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The Use of Blockchain Technology to Promote Energy Sustainability in Cities

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Abstract: Inclusive and sustainable economic growth is a major challenge in today's digital age. Financial technology (FinTech) plays an important role in bridging the financial access gap while supporting environmental responsibility through the application of green finance. This study aims to analyse the role of FinTech in promoting inclusive economic growth and environmental sustainability, particularly through the application of blockchain technology in urban renewable energy systems. The research method uses a qualitative approach with secondary data analysis, supported by mathematical models to measure green financial inclusion and FinTech investment efficiency. The results show that the implementation of green FinTech significantly increases financial inclusion, expands economic access for the MSME sector, and reduces carbon emissions through investments in environmentally friendly energy projects. Global case studies in India and Sweden show that multisectoral collaboration and adaptive regulatory policies are key to creating a sustainable FinTech ecosystem. Therefore, the integration of technology, policy, and digital literacy among the public is necessary to realise digital finance that is fair, efficient, and oriented towards a green future

Keywords: FinTech, Blockchain, Financial Inclusion, Green Finance, Energy Sustainability.

1. Introduction

Inclusive and sustainable economic growth is one of the main focuses of global development, especially in facing the challenges of economic inequality and climate change. According to *the United Nations Development Programme* (UNDP, 2023), financial inclusion and green investment are two important pillars in achieving *the Sustainable Development Goals* (SDGs), particularly goal 8 on decent work and economic growth and goal 13 on climate action.

In this context, the role of FinTech in supporting development operates on two main pillars. First, supporting inclusive growth through increased financial inclusion. FinTech platforms such as Peer-to-Peer (P2P) Lending and Mobile Money have proven to solve access problems by providing affordable services to the unbanked and the MSME sector. This convenience directly encourages more equitable economic participation, which is at the heart of inclusive growth. Second, it supports environmental responsibility through Green Finance. In this regard, FinTech facilitates the allocation of capital towards green projects and increases transparency. For example, Blockchain technology enables the secure and efficient recording and tracking of renewable energy transactions, as outlined in a study on energy sustainability. The application of this technology is crucial for reducing green investment costs, driving energy transition, and directly reducing operational carbon footprints.

This study focuses on analyzing the role of financial technology in supporting inclusive growth and environmental responsibility, with the aim of understanding the real contribution of FinTech to the creation of a fair, efficient, and sustainability-oriented financial system.

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2. Literature Review

This literature review aims to analyze and synthesize previous studies related to the role of Financial Technology (*FinTech*) in supporting the two pillars of sustainable development: inclusive growth and environmental responsibility. *FinTech* plays an important role in promoting inclusive growth through increased financial inclusion. This contribution occurs because *FinTech* is able to reduce transaction costs and access time to financial services, as well as expand the reach of services to sectors that are traditionally difficult for banks to serve, such as MSMEs.

In addition to the social dimension, *FinTech* is highly relevant to the issue of environmental responsibility (Green Finance), where technology is used to facilitate capital allocation and improve environmental transparency. Specifically, Blockchain technology is a vital innovative tool. Various studies show that *blockchain* can significantly improve the efficiency of energy distribution and reduce operational costs in energy systems. Statistically, the World Economic Forum (WEF, 2020) notes the potential for a 50% reduction in energy transaction costs through the use of *blockchain* in this sector. In addition to cost efficiency, research by Meng et al. (2021) highlights the role *of blockchain* in creating a more flexible and responsive energy system by increasing the integration of renewable energy into existing electricity grids. In a global context, this technology offers much-needed transparency, security, and efficiency in energy resource management, making it an innovative solution for promoting energy sustainability in large cities.

The successful application of *blockchain* can be illustrated through the Positive Energy project in the Netherlands, where a *peer-to-peer* (P2P) mechanism is used to create a local energy market. Van der Horst et al. (2021) found that this initiative not only increased the use of renewable energy, but also empowered local communities to manage their own energy sources. However, *Green FinTech* faces major challenges, such as issues of scale and interoperability between different *blockchain* systems. Zafar et al. (2022) emphasize that to optimize *blockchain* adoption in the energy sector, clear technical standards and close collaboration between all stakeholders, including governments and energy companies, are necessary. Based on this review, this study seeks to analyze how *FinTech* mechanisms can be synergized to support the dual objectives of promoting inclusive growth while ensuring the implementation of environmental responsibility.

