to meeting the user's requirements while also taking the price into consideration in the model. The study of (Hald & Kinra, 2019) does not offer such an insight.

Furthermore, in order to make the most of blockchain technology, we should combine it with other current or upcoming ICTs such as the Internet of Things, RFID, sensor devices, cloud computing, and machine learning to maximize its potential. The research conducted by (Astill et al., 2019) suffers from the lack of consideration for such an integrated strategy. We also contend that decision-makers must be aware of the value of information systems architecture. Additionally, they must recognize the importance of the key drivers of technology adoption, as well as the impact of their levels, which may have an impact on sustainable supply chain operations and the overall performance of the organization (Helo & Hao, 2019) . (Bechtsis et al., 2019) created a conceptual framework for food Supply chain digitization, in which the connections between major possibilities and obstacles are hypothesized and discussed. While there have been few research and advice on blockchain in developing nations and companies of varying sizes, they have been unable to address the technological dynamic effect (Kamilaris, Fonts, & Prenafeta-Boldú, 2019).

Previous research has looked at blockchain-based technologies, particularly those used in the food supply chain, and found them to be promising (Krzysztof & Agnieszka, 2020). In these studies, blockchain-based technologies are described in detail at different deployment levels, and the benefits and disadvantages of incorporating them into the supply chain are identified. Most of these studies refer to 'blockchain' as a technology in and of itself, but they do not provide a clear breakdown of the components of blockchain-based technologies from a systemic viewpoint. As a result, the critical function of blockchain is not clearly distinguished from the roles of other components, making it impossible to determine the true scope of its effect. Consequently, the research gap that this study seeks to close is the absence of a comprehensive knowledge of blockchain-based technologies on a systemic level. Furthermore, bridging this gap should allow for the advancement of the discussion of what the social and environmental impacts of blockchain-based technologies are, a discussion that, as noted by (Yadav, Misra, & Goundar, 2020), remains open and unresolved at the time of this publication.

3. TECHNOLOGY ADOPTION THEORIES

Adoption theory describes how a single party in an ecosystem accepts a change; diffusion theory, on the other hand, defines a group phenomenon, which indicates how an invention spreads across the ecosystem through time from a macro-perspective (Bayramova, Edwards, & Roberts, 2021). Integration of these two ideas aids in the understanding of how a new technology will be accepted and disseminated in an industry, since acceptance will almost always result in diffusion of the new technology. IT adoption theories at the company level that are often used include DOI (Diffusion of Innovation) theory as well as the TOE (Technology, Organization, and Environment) framework (Wamba & Queiroz, 2020).

