

THE FINANCIAL INCLUSION-ENVIRONMENTAL QUALITY NEXUS: DO INFORMATION AND COMMUNICATION TECHNOLOGIES MAKE A DIFFERENCE?

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ABSTRACT

Environmental degradation occurs during the initial phase of development. However, after a turning point, the benefits of economic growth supported by the accelerated development of information and communication technology (ICT) can be used for environmental conservation. This research examines the relationship between financial inclusion, ICT, and environmental quality, including the development of ICT in influencing the relationship between financial inclusion and environmental quality. To obtain the research objectives, we used secondary data for the period 2010 to 2021 from 34 provinces in Indonesia using the panel data regression method. This finding is robust for different measures of the financial inclusion index constructed by a modified estimation model. The insights to financial inclusion and emission can be a reference for regulations that financial inclusion and ICT can be used as mitigation measures for environmental quality. Therefore, policymakers should consider the synergistic effect of financial inclusion and ICT in designing development and climate change policies.

Keywords: Environmental quality, financial inclusion, ICT.

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1. INTRODUCTION

The financial sector, information and communication technology, and climate change are the current topics of discussion because the financial sector and Information and Communication Technology (ICT) play an important role in the economy (Asongu et al., 2017; Dar & Sahu, 2022; Nguyen et al., 2020; Pradhan et al., 2021). The financial sector and financial inclusion are an integral part of the development of economic development. In November 2010, the G20 Summit agenda in Seoul, South Korea stated that financial inclusion was recognized as one of the nine

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pillars of the global development agenda GPF (n.d.). Advances in ICT have changed people's lives both socio-economically, for example in economic growth and impact on the environment (Nguyen et al., 2020). In addition, Indonesia is the owner of the largest carbon stock and as the ten largest Greenhouse Gases (GHG) emitting countries in the world.

In the 2015 Paris Agreement, Indonesia plans to reduce emissions by 29% with its own efforts or by 41% if there is support for international cooperation under business-as-usual conditions in 2030. Financial Service Authority (OJK) as one of the financial regulators in Indonesia issues POJK No. 51/POJK.03/2017 concerning the Implementation of Sustainable Finance for Financial Service Institutions (LJK), Issuers, and Public Companies to support the GHG emission reduction movement through the financial sector.

Based on the OJK report, the financial inclusion index in Indonesia was 76.19 percent in 2019, which means that 76 people out of 100 people in Indonesia are already included or have access to financial services. Financial inclusion is recognized as the availability of formal financial services (e.g., saving, access to credit, insurance, investment, and retirement programs) for society that have an impact on economic growth (Dar & Sahu, 2022; Erlando et al., 2020; Grohmann et al., 2018; Kim et al., 2018; Lu et al., 2021; N'dri & Kakinaka, 2020). Financial inclusion can be an adaptive tool to reduce poverty in society and contribute to climate resilience (Renzhi & Baek, 2020). However, this raises the question of how financial inclusion correlates to environmental quality. More households and micro, small and medium enterprises (MSMEs) accessing financial services will result in higher consumption and higher emissions (Renzhi & Baek, 2020).

Environmental problems such as air pollution, forest exploitation, and global warming have been caused by the increase and accumulation of GHGs in the atmosphere (Agliardi et al., 2019; Khezri et al., 2021). In the industrial era 4.0, ICT has a major role in mobilizing all aspects of life that have an impact on climate change (Asongu et al., 2018; Atsu et al., 2021; Haini, 2021) and financial inclusion (Diniz et al., 2012; Le et al., 2020; Pradhan et al., 2021; Shahbaz et al., 2022). With increasing development and convergence between financial platforms and ICTs, emerging digital financial systems have opened up new opportunities to address environmental concerns (Asongu et al., 2017, 2018; Atsu et al., 2021; Nguyen et al., 2020).

Theoretically, the impact of financial inclusion on the environment can be negative or positive. On the one hand, increasing financial inclusion can increase access to individual financial products and increase the use of energy-consuming equipment, leading to higher carbon emissions (Le et al., 2020). On the other hand, a higher level of financial inclusion can increase innovation and technological advances in industrial production processes, which can increase energy efficiency and reduce energy demand and carbon emissions (Shahbaz et al., 2022; Usman et al., 2021; Zaidi et al., 2021) so that it will have an impact on environmental quality.

