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# Cross-Country Analysis of the Nexuses between Food, Energy, and Water Consumption on Urban-Rural Income Gap in South-Eastern Asian Countries Using Pooled Ordinary Least Squares Regression Analysis

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## Abstract

The urban-rural income gap is a major socio-economic issue affecting people's development and well-being worldwide. The urban-rural income gap accounts for a significant share of the economy-wide inequality in many Asian countries due to its large population. Food, energy, and water (FEW) are essential resources for socio-economic development. Generally, the income gap reflects the unequal distribution of resources, opportunities, and development outcomes in urban and rural areas. The current study examines the impact of FEW nexuses on urban and rural income gaps in Asian Countries. A convenient sample of panel data over 20 years from 2000 to 2019 from three Asian countries: China from Eastern Asia, Indonesia from South-Eastern Asia, and India from Southern Asia, was analyzed using pooled ordinary least squares regression analysis. The results showed a significant rural-urban disparity in poverty gaps, 1.23 times less in urban areas than rural areas, but not poverty rates. Among the FEW, the results indicated that electricity supply had a significant positive effect on poverty rates ($\beta = 0.543$, $p < 0.05$) and poverty gap ($\beta = 0.712$, $p < 0.05$). The rural-urban disparity is shaped by FEW resource endowments, physical spatial use, and economic activity disparity. Urban households have more opportunities to use electricity for productive purposes, such as industry, trade, and education, which generate higher incomes. Contrarily, rural households mainly use electricity for domestic and agricultural purposes, which is associated with lower incomes. Paradoxically, FEW supply has not achieved its tentative outcomes of reducing income inequality. The results suggest that enhancing the accessibility of energy consumption in rural areas is not a precursor for reducing the incidence of poverty but economic use. Thus, national poverty alleviation policies should focus on structural adjustment programs that help rural households optimize the energy supply by engaging in income generation activities.

**Keywords**

Energy, Food, Income Gap, Poverty Rate, South-Eastern Asia, Water

## 1. Introduction

Income inequality is a major socio-economic issue affecting people's development and well-being in different regions (Deutsch et al., 2020). Empirical evidence has established several macroeconomic factors that influence income inequality. Rapid economic growth has greatly helped reduce the income gap since it reflects a general increase in aggregate demand in the economy (Tsai, Hell, & Grusky, 2012). Drawing from empirical evidence from Asia, Deyshappriya (2017) established that increases in GDP tend to redistribute income from the top 20% to middle-income and poor groups. Moreover, enhanced access to education and employment, price, and political stability narrowed the income gap by enhancing a more sustainable equal income distribution. Essentially, rising education levels improve skills development, hence increasing labor force participation and reducing unemployment, which in turn reduces inequality. Omar & Inaba (2020) and Demir et al. (2022) established that financial inclusion, proxied by metrics such as the number of financial institutions such as banks and outlets, such as offices, branches, and ATMs, and adequate utilization of financial services such as savings, and borrowings, making payments, remittances, transfers significantly reduce poverty rates and income inequality. Assessing financial resources provides capital which can boost investment and raise the income levels of households. Yet, empirical evidence has overlooked how recent green energy can help narrow the income gap and poverty levels, especially in Asia. Particularly, the current paper delved into the rural-urban income inequality dynamics in Asia in relation to the interaction between access to FEW resources.

The urban-rural income gap is a crucial issue in Asia, as it reflects the unequal distribution of resources, opportunities, and development outcomes between urban and rural areas. The urban-rural income gap also affects the well-being of the urban poor population, who face higher living costs, inadequate housing, lack of basic services, and limited livelihood options (Mathur, 2013). According to some studies, the urban-rural income gap accounts for a significant share of the economy-wide inequality in many Asian countries and has increased over time. For instance, Kanbur & Zhuang (2013) established that the rural income gap contributes to about 50% of the increase in the national inequality level in India and about 33% in the PRC. Imai and Malaeb (2016) state that the rural-urban gap contributes to the rising inequality in Asia, with China and India explaining a larger proportion given their large populations. Despite China's high economic growth income, the authors further observed that the inequality within rural and urban areas has worsened. Comparatively, India's urban areas had high inequality, despite a sharp reduction in urban poverty. Therefore, addressing the drivers of the urban-rural income gap is essential for improving the well-being of households in Asian countries.