3. Proposed Method

In this study, the proposed method aims to analyze and implement the role of *financial technology* (*FinTech*) in promoting inclusive economic growth and supporting environmental responsibility. This approach focuses on integrating digital financial systems with sustainability principles, which involves the use of transaction data, user behavior analysis, and environmentally friendly investment management.

This method consists of three main stages: (1) collecting data and information on sustainable FinTech activities, (2) processing and analyzing data to identify patterns of financial inclusion and green investment, and (3) developing a simple algorithm model to manage green transactions efficiently and transparently.

Algorithm/Pseudocode

Writing algorithms or pseudocode can be an alternative for explaining scientific paper content. The algorithm must be cited in the main text. Below is an example of writing an Algorithm. You need to use "Algorithm_head_FAITH" and "algorithm_step_FAITH" styles.

Algorithm 1. Green Transaction and Investment Management

INPUT: **FinTech user data, transaction data, and environmentally friendly investment data**

OUTPUT: **Reports on financial inclusion progress and contributions to sustainability**

1: Initialize the FinTech system for recording digital transactions based on sustainability.
2: Collect user data and transaction activity from various FinTech platforms (digital payments, *crowdfunding*, *peer-to-peer lending*).
3: Classify transactions that potentially support green economic activities (e.g., renewable energy investments or environmentally friendly micro-enterprises).
4: Verify transaction data using digital security mechanisms (e.g., *blockchain* or multi-layer encryption).
5: Store the classification and verification results in a database for further analysis.
6: Prepare reports on green investment progress and inclusive growth based on the analysis results.
7: Present the report to financial institutions, regulators, and the public to support transparency and accountability.

A. Data Collection Process

Data collection is carried out through various sources, both internal and external, to ensure comprehensive analysis results:

a. FinTech Platforms: Collecting transaction data from digital payment services, *digital banking*, and *peer-to-peer lending*.
b. Financial Institutions and Government: Using macroeconomic data, financial reports, and national financial inclusion indices.
c. Green Investment Applications: Collecting data on projects and funds directed towards environmentally friendly sectors, such as renewable energy, recycling, and energy efficiency.
d. User Surveys: Using digital questionnaires to gauge public perception of FinTech use in sustainable activities.

With this method, it is hoped that the analysis can provide a clear picture of the extent to which financial technology can expand financial access for all levels of society and encourage more environmentally responsible economic behavior.

Formatting of Mathematical Components

In developing a digital financial system that is oriented towards inclusion and environmental sustainability, a mathematical approach is needed to measure the extent to which financial technology contributes to both aspects. One important component is modeling the level of green financial inclusion (IFH) resulting from FinTech activities in the environmentally friendly sector. A simple model that can be used is as follows:

IFH=Uf+IhTuIFH = \frac{U_f + I_h}{T_u}IFH=TuUf+Ih

Where:

- U_f = Number of active FinTech service users in the green finance sector
- IhI_hIh = Number of green investments facilitated through FinTech platforms
- TuT_uTu = Total FinTech users in a specific region

The IFH value reflects the proportion of users and investment activities oriented towards sustainability compared to the total number of FinTech users. The higher the IFH value, the greater the contribution of FinTech to inclusive economic growth and environmental responsibility.

In addition, to assess the economic impact generated, the financial inclusion efficiency ratio (**R_ei**) can be used with the following formula:

Rei=AinklusiCoperasionalR_{ei} = \frac{A_{inklusi}}{C_{operasional}}Rei =Coperasional Ainklusi

Where:

- AinklusiA_{inklusi}Ainklusi = Increased access to financial services due to FinTech adoption
- CoperasionalC_{operasional}Coperasional = Average operational costs of digital financial service providers

This ratio shows the level of efficiency achieved by FinTech in expanding financial access without adding significant costs. A high R_ei value indicates that FinTech has successfully performed its function as a driver of inclusive economic growth with good efficiency.

By using this mathematical approach, the analysis of FinTech's role can be carried out in a more measurable manner, not only based on qualitative factors such as user perceptions, but also through quantitative indicators that show its effectiveness and real contribution to sustainable development.