In general, research related to financial inclusion focuses on the national or inter-country level. As the basis for the differences in research objects and techniques. This is in line with research (Shahbaz et al., 2022) which states that there are differences in research objects and econometric techniques, so research has not reached a consensus on the effect of financial inclusion on environmental quality at the provincial level and whether they have a positive, negative, or neutral effect. In addition, there is still little literature that discusses the impact of financial inclusion on reducing greenhouse gas emissions as represented by the environmental quality index at the

provincial level. The development of financial inclusion in Indonesia is different from that of other countries, and there are large differences in financial inclusion, pollution and carbon emissions at the regional level. It will be more helpful for countries to formulate appropriate policies for different regions to achieve synergistic planning in pollutant and carbon emissions.

The impact of financial inclusion on environmental quality is asymmetric and varies geographically. While very few studies have analyzed regional differences and mediating impact mechanisms in the effect of financial inclusion on collaborative emission reductions at the provincial level. Therefore, the main objective of this research is to study the relationship between financial inclusion, ICT, and environmental quality in 34 provinces of Indonesia as a group of countries with the largest carbon emissions in the world.

2. LITERATURE REVIEW

The population explosion and the advancement of ICT will increase the need for limited resources, resulting in environmental degradation that has an impact on climate change that threatens human survival (Ahmadi, 2015; Dong & Liu, 2020; Luís et al., 2018; Rita et al., 2018). To protect the environment in the future, it is necessary to innovate and adopt ICT to increase financial inclusion in society (Caniëls & Romijn, 2008; Guo et al., 2020). This shows that technology adoption plays an important role in mitigating financial inclusion in CO₂ emissions (Liu & Dong, 2021).

2.1. *Financial Inclusion*

The 2008 global financial crisis marked the beginning of the term financial inclusion or financial inclusion. At the G20 meeting at the Pittsburgh Summit 2009 which was later confirmed at the 2010 Toronto Summit, by mentioning the 9 Principles for Innovative Financial Inclusion, namely leadership, diversity, innovation, protection, empowerment, cooperation, knowledge, proportionality, and framework. These nine principles are used as guidelines for developing financial inclusion.

The Global Partnership for Financial Inclusion (GPFI-CGAP) Forum in 2012 defined financial inclusion as: “a state in which all working age adults have effective access to credit, savings, payments, and insurance from formal service providers. Effective access involves convenient and responsible service delivery, at a cost affordable to the customer and sustainable for the provider, with the result that financially excluded customers use formal.” If the community is prosperous, the economy of a country can also improve.

The results of the study (Zaidi et al., 2021) show a positive relationship between financial inclusion, energy consumption, and carbon emissions. Corruption, infrastructure and economic growth are very sensitive to carbon emissions. The research provides important points for pollution control and the achievement of sustainable development targets. In addition, (Le et al., 2020) state that income, energy consumption, industrialization, urbanization, foreign investment and financial inclusion appear to have led to higher CO₂ emissions. Empirically their research implies no policy synergy between financial inclusion growth and CO₂ emission mitigation. Research conducted by (Renzhi & Baek, 2020), increased financial inclusion seems to lead to lower CO₂ emissions and financial inclusion as a CO₂ emission mitigation tool. Developing countries such as Indonesia are

struggling to improve people's living standards through increasing levels of financial inclusion. At the same time, developing countries are using limited resources to meet their Nationally Determined Contribution (NDC) as part of international efforts to combat climate change. However, research (Shahbaz et al., 2022) reveals that financial inclusion can achieve collaborative reductions in pollutant and carbon emissions. This further proves the negative impact of financial inclusion on pollutant emissions, which is universal in different geographic locations with different levels of pollution. Increasing financial inclusion on reducing pollutant and carbon emissions has an insignificant direct impact, but a significant indirect effect by increasing the renewable energy sector. Thus, financial inclusion should be integrated into climate change adaptation strategies at local, national and regional levels, particularly to address the side effects of higher CO₂ emissions associated with increased financial inclusion.

H1: It is suspected that financial inclusion improves environmental quality in Indonesia.

2.2. Environmental Quality

Indonesia is one of 17 countries with extraordinary biodiversity (Lestari, 2020), but Indonesia is one of the largest carbon-producing countries in the world (Usman et al., 2021). Thus, to inhibit the acceleration of carbon emissions, through mitigating greenhouse gas emissions (such as CO₂) is an urgent agenda for the achievement of the Sustainable Development Goals (SDGs) (Asongu et al., 2017, 2018).

In the relationship between the financial-environmental literature, the most controversial issue is to determine whether financial development accelerates environmental quality, is detrimental or has a neutral effect on environmental quality. The emergence of a paradigm of separate indicators between the financial sector, ICT policy and sustainable development. according to Ciocoiu (2011), the integration of these indicators creates opportunities for sustainable development and economic recovery in times of crisis.