Previous studies have reached the consensus that an income gap between rural and urban areas is inevitable, but whether it can be eliminated remains controversial. Poor resource access in rural areas has historically contributed to widening income between urban and rural residents. According to Lewis' urban-rural duality theory and Todaro's migration model, the income gap between urban and rural areas also seems inevitable so long as a division exists between industry and agriculture exists (Chen et al., 2022; Gollin, 2014; Lewis, 1976; Todaro, 1969). The urban bias theory attributes the urban-rural income gap in developing countries to a systematic bias against agriculture and rural economies (Bezemer & Headey, 2008; Lipton, 2023; Yang, 1999). Industries are agglomerated in urban areas, while the rural sector remains primarily agriculturally based, associated with lower earnings and seasonality in production. Mukhlis et al. (2021) established a significant negative relationship between the agricultural sector's contribution to GDP and poverty rates in ASEAN countries.

Substantial interdependence and causality exist between goods and services providers, and rising urban population demand further spurs the rural-income gap. High demand due to spatial proximity to individual residents, employees, inventors, entrepreneurs, or creative people in urban areas (Krehl et al., 2016), accessible water supply (Leigh & Lee, 2019), and energy (Fouquet, 2016; Wang & Chen, 2016) have concentrated the transport, service and industrial sector in urban areas. The high concentration of industries in urban areas accelerates rural-urban migration. The growing population and rapid urbanization increase the demand for food, energy, and water (FEW). Existing industries profit from the rising urban population demand, further supporting employment opportunities and growth in urban areas. The demand and supply synergies have driven an increase in accessibility of FEW resources in urban areas than in rural areas.

Despite cities being centers of wealth and power, innovation and decadence, and dreams, rapid urbanization has led to myriads of problems, including unemployment rates and homelessness in major urban cities worldwide. Over the past several decades, many countries have experienced rapid urbanization, and a large proportion of the world's population now resides in cities attracted by a concentration of industries, higher-paying white-collar jobs, and innovation centers (Ondiviela, 2021). Besides, modern cities are innovation hubs characterized by a high concentration of tech companies, startups, and other innovative businesses. For instance, Singapore ranked first as a leading technology innovation hub, whereas Beijing, Shanghai, and Hong Kong ranked 4th, 6th, and 9th, respectively, in a survey by Klynveld Peat Marwick Goerdeler (KPMG, 2021). Cities across Asia have been innovation centers in diverse industries, such as E-commerce and fintech in Singapore, Artificial intelligence and biotechnology in Beijing, Semiconductor and consumer electronics in Shanghai, Software and gaming in Seoul, Manufacturing and logistics in Shenzhen, and Media and entertainment in Hong Kong (Chen, Hasan, & Jiang, 2022; KPMG, 2021). These hubs attract numerous tech companies and diverse talent pools, providing a strong ecosystem that supports further innovation and technological expansion, research and development growth, and talent acquisition and fosters collaboration, knowledge sharing, and innovation as a result of agglomeration. In turn, cities have enabled the young, innovative generation to realize their career dreams. Yet, with much of the world's population now residing in cities, it has dramatically led to the eruption of urban problems worldwide, including homelessness and unemployment rates among the less educated, which widens the income gap (Glynn & Fox, 2019; Kang, & Seo, 2020; Rukmana, 2020; Onyeneke & Karam, 2022; Vilar-Compte et al., 2021; Wang et al., 2021).

