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Cryptocurrencies and Blockchain: A Comprehensive Review of Emerging Trends, Challenges, and Opportunities

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ABSTRACT:

Cryptocurrencies and blockchain technologies are emerging as revolutionary innovations that are changing the way finance, governance, and digital interaction occur. This review integrates findings from six recent research articles on cryptocurrency adoption, environmental implications, user behaviour, and institutional integration. One of the main findings identifies usability concerns and trust deficits in human-computer interaction (HCI) as major impediments to user use of blockchain applications. Research on user adoption finds that performance expectancy, awareness of technology, and financial literacy are important drivers of behavioural intentions, particularly in developing economies such as India. In parallel, the environmental impact of cryptocurrencies, with primary mechanisms based on proof-of-work, gives rise to sustainability issues, with high geopolitical implications from nations such as China and the USA. Economically, scalability issues arise with decentralized trust systems on account of their elevated operational costs. In addition, cryptocurrency adoption is not only a chance for, but also a threat to, traditional banking institutions, as it complicates regulatory systems and forces financial institutions to evolve. In countries such as Indonesia, cryptocurrencies have the potential to increase financial inclusion while elevating legal and security concerns. Overall, these studies highlight the necessity of immediate interdisciplinary collaboration to overcome usability, sustainability, economic feasibility, and regulatory consistency. The review concludes by calling for human-centered design, green innovation, and adaptive policy frameworks to facilitate the responsible growth of blockchain ecosystems.

Keywords: Blockchain Technology, Human-Computer Interaction (HCI), Cryptocurrency Adoption,

Crypto Market Disruption, Sustainable Blockchain Systems, Digital Currency Regulation.

1. Introduction:

Cryptocurrencies and blockchain technologies have transformed the paradigm of digital finance, providing decentralized solutions to traditional monetary systems and institutional structures of trust. From the launch of Bitcoin in 2008, the space has expanded manifold—ranging from digital payments to decentralized finance (DeFi), smart contracts, and more. With the expansion came an increased academia and industry interest, with researchers from various fields examining the implications, advantages, and dangers of these technologies.

Though they have the potential to disrupt, mainstream cryptocurrencies are beset by a variety of key challenges. Concerns regarding user trust, regulatory clarity, energy usage, and usability all continue to hold back greater inclusion in mainstream economic systems. Moreover, the relationship between blockchain and the traditional financial system remains complicated, swinging between confrontation and cooperation. With governments and companies investigating Central Bank Digital Currencies (CBDCs) and blockchain-based applications, the necessity for transparent policies, environmentally sustainable practices, and people-oriented design has gained more importance.

This review of research seeks to systematically examine recent academically published work that explores the complex effects of cryptocurrencies and blockchain. On the basis of six recent peer-reviewed articles, this article points out emerging themes in technology adoption, user behaviour, environmental sustainability, and dislocating the financial system. It seeks to recognize gaps in the research and suggest a future agenda for interdisciplinary research and innovation.

2. Key Themes and Findings:

The five core themes that come out of this review are cryptocurrencies and blockchain technologies concerning the following: user adoption, human-computer interaction, energy consumption, disruption to traditional finance, and economic scalability.

2.1 User Adoption and Behavioural Factors

Kumari et al. (2023) emphasize how individual innovativeness, financial literacy, and technology awareness play a crucial role in shaping user intentions towards adopting cryptocurrencies. Applying the UTAUT2 model, the research validates that performance expectancy, trust, and social influence are significant predictors of behavioural intention. For emerging economies such as India, these elements are notably vital.

2.2 Human-Computer Interaction (HCI) and Usability

Fröhlich et al. (2022) carried out a systematic review of blockchain use in HCI and found six key themes: trust, user motivation, usability of wallets, engagement with blockchain, application-specific use cases, and support tools. Lack of usability and minimal user-centric design are still significant adoption barriers.

2.3 Environmental and Energy Concerns

Anandhabalaji et al. Regarding the energy expended by cryptocurrencies, (2024) published a bibliometric overview in 2024. The research indicates that proof-of-work (PoW) algorithms, especially Bitcoin mining, are ecologically unsustainable. Other consensus models, such as proof-of-stake (PoS) and the adoption of renewable energy, are recognized as areas for immediate research and policy intervention.

2.4 Traditional Finance Disruption and Integration

Benediktus (2025) and Kayani & Hasan (2024) analyse the influence of cryptocurrencies on banking systems. Cryptocurrencies are both a threat and a complement to conventional banks in Indonesia, depending on the clarification of regulations. In the UK and USA, smart contracts and DeFi are changing institutional functions and disrupting legacy financial frameworks.

2.5 Economic Viability and Constraints of Blockchain Trust

A critical perspective on the economic sustainability of decentralized trust models, including Bitcoin, is offered by Budish (2025). He contends that security based on blockchain (e.g., through PoW) is expensive and inefficiently scales. Without the backing of rule of law or external mechanisms, these systems become economically non-viable at scale.