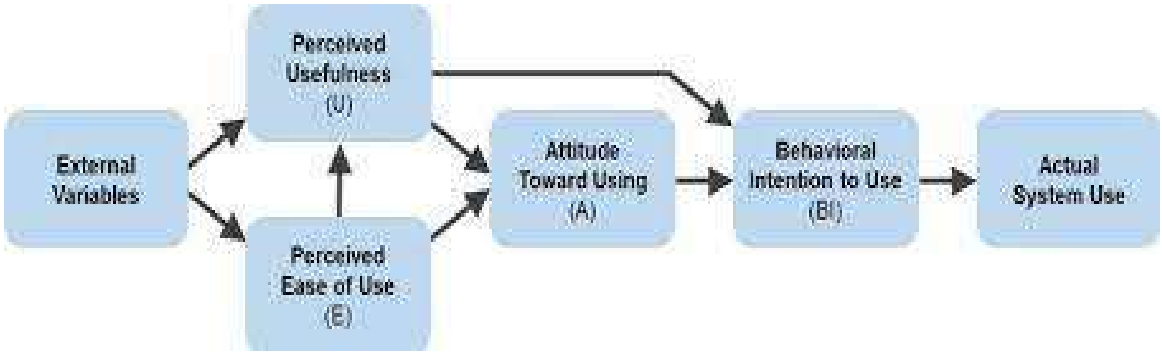

Fig 3: Technology Acceptance Model

DOI (Diffusion of Innovation) theory and the TOE (Technology, Organization, and Environment) framework are the most widely used information technology adoption theories (Chang, Iakovou, & Shi, 2020). Both theories have looked at the variables that affect an organization's ability to innovate in the field of technology. Technological innovation, according to DOI theory, is linked to the invention itself as well as to communication channels, time, and social systems (Chen, Liu, Yan, Hu, & Shi, 2020). The TOE framework places a strong emphasis on technological innovation decision-making, which is influenced by a variety of variables, including the external task environment, the availability and features of technology, and the characteristics of the organizations involved (Köhler & Pizzol, 2020). To evaluate technological innovation in the TOE framework, the environmental context is regarded a novel and significant component of the analysis of technological innovation (Kshetri, 2021)

However, although both theories examine the variables that influence technological innovation, they place a strong emphasis on the decision-making process, with little attention paid to the technological innovation processes themselves. Following the Individual Innovativeness (DOI) hypothesis, five adopter categories are defined, each based on the level of individual innovativeness: innovators, early adopters, early majority, late majority, and laggards (Saurabh & Dey, 2021b). The process of technological adoption is investigated in previous research, with an emphasis on the initiation phase rather than the implementation process. The implementation process at the business level, on the other hand, includes a huge number of stakeholders, each of whom has a role to play in the decision-making process, making the whole process more difficult to manage (Ali, Chung, Kumar, Zailani, & Tan, 2021)

Prior research have placed a strong emphasis on the study of factors associated with technology adoption (Della Valle & Oliver, 2021). Using DOI theory, for example, (Jabbar, Lloyd, Hammoudeh, Adebisi, & Raza, 2021)were able to identify the many reasons why families should use solar water disinfection equipment. Only a few studies, on the other hand, have looked at the consequences of adopting new technologies. Following (Bayramova et al., 2021), the effects of innovations may be divided into three categories: 'pleasant or unwanted consequences,' "direct or indirect consequences, and "expected vs unforeseen consequences." 'Desirable vs unwanted' refers to the fact that an invention may be useful to a system while having a negative impact on certain specific people inside the system.

As a result of the distinction between direct and indirect consequences, it is recognized that the adopter in a system may suffer direct consequences as soon as an invention is accepted, and that this consequence may result in indirect implications for other people in the system (Vu, Ghadge, & Bourlakis, 2021). The uncertainty element of innovations, which may arise from the technology itself or from change agents, is included in the comparison of expected and unforeseen outcomes. Both the participants in the system and the change agents have difficulty anticipating whether or not the innovation will be implemented. All three aspects, in general, provide some advice on management in companies after the introduction of new technologies.

Finally, the DOI theory and TOE framework have identified a number of variables that affect technology adoption as well as the repercussions of technological innovations. These considerations serve as the foundation for this study's examination of the benefits, difficulties, and procedures associated with blockchain implementation in food supply chains. Blockchain technology has the potential to be a game-changing innovation in the field of supply chain management (Saurabh & Dey, 2021b). Before blockchain-based food supply chains, the majority of the study focused on how to get started with the usage of blockchains, including both theoretical and practical investigations. Few studies, on the other hand, have examined and assessed adoption procedures in order to aid in the improvement of blockchain adoption in food supply chains. This study examines the use of blockchain technology in food supply networks. It is also important to highlight the difficulties and advantages that businesses may reap from implementing blockchain technology in order to aid them in their transition from a conventional food supply chain to a blockchain-powered food supply chain(Nurgazina, Pakdeetrakulwong, Moser, & Reiner, 2021).