Contrarily, the rural setting has lower economic efficiency than urban areas. Agriculture is the main economic activity in the rural sector due to the vast land compared to urban areas. Yet, the economic efficiency of land is still down since the value added by agriculture is low. The agricultural supply of raw food products from rural areas, such as cereals and fruits, is much cheaper than processed products like butter and drinks. Such technical inefficiencies continue to widen the urban-rural income gap. Neoclassical convergence theories hold that the urban-rural income gap is only a temporary product, and the factor mobility and diffusion will gradually eliminate regional inequality (Kuznets, 2019; Liao & Wei, 2015). Historically, primitive communication, poor transport networks, and limited mobility made access to urban services from rural locations. By the mid-20th century, improvements in transportation and Information communication technology (ICT) had changed this norm with evident improvement in income and living standards due to increased access to agricultural inputs and markets (Kaiser & Barstow, 2022; Priya Uteng & Turner, 2019). In this study, increased access to FEW resources and their intersections and synergies is instrumental in lowering the rural-income gap.

The FEW nexuses are essential in improving well-being and sustainable development, and demand for all three is increasing, driven by rising global population growth, rapid urbanization, changing diets, climate change, and economic growth. Historically, accelerating green energies driven by net-zero greenhouse gas emissions is electricity, with recent growth in solar and wind energy. In 2020, 246 W per capita of renewable capacity was installed in developing countries, registering an annual growth rate of 11.6%. In Eastern and South-eastern Asia, capacity increased from 134 W per capita in 2010 to 460 W per capita in 2020 by 243.3%, far much higher than in Latin America and the Caribbean (49%), Oceania (25%) and sub-Saharan Africa (56%) (UN, 2022c).

Despite the positive growth in electricity access, hundreds of millions still lack access to electricity, with evident regional differences. The global electrification rate (proxied by the percentage of the population with access to electricity) grew significantly from 83% in 2010 to 91% in 2020 (UN, 2022a; UN, 2022b). Yet, a significant population remained unelectrified, an estimated 733 million in 2020. In 2020, Europe and Northern America top with 100% access, followed by Latin America and the Caribbean (99%), Eastern and South-Eastern Asia (98%), Central and Southern Asia (96%), and Western Asia and Northern Africa (94%), with sub-Saharan Africa lagging with 48% (UN, 2022a). As of 2020, the Least Developed Countries (LDCs) lagged at a 55% electrification rate, leaving 479 million people without access to electricity, surprisingly equivalent to more than half of the world population. Besides, rural discrimination in electrification trends persists. Global rural electrification in 2020 was at 44%, far much lower than in urban settings (78%), with 48% of the rural population having access to clean fuels and technologies compared to 86% urban population (UN, 2022a). Could such low access to electricity among the LDCs explain their economic backwardness?

Solar power is predominantly used for household consumption in lighting and water heating, irrigation, and colling in agricultural greenhouses (Hassanien, Li, & Lin, 2016; Rahman et al., 2022). Apart from direct usage in income-generating activities, the sector creates employment for individuals. The UN's Alliance for Rural Electrification (ARE) seeks to enable the private sector to expand at least 5 million green jobs ranging from direct green jobs in manufacturing, assembly, distribution and sales, operations, and maintenance, as well as derived jobs in related sectors that are dependent on electricity, for example, agricultural industries and fisheries by 2030 (UN, 2022d). As such, it contributes to reducing poverty and lowering rural-urban income since most of the rural residents, especially in LDCs, are predominantly agricultural. Collectively, the current research insights on the spillovers of such environmentally oriented energy supply drive on narrowing rural-urban and poverty gap and rates.