Bappenas (2021) formulates five characteristics of a green economy as sustainable development such as increased green investment, job creation, increased share of the green sector, decreased energy use, reduced emissions or CO₂ and pollution levels per Gross Domestic Product (GDP), and decreased consumption. products that generate waste. The fifth characteristic of a green economy based on carbon emissions per GDP is in line with the Paris Agreement which aims to reduce GHG emissions globally.

Increasing the penetration of ICT in Sub-Saharan Africa (SSA) can contribute to environmental sustainability by reducing CO₂ emissions (Asongu et al., 2018), because through ICT it can be used on many devices, so the penetration of ICT in the economy makes sense. ICT has been considered as a potential solution to environmental problems. This is because if ICT incorporates an element of sustainability or what is called Green-ICT it is able to reduce energy consumption and CO₂ emissions by changing the involvement of physical resources into information resources that can be equally efficient in productivity (Sadorsky, 2012; Salahuddin & Alam, 2015; Salahuddin et al., 2018).

H2: It is suspected that ICT has an effect on environmental quality in Indonesia.

In line with research Shahbaz et al. (2022) conducted with research objects at the provincial level in China, it shows that financial inclusion does not directly affect carbon emissions, but if the effect of financial inclusion on CO₂ emissions is moderated by regional elements such as the use of technology. finance has different results, so this research formulates the following hypothesis:

H3: It is suspected that ICT reduces the effect of financial inclusion on environmental quality in Indonesia.

3. METHODOLOGY

This study examines the effect of financial inclusion on environmental quality by including the role of ICT in 34 provinces in Indonesia. From the available data, we use the data for the period 2010 to 2021. The carbon emissions data we use are obtained from the environmental quality index proxy sourced from the Ministry of Environment and Forestry (KLHK). The use of financial inclusion variables and ICT are the main independent variables in this study. This is to answer the main purpose of this research. The role of all sectors is needed, including the financial sector to achieve a low-carbon Indonesia.

We have selected data measuring the variables used from various comprehensive references. Referring to (Dong et al., 2022; Renzhi & Baek, 2020; Zaidi et al., 2021) which uses index calculations from indicators of financial services penetration, financial services availability, and financial services utility as the calculation of financial inclusion index. The use of these indicators is to fulfill the financial inclusion landscape. The construct of financial inclusion index in this study are determine in the table below.

Table 1: The formulation of Financial Inclusion Index

Indicator Dimensions	The data measurement
Financial services penetration	Number of banking financial institutions per 10,000 people
	Number of employees in banking financial institutions per 10,000 people
	Number of banking financial institutions per square kilometer
	Number of employees in banking financial institutions per square kilometer
	The balance of deposits in financial institutions per 10,000 people
	The balance of loans in financial institutions per 10,000 people
Financial services availability	The proportion of the balance of deposits in financial institutions to GDP
	The proportion of the balance of loans in financial institutions to GDP
Financial services utility	The ratio of deposits to loans

Consistent with (Asongu et al., 2018; Diniz et al., 2012; Lee & Brahmasurene, 2014; Salahuddin & Alam, 2015), ICT data is a standard for the level of ICT development in an area with 3 sub-calculations, namely the ICT access and infrastructure sub-index. ICT use sub-index, and ICT expertise sub-index obtained from Statistics Indonesia. This ICT development variable is to support the technology and information revolution to encourage Indonesia in the 4.0 Internet era

as an important role holder in terms of disseminating information and improving public services (such as digitizing banking and education services) (Bappenas, 2021).

Table 2: Summary Statistics and data sources

Variable	Denotations	Obs.	Mean	Std. dev.	Min	Max
Environmental Quality Index	eq	300	66.79953	10.5057	31.97	91.5
Financial Inclusion Index	fi	403	0.498362	0.148842	0.2	0.79
Information Communication and Technology Index	wict	198	4.977778	1.156245	2.41	8.03
Total Investment	inv	374	14.5513	1.875438	8.778264	17.82584
Electricity use	elec	304	7.657046	1.399826	5.197004	10.81058
Total population	pop	374	11.34298	1.937545	8.995909	16.47312
Size of Provinces in km square	size	405	10.40601	1.202827	6.498297	12.67306

Sources: Ministry of Environment and Forestry (KLHK), Financial Services Authority (OJK), and Statistics Indonesia (BPS).