3. Cross-Cutting Challenges

Literature reviewed indicates a number of enduring and overlapping challenges that cross-cut the fields of technology, policy, environment, and user experience. These challenges impede the general adoption and sustainable growth of cryptocurrency and blockchain systems.

3.1 Usability and User Trust

Even with increasing interest, blockchain systems are unintuitive and complex for most users. Terrible user interface design, poor onboarding processes, and inadequate education support have been repeatedly identified as impediments to adoption. Trust in decentralized systems is further eroded by issues of usability, which prompt hesitation among non-technical users.

3.2 Regulatory Uncertainty

Cryptocurrencies have an uncertain legal environment in most areas. This unpredictability poses risks to consumers, investors, and institutions. Unclear or overly restrictive rules—e.g., the Indonesian commodity classification are stifling innovation, while unregulated settings expose them to more risks of fraud, money laundering, and market manipulation.

3.3 Environmental Sustainability

Proof-of-work (PoW) systems, which are still in use by top cryptocurrencies such as Bitcoin, are energy intensive and environmentally destructive. Their carbon emissions, e-waste, and strain on power infrastructure are serious issues, especially as world focus is drawn to climate change and energy equity.

3.4 Economic Viability and Scalability

Maintaining decentralized trust through PoW or similar mechanisms incurs high operational costs that scale linearly with network value. As Budish (2025) argues, the cost of securing these networks could exceed global GDP if broadly implemented. This raises questions about long-term economic feasibility without hybrid trust models or external institutional support.

3.5 Financial System Integration

Cryptocurrencies pose both risks and opportunities for conventional financial institutions. On the one hand, DeFi can enhance financial inclusion and decrease the cost of transactions. On the other, it threatens the strength and control of regulated financial systems. Institutions have to walk a delicate tightrope between innovation and risk management.

4. Research Gaps and Future Directions

Although current research offers useful insights into the technology, economics, and behaviors of cryptocurrencies and blockchain, some main gaps exist. The gaps suggest further interdisciplinary research, empirical testing, and experimentation in the real world to inform responsible adoption and policy formulation.

4.1 Limited Real-World Usability Studies

In spite of usability barrier awareness, few empirical studies have investigated how actual users engage with blockchain interfaces in real-world scenarios. Fröhlich et al. (2022) point to user-centered design needs, but the majority of systems continue with little usability testing. Longitudinal user studies, inclusive design processes, and co-creation with non-tech populations must be a part of future work in constructing more accessible wallets, dApps, and platforms.

4.2 Fragmented and Inconsistent Regulatory Research

Though research like Benediktus (2025) and Kayani & Hasan (2024) delves into regulatory environments, most of it addresses individual areas or country-specific systems

There is an urgent requirement for cross-border, comparative regulatory analysis assessing the effects of convergent legal strategies on innovation, consumer protection, and market stability. Future research must investigate the possibility of international standards or collaborative models of governance.

4.3 Green Innovation and Sustainability

There is extensive documentation of environmental issues, but technical and economic analyses of new consensus mechanisms are still scarce. Anandhabalaji et al. (2024) mention the energy requirements of PoW, but few studies carefully analyse the trade-offs between Proof of Stake (PoS), Proof of Authority (PoA), and new eco-friendly algorithms. More research is required to assess performance, security, and scalability of greener blockchain platforms in various use cases.

4.4 Behavioural Cryptocurrency Usage Economics

The majority of adoption models are based on conventional technology acceptance models (e.g., UTAUT2). Nevertheless, as proposed by Kumari et al. (2023), more profound psychological and socio-economic motivators like perceived risk, financial worry, or digital disparity are underutilized.

Future research must incorporate behavioural economics, cultural research, and qualitative research to capture heterogeneous user motivators and obstacles.

4.5 Economic Feasibility Under Realistic Scenarios

Budish (2025) delineates the theoretical cost boundaries of blockchain-based trust systems, but there are few experiments that test such models in real-world environments or in hybrid architecture that blends decentralized consensus with institutional or legal backing. Future work should measure whether semi-decentralized models (e.g., consortium chains) provide more viable alternatives in key areas such as finance, supply chains, and governance.

4.6 Institutional and Financial Coexistence Models

There has not yet been adequate study of the co-evolution of traditional banks, fintech's, and DeFi systems. Benediktus (2025) proposes potential coexistence in the hands of proper regulation, but empirical case studies in hybrid ecosystems, bank-originated crypto services, or central bank digital currencies (CBDCs) are scant. Further research should assess strategic alliances and governance frameworks balancing innovation with systemic stability.

In short, the future of blockchain and cryptocurrency research needs to go beyond technical possibility towards policy-informed, interdisciplinary, and inclusive inquiry. Priorities are real-world applicability, regulatory harmonization, green tech, economic modelling, and institutional integration making these technologies develop in the service of sustainable, equitable, and secure global systems.