3.1 Theoretical Framework

The development of a holistic and ontological universal definition of technology would be a first step in decolonizing the notion of technology. What is required is an open-ended technology conception that allows us to understand the relationships between technical and social development, as well as develop inter-disciplinary techniques for identifying and solving technological transformation issues. McLoughlin has a good explanation of various meanings of technology (Hald & Kinra, 2019). The interdependence of supply chain players for technology adoption must be understood in order to build a theoretical framework. Technology digital platform developers, Agro-ICTs organizations and blockchain start-ups, for example, have several opportunities to learn what supply chain actors value most for the chain configuration and how they can be assisted to further re-engineer the attributes of platform-based application services (Hald & Kinra, 2019).

Note that a variety of players play their roles in the supply chain such as input providers. complexity and prices of processing technologies all have a role in how well players coordinate and how much power imbalance there is (Kshetri, 2021). Each component in the model has a reason, which is later outlined in this research. In the supply chain architecture, level refers to how strong or intense a characteristic is preferred by the players in the chain or its users.

3.2 Conceptual Framework

New theories and conceptual frameworks have emerged in development research during the last several decades, although they have primarily been found in the social and political sciences, which tend to be Eurocentric. Too far, the notion of "technology" as such has not been seriously questioned. Technique and technology are frequently used interchangeably, and few, if any, development scholars explicitly define technology. But most development literature makes no such difference, but instead uses basic comparisons. People use technology to reproduce and improve their living circumstances. Technology has four elements: technique, knowledge, organization, and product.

Any technology has the four elements as inseparable parts. Consequently, all components and their interrelationships must be included in a thorough study of a specific technology. Of course, each individual element or component may be described and analyzed on their own. A technological analysis is composed of many areas, each of which may be used as an entrance point. The four elements may be seen as the most important interacting factors in technological development. All of these must thus be considered when it comes not just to the analysis but also to the implementation of technological change.

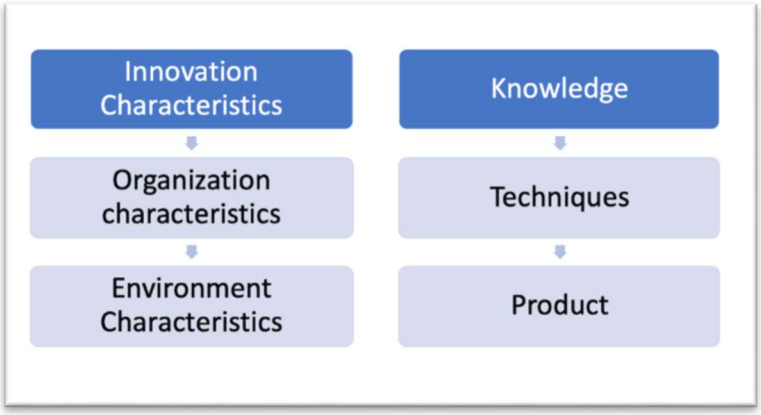

Fig 4: CConceptual Framework - haracteristic Mapping

4. TECHNIQUE COMPONENT

Blockchain technology, tracking technology, data input, data administration, data storage, and data transfer, as well as tokenized incentives, are all parts of the method element. Anyone can view all transactions on a completely open blockchain. Combining public and private blockchains creates a more flexible system that can be customized to suit specific needs. For token transactions and traceability, (Köhler & Pizzol, 2020) proposes using both a public and a private blockchain.

IBM Food Trust is built on Hyperledger Fabric, a private blockchain that limits access to data to only those with the appropriate rights (Malik et al., 2018). All blockchains utilize a peer-to-peer network to guarantee decentralization.

4.1 Knowledge Component

To deploy blockchain-based technology in the food supply chain, software developers, supply chain players, and other stakeholders need specialized expertise. Software developers need to master new languages like Solidity for Ethereum. They should also be familiar with blockchain architecture, off-chain storage alternatives, cryptography, smart contracts, and IoT device integration. Because the blockchain landscape is rapidly evolving, these players must constantly evaluate whether new components should be tested and deployed. They must also explain the benefits of their particular implementation to others.