Measurement of environmental quality index parameters is measured for each IKLH component and the weight of each with the formula:

$$eq_i = (30\% \times IKA) + (30\% \times IKU) + (40\% \times IKTL)^1$$

where IKA is water quality index, IKU as air quality index, and IKTL is land cover quality index. In order to find the relationship among variables with environmental quality as dependent variable, we develop a model

$$eq = f(fi, ict, inv, elec, pop, size)$$

Where the main independent variable is financial inclusion and ICT. The other variables are the control variables in this research model. Before continuing the empirical analysis, the numerical variables in the model are made in natural logarithms to get consistent results. So, the log linear equation is as follows:

$$eq_{i,t} = \beta_0 + \beta_1 FI_{it} + \beta_2 control_{it} + \varepsilon_{it} \tag{1}$$

$$eq_{i,t} = \beta_0 + \beta_0 + \beta_1 ITC_{it} + \beta_2 control_{it} + \varepsilon_{it} \tag{2}$$

$$eqL_{i,t} = \beta_0 + \beta_1 (FI)_{it} + \beta_2 (FI.ITC)_{it} + \beta_3 ITC_{it} + \beta_4 control_{it} + \varepsilon_{it} \tag{3}$$

We construct into 3 models to explain the goals of this study. Environmental quality (Eq) is the dependent variable in area I at time t. The financial inclusion variable (Fiit) is calculated based on

¹ with the assumption that $0 > eq < 100$, that means, environmental quality index will be better when it gets closer to 100.

the previously mentioned reference, while the control variable includes elements of territory in each region such as the amount of investment, total electricity uses in GwH, population, and area. Our selection of control variables refers to research (Khan & Ozturk, 2021; Le et al., 2020; Shahbaz et al., 2022; Vo et al., 2021; Zafar et al., 2022; Zaidi et al., 2021). In addition, the fixed effect for each province (i), controls for variables that are not observed within a province, and the time fixed effect (t) controls for global shocks. “_it” refers to the term research model error.

Heteroscedasticity test using modified Wald test, autocorrelation test using Wooldridge test, and cross-sectional dependency test (CD) were used to examine the data. The results showed that the data had heteroscedasticity problems. Therefore, we conducted a robustness test to treat this problem. In addition, we estimate the fixed effects and random effects model to determine the relationship between financial inclusion, ICT, and environmental quality.

4. RESULTS AND DISCUSSION

This study examines whether financial and ICT inclusion on carbon emissions. Apart from examining the effects of financial inclusion on emissions and ICT on emissions, another question is what if there is a moderation of ICT on financial inclusion and emissions? Will ICTs affect the impact of financial inclusion on carbon by leveraging the use of ICTs? From this question it is interesting to know the mechanism of the influence of ICT as a mediator between financial inclusion and ICT.

Table 3 shows the estimation results of financial inclusion and ICT on carbon emissions. The estimation results of 4 models show that in model 1 financial inclusion has no significant effect on carbon emissions. Model 2 shows that ICT has a significant effect on carbon emissions. Model 3 shows that in a condition of financial inclusion and ICT in one model, then ICT financial inclusion has no significant effect on emissions. Meanwhile, model 4 shows that if there is an interaction of ICT in financial inclusion, then financial inclusion can inhibit the rate of carbon emissions.

Table 3: Estimation Results

	Dependent variable: environmental quality index			
	FI (FEM) (1)	ICT (REM) (2)	IFI-ICT (FEM) (3)	IFI*ICT (4)
elec	5.251*** (3.01)	-3.465*** (-4.91)	7.831* (1.91)	8.857*** (2.77)
size	-3.521 (-1.40)	4.366*** (5.78)	238.3*** (4.60)	191.8*** (3.83)
inv	0.503* (1.82)	-0.406 (-0.52)	1.101 (1.54)	1.304* (1.81)
pop	-0.950 (-1.12)	-0.373 (-0.74)	1.328** (2.04)	0.771 (1.17)
fi	-6.947 (-0.81)		9.474 (1.13)	56.12*** (3.22)
ict		0.893 (1.28)	-2.172** (-2.24)	3.023 (1.40)

Table 3: continued

mod_fict				-10.56*** (-2.95)
cons	70.21** (2.18)	56.45*** (4.99)	-2494.7*** (-4.56)	-2038.1*** (-3.88)
N	267	132	132	132
N_g	34	34	34	34
r2	0.0978		0.0731	0.140

Notes: *t* statistics in parentheses. (*) means $p < 0.1$, (**) means $p < 0.05$, (***) means $p < 0.01$.