5. Critical Analysis and Discussion

The literature reviewed presents a rich, cross-disciplinary perspective of the blockchain and cryptocurrency landscape across areas including user adoption, economic theory, environmental concerns, financial disruption, and regulatory policy. A strong point of the studies is the thematic heterogeneity between them, which enables multi-layered comprehension of individual and systemic factors in blockchain adoption. A major failing, though, is the lack of connection between theory and practice. Whereas Budish (2025) offers a stringent economic critique of decentralized trust mechanisms, analysis is rather conceptual with no empirical testing. Likewise, whereas user studies such as that conducted by Kumari et al. (2023) point to significant behavioural considerations, actual implementation and longer-term effects are not well examined. Another weakness is geographical focus, with much work cantered in India, Indonesia, the UK, and the USA. This excludes major activity in other international regions like Latin America and Africa. Additionally, regulatory research shows fragmented and incoherent policy structures across countries, highlighting the necessity for concerted international policies. Environmental issues are discussed well by Anandhabalaji et al. (2024), but ethical effects of energy consumption and social consequences are not discussed well enough. Notably, although Fröhlich et al. (2022) touch on usability, the general literature tends to overlook user experience and interface accessibility, which are essential for large-scale adoption. In general, the studies emphasize the need for combining technical, behavioural, and policy approaches to ensure responsible, inclusive, and sustainable blockchain technology development.

5.1 Strengths and Limitations of Previous Studies

- **Strengths**

o Human-Centered Approach: Fröhlich et al. (2022) place strong focus on usability and human-computer interaction, a very important but frequently neglected aspect in blockchain design.

o Behavioural Models of Adoption: Kumari et al. (2023) make use of the UTAUT2 model to evaluate user behaviour, focusing on personal innovativeness and financial literacy.

o Theoretical Rigor: Budish (2025) offers a sound economic model to test the scalability and affordability of decentralized trust mechanisms.

o Trend Identification: Anandhabalaji et al. (2024) employ bibliometric analysis to uncover cryptocurrency energy consumption research trends.

o Contextual Depth: Region-specific research (e.g., Indonesia and India) offers contextualized information on adoption, policy, and financial integration.

- **Limitations**

o Lack of Empirical Validation: Numerous studies depend on theoretical models or surveys without actual implementation or longitudinal data.

o Geographic Narrowness: Concentration is kept limited to only a few nations, with non-representation of African, Latin American, and underdeveloped countries.

o Inadequate Inclusivity Analysis: Special consideration is rarely provided to gender, age, or digital inequality in user take-up and experience.

o Disjointed Regulatory Analysis: Regulatory analysis remains largely country-specific, without comparative or international coordination perspectives.

o Environmental and Ethical Gaps: While energy usage is debated, broader ethical concerns (e.g., e-waste, equity, climate justice) are touched on minimally.

o Overlooked Accessibility of Design: User interface and accessibility issues of marginalized or non-technical groups are under-addressed.

5.2. Conflicting Findings and Unresolved Questions

o There is debate about the extent of decentralization that blockchain-based systems should have—whether complete sovereignty in a techno-libertarian framework is feasible or institutional hybrid governance is more feasible in the long term for integrating into society.

o Scholars provide two-edged analyses of the social implications of blockchain, particularly in the developing world or low-technology-penetration areas, where blockchain could facilitate greater inclusion or amplify digital disparities.

o Some open challenges include legal accountability challenges of decentralized finance (DeFi), environmental sustainability of consensus and mining algorithms, and technical optimization of consensus protocols (e.g., PoW, PoS) that are yet to be solved.

6. Conclusion

This review paper reviewed six recent works to gain insight into the developing world of cryptocurrencies and blockchain technology. The findings are that, although these technologies hold great promises decentralization, financial inclusion, and increased transparency they also have multifaceted challenges bridging usability, regulation, environmental sustainability, and economic viability.

User acceptance is profoundly affected by awareness of technology, trust, and user interface, implying the necessity of even more human-focused blockchain solutions. Uncertainty around regulation still holds back innovation as well as security, particularly in emerging markets. In addition, the environmental cost of energy-hungry consensus protocols such as Proof of Work presents a deep concern regarding the long-term viability of existing blockchain models.

Economically, decentralized systems have limitations if scaled globally without institutional support, as high costs of operations jeopardize their viability. Simultaneously, the conventional financial institutions are being compelled to respond to the growth of decentralized finance, with varying responses depending on local financial and legal contexts.

To promote responsible and effective integration of blockchain technologies, future research has to meet these challenges by drawing on interdisciplinary methods that integrate knowledge from technology, law, economics, and environmental science. In this way, stakeholders can assist in building a secure, sustainable, and inclusive digital financial future**.**

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