Actors in the supply chain must be able to utilize the platform, record a harvest or catch, transfer asset ownership, update assets, and, if feasible, connect their current software to blockchain-based technology. The platform's usability may be a critical element in the adoption of blockchain-based technologies in the food supply chain. Only when the platform is simple to use will all types of users be able to take full benefit of what it has to offer. New asset registration can also be handled in a variety of ways depending on the situation.

4.2 Product Component

The information supplied on the management dashboard of their blockchain-based software system is the product for the businesses. It has the potential to provide businesses with near-real-time access to product information. Data accessibility for businesses may therefore aid in the optimization of current operations.

4.3 Innovation Characteristics

The features of the invention under consideration that may have an impact on the adoption choice and the way the adoption process develops are referred to as innovation characteristics (Papa, 2017). In this particular instance, the Blockchain applications cluster contains information on the usage and potential of Blockchain, as well as information on system-related obstacles, which indicates the limitations of the technology. For example, before assessing the viability of using Blockchain, businesses must first identify the particular goal of the project, such as product traceability, and then understand the existing technological limitations/challenges of Blockchain.

4.4 Organization Characteristics

Organizational features refer to certain qualities of the adopter that may have an effect on the adoption process (Bechtsis et al., 2019). Intra-organizational motivations, such as the benefits companies expect from adopting Blockchain, and various intra-organizational obstacles, such as a lack of competence or a fear of losing privacy, may both be considered features of an organization. These variables may have a significant effect on various phases of implementation, as previously discovered in research analyzing various technical innovations (Vu et al., 2021). For instance, it is discovered that a barrier such as a lack of IT capacity has an effect on the initiation and adoption stages.

5. CHALLENGES OF BLOCKCHAIN ADOPTION IN FOOD SUPPLY CHAIN: IMPLEMENTATION BARRIER

In the literature on innovation uptake, technology complexity has long been a central theme (Hayati et al., 2020).According to research, companies choose innovative products that are easy to use, helpful, and provide comparative benefits. Small and medium-sized businesses are having a hard time embracing blockchain technology (Kamilaris et al., 2019; Wong et al., 2020). Blockchain technologies (Zhao et al., 2019) need highly specialized understanding of IT and equipment, which is uncommon among halal food SMEs. Additionally, all Supply players engaged in data input into the network chain must have access to digital devices (Kamble et al., 2020). SMEs, on the other hand, are still utilizing pen and paper to capture data. Case C, for example, involves personally inspecting every incoming material.

Firms may also rely on halal certification and labeling to ensure their products are kosher. Moreover, since the manufacturing materials are conventional and uniform, switching from traditional paper and pen to digital devices may be prohibitively expensive (Antonucci et al., 2019). In all instances, home-made systems are utilized for monitoring and controlling. As can be seen, each of the five systems is distinct, making it difficult to transfer data to a blockchain (Nash, 2018). It follows therefore that halal food SME companies' preparedness for the full adoption and application of the food SC's blockchain technology is dubious.

5.1 Change management and external pressure

The food Supply chain is often unaware of or lacks expertise in blockchain (Zhao et al., 2019). However, blockchain specialists and professionals who can educate the food SC are few and are still learning (Papa, 2017). This study's cases all knew about blockchain technology. However, owing to insufficient references and advice on blockchain deployment in reality, the food SC still understands blockchain technology conceptually (Nurgazina et al., 2021). SMEs often have flatter structures and centralized decision-making. The adoption of blockchain is dependent on top management's understanding. A comprehensive knowledge of the architecture and setup required to enable blockchain technology adoption and deployment inside a business is required. Firms' current infrastructure and support systems are probably obsolete and not compatible with blockchain technology. Some company models and activities may not be compatible with blockchain technology, requiring a new business model (Astill et al., 2019). Change management will be impacted by a company adopting blockchain. Employers must persuade workers to embrace blockchain technology, which is a major problem (Krzysztof & Agnieszka, 2020).