Based on the results of the analysis of model 1, it has been shown that the financial inclusion index variable has no significant effect on environmental quality. In theory, the development of a financial inclusion index could affect the quality of the environment in the opposite way. On the one hand, the financial inclusion index can lead to investment in technological innovation by expanding financing channels and reducing financing costs, which will result in more energy efficient and environmentally friendly production (Tamazian & Bhaskara Rao, 2010). On the other hand, financial inclusion drives economic growth, which in turn increases energy demand. The increase in energy demand then leads to a high increase in carbon emissions (Sadorsky, 2012). The higher the carbon emission, the worse the environmental quality.

However, in analyzing the relationship, a comprehensive and accurate measurement of the financial inclusion index is needed as an important prerequisite. Many researchers have measured the financial inclusion index which is usually measured by a composite index which is then divided into four categories, including penetration, availability, utility, and affordability of financial services. Of the four categories, there are nine indicators that are used to measure the financial inclusion index. However, these indicators are still classified as conventional indicators and have not included technology indicators. Each of these financial inclusion indicators also has a different unit and scale. Therefore, the financial inclusion index variable is an aspect that does not have a significant effect on environmental quality due to the lack of technological indicators that are included in the calculation of the financial inclusion index.

Based on model 2, the results of the Random Effect Model (REM) indicate that the ICT development variable has a significant effect on carbon emissions with a positive coefficient value. This means that the level of ICT development has a positive effect on carbon emissions. The effect of ICT development on carbon emissions varies, depending on the target country being analyzed. In some countries, ICT development leads to carbon reduction, while in other countries, ICT development actually increases carbon emissions. Based on the results of this study, the development of ICT can increase carbon emissions, so that the quality of the environment will decrease. This is because electricity consumption has increased due to the rapid growth of information and communication equipment and facilities, and the energy saving effect of ICTs was not that great during that period (Kim, 2021). In other words, the spread of Internet-related devices, such as cell phones, Internet servers, and personal computers, is accompanied by an increase in electricity usage. However, along with the deployment of such hardware, software development for efficient energy consumption is also accompanied. Therefore, the two effects have the effect of increasing energy consumption on the one hand, but also reducing energy consumption on the other.

Lee and Brahmastre (2014) in their research show that the development of ICT will lead to an increase in carbon emissions. This is because the development of higher ICT requires more energy consumption, and can result in an increase in CO₂ emissions. The results of this study are in accordance with research (Haseeb et al., 2019; Lee & Brahmastre, 2014; Park et al., 2018) which says that the development of ICT has an effect on increasing carbon emissions.

In models 3 and 4, it shows that financial inclusion and ICT are in one condition. It can be seen that the p-value (standard error) on the ICT moderating variable on financial inclusion on carbon emissions shows a significant number at alpha 5%, which indicates that the financial inclusion index has a significant effect on carbon emissions at the 95% confidence level. The value of the coefficient with a negative sign of 10.56 indicates that if the value of the ICT moderating coefficient on financial inclusion on environmental quality decreases by 10.56. This means that the financial inclusion index which was previously not interacted with ICT, if it increases by 1% the environmental quality index increases by 56.12% and when there is moderation between the financial inclusion index and ICT it will reduce the environmental index to 45.56%, so that during this moderation, emissions will take place. carbon has increased.

Thus, the influence of the role of ICT in the financial inclusion index on environmental quality has slowed down due to the absence of policy synergy between the growth of financial inclusion and mitigation of carbon emissions (Le et al., 2020). Thus, financial inclusion should be integrated into climate change adaptation strategies at local, national and regional levels, particularly to address the side effects of higher carbon emissions associated with increased financial inclusion. Efforts need to be made across countries in the region to align financial inclusion initiatives with environmental policies.

5. CONCLUSIONS

In the early stages of financial inclusion, the credit market will develop as the focus is on improving access to finance and providing basic financial services. At this stage, people will focus on improving their standard of living, and companies will try to expand their business with new credits, which results in greater consumption, which leads to higher CO₂ emissions. However, it is also an adaptation measure as vulnerable people can prepare for the impacts of climate change.

Reducing CO₂ emissions efficiently can overcome environmental quality in supporting the SDGs program in Indonesia, energy-saving methods using ICT must be implemented further. Energy savings should be implemented, and economic incentives should also be given to companies that have been saving energy efficiently through this technology. This is to support the use of environmentally friendly ICT. When the financial inclusion indicator scheme with ICT synergizes, the CO₂ mitigation effect can be maximized. Therefore, the application of ICT and financial inclusion should be implemented further.

Widespread convenience and use of financial services, public consumption of fossil fuels, thereby triggering CO₂ emissions. Thus, there is a positive relationship between financial inclusion and indicates a correlation between financial inclusion and carbon emission reductions in Indonesia.

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