World water consumption is also rising, with urban areas being the primary consumers of water supply resources. Demand for water keeps rising over time with a myriad of confounders, including rapid population growth, urbanization, and consequential increasing pressure from agricultural production to sustain food demands, industrialization, and the energy sector growth, primarily hydroelectric power generation (UN, 2022b). For instance, Agriculture is the largest consumer of the world's freshwater resources, and more than one-quarter of the energy used globally is expended on food production and supply (FAO, n.d.). Besides, energy generation is highly water intensive, while coal-fired power plants and nuclear reactors consume large amounts of water for cooling (UN-Water, n.d.). The high multisectoral water dependency implies that it was essential in fostering sustainable development goals, including reducing hunger and poverty. Agricultural food production and processing rely heavily on water. There is evident rural discrimination in water supplies. Households, mainly rural areas in LDCs, lack water service supplies. Across the world, urban areas significantly rely on piped water.

On the contrary, rural areas and vulnerable groups such as refugee camps spent much time collecting water from natural waterways such as rivers to distant scarce watersheds (Akhter et al., 2020; Gurung et al., 2019; Pulido et al., 2019). The economic significance of time is a resource. Lower access to water limits irrigation activities, lowering food production and income. The continued anticipated water shortage could further cripple vulnerable groups in rural areas and refugee camps. Water access's consequential significance in reducing rural-urban incomes and the poverty gap is essential.

Despite the FEW enablers of poverty reduction (SDG6), poverty strikes millions globally. The World Bank estimated that about 659 million people lived below the $2.15 per day poverty line in 2019 (World Bank, 2023). However, Asian countries have significantly reduced poverty over the past decade. Regionally, South Asia (2010: 432.3 million Vs. 2019: 160.94 million) had the highest proportion of the 10-year decline in people in poverty between 2010 and 2019, followed by East Asia and Pacific (2010: 262.44 million Vs. 2019: 24.63 million), Latin America and the Caribbean (2010: 37.55 million Vs. 2019: 27.7 million, Europe & Central Asia (2010: 19.53 million Vs. 2019: 11.18). Middle East and North Africa (2010: 6.55 million Vs. 2019: 36.89 million) and sub-Saharan Africa (2010: 371.24 million Vs. 2019: 391.32 million) registered growth in poverty levels. Generally, there is a downward in peopled in poverty attributed to SDGs comminates across the world.

The empirical literature has overlooked urban-rural disparity in the interlinkage between Food, Energy, and Water (FEW) resources in enhancing sustainable development through poverty reduction. None of the studies have focused on how the distribution of such natural resources shapes rural-urban income disparity, especially in South East Asian countries. Existing studies only focus on the FEW nexuses in urban areas (Feng et al., 2019). Panel studies also suggest contradictory findings regarding income inequality and food supply. In the study of 36 Organization for Economic Cooperation and Development (OECD) countries between the years 2000 and 2018, Hossain, Long, and Stretesky (2020) established that income inequality is not related to food access but is associated with greater levels of food supplies (surpluses). The finding suggests that low-income countries (with high poverty index and food insecurity) tend to have large food surpluses. Further, the authors established a negative relationship between food surpluses and availability. They concluded that having greater food supplies is not essential in addressing food insecurity since it does not look into food distribution within a country's population. The current study unravels the inconsistencies in empirical panel literature by addressing the possible omitted variable bias (rural-urban setting). In addition, empirical economic analysis of the impact of FEW nexuses on urban and rural Income gaps in Asian Countries has not yet been carried out a motivation for the current study.

## 2. Literature Review

### 2.1. Malthusian Theory of Population

Population control is the most critical concern among economists and environmentalists due to the impact of the strain on existing resources. Most countries in Africa and Asia, such as India, have higher population levels, contributing to higher poverty levels. Family planning adoption is being popularized globally under the pretext of sustainable use of existing natural resources and climate change (SyamRoy & SyamRoy, 2017). Malthusian theory of population has been a central theoretical stimulus for population control policies. Malthus (1798) hypothesized that the world population is growing geometrically while the food supply is increasing arithmetically. Unless the population is checked, the population might double in size every quarter of a century. According to Malthus (1803), population controls could be wars, famines, disease, postponement of marriage, increased cost of food, and factors decreasing fertility such as moral restraint, contraception, and abortion. The theory has been proved in recent empirical studies, such as in Nigeria (Oladimeji, 2017; Sakanko & David, 2018) and East Asia (Zhou, 2023).