5.2 Complexity of integrating different systems

Data quality is critical for the success of blockchain-based solutions. To launch a blockchain-based system, all providers must participate. If suppliers refuse to cooperate, some data may be lost, making food monitoring more difficult (Antonucci et al., 2019) .Furthermore, since blockchain technology should be used in food manufacturing, some suppliers may be reluctant to give their data (BMI Research , 2018b).To encourage information exchange among supply chain firms, a strong business environment is required. However, it is difficult to execute since the ecosystem requires amicable collaboration and efficient information exchange while not all businesses in the supply chain have similar rights.

Aside from that, certain goods may include sensitive data, making system integration more challenging. It's difficult to combine secrecy with openness.

5.3 Lack of knowledge and expertise

The fact that not enough people understand Blockchain technology and how it works is a source of concern for many businesses. There are several factors to consider before beginning the implementation of a Blockchain system. This includes the availability of the necessary infrastructure, know-how, and technical capacity.

5.4 High investment on blockchain

To integrate all businesses into the blockchain-based system, financial assistance and infrastructure expenditures are required. Another factor to consider is that time consumption is critical for small providers. A potential option is for the government to make money and equipment investments. At the moment, the majority of companies use blockchain to monitor food, but the expense of tracking food exceeds the worth of the item itself. The high expense of food traceability, particularly for some agricultural goods, must also be considered.

6. THEORETICAL CONTRIBUTION

The findings of this study have benefited theory in a variety of ways. To begin, the suggested paradigm fills in the study gap identified by Tieman et al. in the halal food SC literature about the scarcity of studies examining blockchain (Kshetri, 2021). Practitioners may use the suggested conceptual framework to review problems and possibilities that have arisen since the adoption of blockchain technology. This research tackles the paucity of empirical blockchain studies, particularly with regard to halal food, by using the case study approach (Bayramova et al., 2021) . Due to the involvement of five SMEs in this study, an in-depth explanation and rationale for the spread of blockchain technology could be provided. Third, this study responds to the request made by (Nurgazina et al., 2021) for a real-life examination into the adoption of blockchain and its use in the halal sector. Fourth, as proposed by (Krzysztof & Agnieszka, 2020) this research focuses on unresolved non-technical problems surrounding blockchain (2019). Fifth, this study expands Wong et al research.'s by focusing on SMEs as the primary debate point.

To begin, managers may utilize the findings of this study as a roadmap to better understand the connection between the possibilities and difficulties associated with blockchain implementation. Additionally, companies with characteristics comparable to those of the instances examined in this study may discover that using blockchain in their Supply chain poses similar difficulties. As a result, companies should be more proactive and ready when planning for potential blockchain use. In addition, the findings of this study shed light on the difficulties faced by halal food SMEs in practice. This study provides essential information for governmental policy formulation via a thorough examination and debate of the blockchain's possibilities and problems.

7. DISCUSSION AND CONCLUSIONS

In this study, six cases of blockchain-based technologies in the food supply chain were analyzed using a technology assessment framework. Findings were used to provide a deeper understanding of the state-of-the-art role of these technologies in food supply chains. The study contributes to build a foundation for further analysis and discussion of the social and environmental implications. A technological evaluation methodology was used to evaluate six blockchain-based food supply chain solutions. The evaluation looked at four components: method, knowledge, organization, and product. The results helped researchers better understand how blockchain-based technologies are utilized in food supply chains today. As a result of the research, we have a better understanding of the current status of blockchain-based technology in food supply chains.

More study is required to determine the long-term effects of blockchain-based technologies in the food supply chain and establish whether they will bring about the beneficial change anticipated. The major issue here is the scarcity of recent literature and the lack of systematic monitoring or quantification of the direct and indirect social and environmental benefits associated with the technology. As a result, long-term research using blockchain-based technology in the food supply chain may be very helpful in closing this gap. It would also be beneficial to examine the differences in effect between long and short supply chains, for example.