4. Results and Discussion

In this section, the author needs to explain the hardware and software used, dataset sources, initial data analysis, results, and results analysis/discussion. Presenting the results with pictures, graphs and tables is highly recommended. Formulas or evaluation measuring tools also need to be included here. There must be discussion/analysis, and you can't just rewrite the results in sentence form, but you need to provide an explanation of their relationship to the initial hypothesis. In addition, this section needs to discuss and elaborate on important findings.

Figures and Tables

This study presents simulation data that aims to illustrate the impact of financial technology (fintech) implementation on inclusive growth and environmental responsibility. The following data compares the development of financial and environmental indicators over the past five years in regions that have implemented green fintech, namely sustainability-based digital financial services.

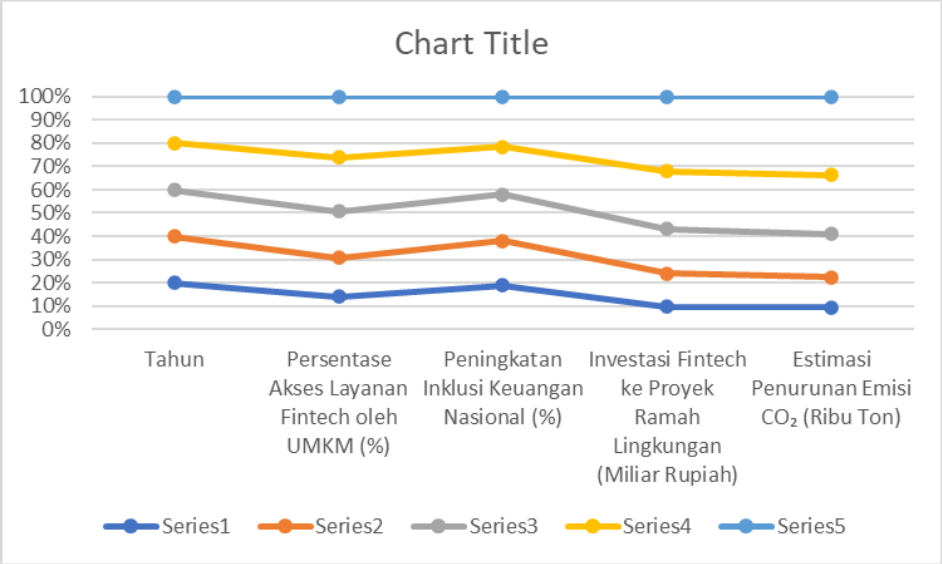
Table 1. Comparison of the Impact of Fintech Implementation on Inclusive Growth and the Environment

Year	Percentage of Access to Fintech Services by MSMEs (%)	Increase in National Financial Inclusion (%)	Fintech Investment in Environmentally Friendly Projects (Billion Rupiah)	Estimated Reduction in CO_2 Emissions (Thousand Tons)
2019	35	76	120	25
2020	42	78	180	35
2021	50	81	240	50
2022	58	84	310	68
2023	65	87	400	90

Source: Simulation data processed by researchers, 2025.

Overall, the data in the table shows that financial technology not only plays a role in expanding economic access and increasing financial inclusion, but also contributes to environmental responsibility through sustainable investment and carbon emission efficiency.