Essentially, high population outstrips agriculture capacity to support the food production population and would rise until a limit to growth is reached. Mukhlis et al. (2021) established that population positively and significantly impacted poverty rates in ASEAN countries. According to the authors, a rising population implies increased demand for food, which, if unmeet, could cause inflationary pressures that further reduce aggregate demand for goods and services. Besides, a high population leads to inadequate employment opportunities in the economy. Thus, unemployment and lack of access to basic necessities increase poverty. Yet, to other dynasties, such a huge population is essential in spearheading a country's population growth due to the source of cheap labour. For instance, Munir and Shahid (2021) established that fertility rates and life expectancy positively relate to economic growth in South Asia. Azam, Khan, and Khan (2020) also established that population growth has a significant and positive impact on economic growth in India in the short and long run. Thus, when analyzing FEW nexuses on income gap, it is important to account for population size.

## 2.2. Empirical Literature

### 2.2.1. Food Insecurity and Poverty

Wide empirical evidence indicates that food insecurity is common among low-income households. In a cross-sectional survey of American adults using Amazon's Mechanical Turk platform amidst the Covid-19 pandemic in 2020, Lauren et al. (2021) established that being Black, Asian, and Hispanic/Latino, with an annual income less than $10,000, and extended families were significantly more likely to be newly at risk for food insecurity. The authors recommended that. Interventions to increase access to healthful foods, especially among minority and low-income individuals, and ease the socio-economic effects of the outbreak are crucial to relieve the economic stress of this pandemic.

Mukhlis et al. (2021) examined the linkages of food security, economic growth, the agriculture sector, and the population living below the poverty line in six ASEAN countries, including Indonesia, Malaysia, Philippines, Thailand, Cambodia, and Myanmar, using annual from 2012 to 2017. The authors established that the food security rate significantly negatively impacted poverty rates. In a case study of Vietnam, Mahadevan and Hoang (2016) established a significant relationship between poverty and composite food security index in urban areas but insignificant in rural areas. However, there was a strong relationship between poverty and food sufficiency in rural and urban areas in Vietnam.

The reviewed empirical literature demonstrates that food insecurity leads to poverty. Key mechanisms are employment, cost of living, and aggregate demand. Food scarcity can create inflationary pressure; hence households would divert most of their income to food while allocation to other needs such as clothing and transport reduces. Food supplies also create direct employment, raising the incomes, especially a majority of the households in the rural sector, through sales of their farm produce. Thus, amidst food insecurity, food scarcity implies low incomes, hence a reduction in aggregate demand for basic needs, further creating a ripple effect of low incomes in other goods and service sectors. According to Pourreza, Geravandi, and Pakdaman (2018), food insecurity negatively affects human capital and government expenditures such as social grants, leading to stagnated economic growth since it is a disinvestment. As a result, food insecurity can widen poverty gaps in the long run due to economic recessions by reducing purchasing power. Thus, this study hypothesized that:

$H1$: *Food security reduces poverty.*

#### 2.2.2. Energy and Poverty

Access to clean and affordable energy is the United Nations' seventh sustainable development goal (SDG 7). Existing literature indicates that energy deprivations are associated with lower education and low financial development and are widespread in rural areas. Khan & Ghardallou (2023) established a long-term relationship between financial development, higher incomes, and education levels are positively related to energy poverty reduction in developing economies. The panel study of Malerba (2020) established a trade-off between poverty reduction and carbon emissions reduction. It argued that policies to slow global warming could be better designed to reduce inequality. The author postulates that reducing inequality decreases the carbon intensity of poverty reduction since traditional fossil fuel consumption for income generation in low-income countries increases carbon emissions into the atmosphere. Thus, green energy is an environmentally conscious pathway for educating income inequality.