REFERENCE

1. Ali, M. H., Chung, L., Kumar, A., Zailani, S., & Tan, K. H. (2021). A sustainable Blockchain framework for the halal food supply chain: Lessons from Malaysia. *Technological Forecasting and Social Change*, *170*(April), 120870. https://doi.org/10.1016/j.techfore.2021.120870
2. Antonucci, F., Figorilli, S., Costa, C., Pallottino, F., Raso, L., & Menesatti, P. (2019). A review on blockchain applications in the agri-food sector. *Journal of the Science of Food and Agriculture*, *99*(14), 6129–6138. https://doi.org/10.1002/jsfa.9912
3. Astill, J., Dara, R. A., Campbell, M., Farber, J. M., Fraser, E. D. G., Sharif, S., & Yada, R. Y. (2019). Transparency in food supply chains: A review of enabling technology solutions. *Trends in Food Science and Technology*, *91*(December 2018), 240–247. https://doi.org/10.1016/j.tifs.2019.07.024
4. Bayramova, A., Edwards, D. J., & Roberts, C. (2021). The role of blockchain technology in augmenting supply chain resilience to cybercrime. *Buildings*, *11*(7). https://doi.org/10.3390/buildings11070283
5. Bechtsis, D., Tsolakis, N., Bizakis, A., & Vlachos, D. (2019). *A Blockchain Framework for Containerized Food Supply Chains*. *Computer Aided Chemical Engineering* (Vol. 46). Elsevier Masson SAS. https://doi.org/10.1016/B978-0-12-818634-3.50229-0
6. Chang, Y., Iakovou, E., & Shi, W. (2020). Blockchain in global supply chains and cross border trade: a critical synthesis of the state-of-the-art, challenges and opportunities. *International Journal of Production Research*, *58*(7), 2082–2099. https://doi.org/10.1080/00207543.2019.1651946

7. Chen, S., Liu, X., Yan, J., Hu, G., & Shi, Y. (2020). Processes, benefits, and challenges for adoption of blockchain technologies in food supply chains: a thematic analysis. *Information Systems and E-Business Management*, *1*, 1–4. https://doi.org/10.1007/s10257-020-00467-3
8. Domínguez, D. L., Espallargas, C. S., & Figueras, M. P. (2021). *Ecofeminismo: Redes que tejen futuro*. Ediciones Octaedro.
9. Della Valle, F., & Oliver, M. (2021). A guidance for blockchain-based digital transition in supply chains. *Applied Sciences (Switzerland)*, *11*(14). https://doi.org/10.3390/app11146523
10. Hald, K. S., & Kinra, A. (2019). How the blockchain enables and constrains supply chain performance. *International Journal of Physical Distribution and Logistics Management*, *49*(4), 376–397. https://doi.org/10.1108/IJPDLM-02-2019-0063
11. Hayati, H., Mao, D., Wang, F., Hao, Z., Li, H., Azzi, R., … Al-Mashari, M. (2020). The role of blockchain technology in augmenting supply chain resilience to cybercrime. *Computers and Industrial Engineering*, *11*(5), 582–592. https://doi.org/10.1016/j.cie.2020.106684
12. Helo, P., & Hao, Y. (2019). Blockchains in operations and supply chains: A model and reference implementation. *Computers and Industrial Engineering*, *136*(July), 242–251. https://doi.org/10.1016/j.cie.2019.07.023
13. Jabbar, S., Lloyd, H., Hammoudeh, M., Adebisi, B., & Raza, U. (2021). Blockchain-enabled supply chain: analysis, challenges, and future directions. *Multimedia Systems*, *27*(4), 787–806. https://doi.org/10.1007/s00530-020-00687-0
14. Kamilaris, A., Fonts, A., & Prenafeta-Boldú, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. *Trends in Food Science and Technology*, *91*, 640–652. https://doi.org/10.1016/j.tifs.2019.07.034
15. Köhler, S., & Pizzol, M. (2020). Technology assessment of blockchain-based technologies in the food supply chain. *Journal of Cleaner Production*, *269*. https://doi.org/10.1016/j.jclepro.2020.122193
16. Kouhizadeh, M., & Sarkis, J. (2018). Blockchain practices, potentials, and perspectives in greening supply chains. *Sustainability (Switzerland)*, *10*(10). https://doi.org/10.3390/su10103652
17. Krzysztof, M., & Agnieszka, W. (2020). Proceedings of the 3 rd INFER Symposium on Agri-Tech Economics for Sustainable Futures. *Proceedings of the 3rd INFER Symposium on Agri-Tech Economics for Sustainable Futures*, (October).
18. Kshetri, N. (2021). Blockchain and sustainable supply chain management in developing countries. *International Journal of Information Management*, *60*(May 2019), 102376. https://doi.org/10.1016/j.ijinfomgt.2021.102376
19. Malik, S., Kanhere, S. S., & Jurdak, R. (2018). ProductChain: Scalable blockchain framework to support provenance in supply chains. *NCA 2018 - 2018 IEEE 17th International Symposium on Network Computing and Applications*, (November), 1–10. https://doi.org/10.1109/NCA.2018.8548322
20. Management, S. C., & Journal, I. (2019). Blockchain: case studies in food supple chain visivility.
21. Menon S (2018) Supply chain: applications of blockchain platform in agri-food supply chains. Bio Voice. https ://www.biovoicenews.com/applications-blockchain-platform-agri-food-supply-chain