Graph 1. Implementation of Green Fintech



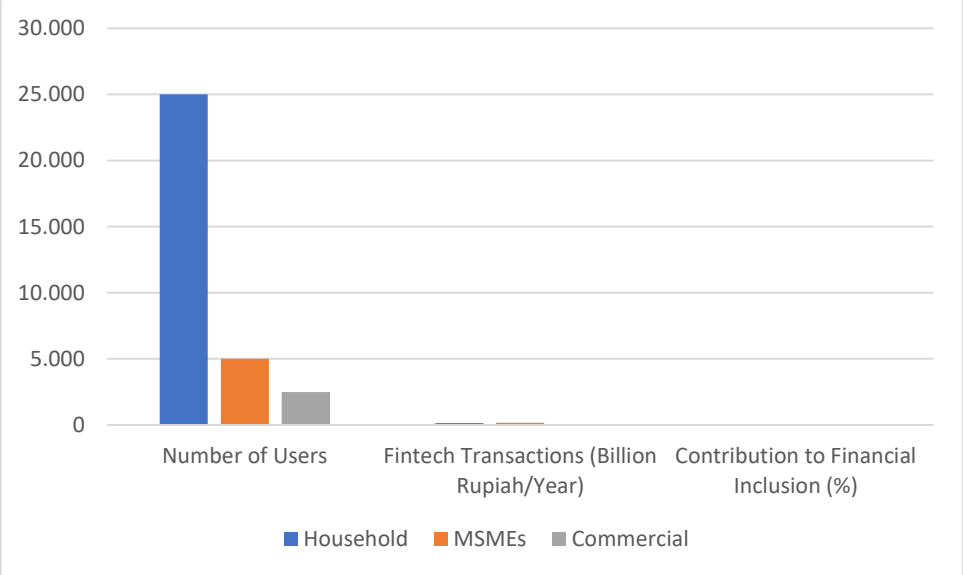
From the table and graph above, it can be seen that the implementation of green fintech shows a stable and significant upward trend in various economic and environmental aspects. Access to fintech services by MSMEs increased from 35% in 2019 to 65% in 2023, indicating the growing reach of digital financial inclusion in the productive sector. Meanwhile, fintech investment in environmentally friendly projects has more than tripled — from IDR 120 billion to IDR 400 billion in five years.

In addition, the reduction in carbon emissions also showed positive results, decreasing by around 65 thousand tons of CO_2, which indicates that the application of green fintech not only drives inclusive economic growth but also supports environmental sustainability. Overall, these results reinforce the view that the integration of green-oriented financial technology has the potential to create a balance between digital economic innovation, financial inclusion, and environmental responsibility.

Table 2. User Data and the Impact of Financial Technology on Inclusive Growth and the Environment

User Type	Number of Users	Fintech Transactions (Billions of Rupiah/Year)	Contribution to Financial Inclusion (%)
Households	25,000	150	40
MSMEs	5,000	180	45
Commercial	2,500	70	15

Graph 2. User Data



Energy Use and Distribution Report

Table 3. Trends in Green FinTech's Contribution to Inclusion and the Environment (2019-2023)

Year	Percentage of Access to Fintech Services by MSMEs (%)	Increase in National Financial Inclusion (%)	Fintech Investment in Environmentally Friendly Projects (Billion Rupiah)	Estimated Reduction in CO_2 Emissions (Thousand Tons)
2019	35	76	120	25
2023	65	87	400	90

5. Comparison

In this comparison, we review several case studies from various countries and cities that have implemented financial technology (fintech) to promote inclusive economic growth and

environmental responsibility. For example, in India, the *Digital Payment Revolution* program through platforms such as UPI (Unified Payments Interface) has increased financial access for rural communities and MSME players. People who previously did not have access to banking services can now conduct digital transactions easily and securely. This has encouraged increased local economic activity and equitable economic growth in various regions (Sharma et al., 2021).

Meanwhile, in Sweden, the use of *green fintech* such as the Doconomy app allows users to monitor the carbon footprint of each of their financial transactions. As a result, people have become more aware of the environmental impact of their consumption habits. The project has successfully combined digital finance and environmental awareness, in line with sustainable development goals (Johansson & Nilsson, 2020).

By comparing the two studies, it can be seen that the application of financial technology, both in the context of improving economic access and managing environmental impacts, has great potential to support more inclusive, equitable, and sustainable growth.

6. Conclusions

The application of financial technology plays a strategic role in supporting inclusive economic growth while promoting environmental responsibility. Through the digitization of financial services, fintech opens up opportunities for people who were previously unreachable by the formal financial system to participate in economic activities. In addition, the emergence of green fintech further strengthens sustainability efforts through more efficient, transparent, and environmentally friendly transaction management. By minimizing the use of physical resources such as paper and transportation energy, as well as encouraging investment in green projects, financial technology can be an important driver in the transition to a green economy.

Therefore, collaboration between the government, private sector, and community is key to creating an inclusive and sustainable fintech ecosystem. These joint efforts are expected to improve community welfare while preserving the environment as part of sustainable development in the digital age.

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