22. Nurgazina, J., Pakdeetrakulwong, U., Moser, T., & Reiner, G. (2021). Distributed ledger technology applications in food supply chains: A review of challenges and future research directions. *Sustainability (Switzerland)*, *13*(8). https://doi.org/10.3390/su13084206
23. Papa, S. F. (2017). Use of Blockchain Technology in Agribusiness: Transparency and Monitoring in Agricultural Trade, (January 2017). https://doi.org/10.2991/msmi-17.2017.9
24. Saurabh, S., & Dey, K. (2021a). Blockchain technology adoption, architecture, and sustainable agri-food supply chains. *Journal of Cleaner Production*, *284*(xxxx), 124731. https://doi.org/10.1016/j.jclepro.2020.124731
25. Saurabh, S., & Dey, K. (2021b). Blockchain technology adoption, architecture, and sustainable agri-food supply chains. *Journal of Cleaner Production*, *284*, 124731. https://doi.org/10.1016/j.jclepro.2020.124731
26. Stoyanova, M., Nikoloudakis, Y., Panagiotakis, S., Pallis, E., & Markakis, E. K. (2020). A Survey on the Internet of Things (IoT) Forensics: Challenges, Approaches, and Open Issues. *IEEE Communications Surveys and Tutorials*, *22*(2), 1191–1221. https://doi.org/10.1109/COMST.2019.2962586
27. Tahir, H., Masri, R., Rahman, M. M., Man, A. J., Fin, A., Ngozi, P., … Emmanuel, U. I. (2020). The Relationship Between Dividend Payments And Firm Performance: A Study Of Listed Companies In Morocco. *European Scientific Journal, ESJ*, *8*(1), 15–27. https://doi.org/10.37745/ejaafr/vol8.no6.pp15-27.2020
28. Vu, N., Ghadge, A., & Bourlakis, M. (2021). Blockchain adoption in food supply chains: a review and implementation framework. *Production Planning and Control*, *0*(0), 1–18. https://doi.org/10.1080/09537287.2021.1939902
29. Wamba, S. F., & Queiroz, M. M. (2020). Blockchain in the operations and supply chain management: Benefits, challenges and future research opportunities. *International Journal of Information Management*, *52*(xxxx). https://doi.org/10.1016/j.ijinfomgt.2019.102064
30. Yadav, J., Misra, M., & Goundar, S. (2020). An overview of food supply chain virtualisation and granular traceability using blockchain technology. *International Journal of Blockchains and Cryptocurrencies*, *1*(2), 154. https://doi.org/10.1504/ijbc.2020.108997