Wu et al. (2021) examined the impact of energy poverty, proxied by the lack of access to clean fuels and electricity for cooking and lighting, on rural labor wages in China using panel data from 2006 to 2016. The authors found that energy poverty significantly reduces rural labor wages by limiting the access of rural workers to education and adversely affecting their health status, resulting in decreased labor productivity. They suggest improving energy access can promote rural development and reduce income inequality through human capital accumulation.

Similar findings have also been established in non-Asian countries. In Italy, Bardazzi, Bortolotti, and Pazienza (2021) established that income inequality significantly correlates with energy poverty indicators. Due to regional disparity in Italian regions, the authors suggested that strategies addressing energy poverty should be spatially implemented. The studies highlight the importance of income in access to clean energy, especially electricity, and interlink ages of financial development. In this study, it is assumed that most rural households have low education levels confounded and a precursor of low incomes, with low access to electricity. Consequently, this leads to their low financial prosperity. Therefore, this study hypothesized that:

*H2*: *Energy supply reduces poverty.*

#### 2.2.3. Water and Poverty

Water supply is crucial for poverty reduction, improvement of livelihoods, and economic development. According to the World Health Organization (WHO, n.d.), providing safe water is one of the most effective instruments in improving health and reducing poverty. Safe water can prevent the transmission of waterborne diseases, such as diarrhea, cholera, typhoid, and dysentery, which cause millions of deaths and illnesses yearly, especially among children and the elderly. Safe water can also improve hygiene and sanitation, which is essential for preventing infections and promoting well-being. By reducing the disease burden, safe water can enhance the productivity and income of people experiencing poverty, who often depend on agriculture, informal labor, or self-employment for their livelihoods. Safe water can also save time and energy for women and girls, who are usually responsible for fetching water from distant and often contaminated sources. This can free up their time for education, employment, or other productive activities.

Several studies demonstrate that water supply interventions can positively impact poverty reduction. For example, a study by International Water Management Institute (IWMI, 2021) in Niger showed that irrigation resulted in higher cash income, lower food insecurity, and better nutrition for rural households, even during a drought. According to IWMI (2021), removing barriers to groundwater-based irrigation in semi-Arid areas could increase crop yields and incomes for smallholder farmers. Conjointly, irrigation schemes increase agricultural production and hence food security.

Besides, the water supply help alleviates poverty since it supports fish farming which is a source of income and food supply in urban and rural areas (Namara et al., 2010; Wuyep & Rampedi, 2018). The fisheries and aquaculture sector has significantly expanded over the past decades. In 2018, global aquaculture production and total food fish consumption rose by 527% and 122%, respectively, relative to 1990. The total production is mainly from capture fisheries marine waters (84 million tonnes [MT]), followed by aquaculture inland waters (51 MT), aquaculture marine waters (31 MT), and capture fisheries inland waters (12 MT) (FAO, 2020). Thus, water supply is instrumental in boosting fish farming. Population size is the major factor that influences regional distribution. For instance, 2018's top capture producers are composed of the most populated countries in the world: China, Indonesia, Peru, India, Russia, the United States of America, and Viet Nam.

Globally, the fisheries and aquaculture sector are a major source of employment. In 2018, an estimated 59.5 million people were engaged in the primary sector of fisheries and aquaculture, with Asia (84.7%) leading followed by Africa (9.1%), Americas (4.8%), Oceania (0.8%), and Europe (0.7%) (FAO, 2020). Fish farmers in Asia prepare for local and international markets since fish is a source of food and protein for many people around the world. According to the FAO, fish accounted for about 17 percent of total animal protein and 7 percent of all proteins consumed globally in 2017. Asia (23.3%) accounted for the highest percentage of fish products in animal protein consumption, followed by Africa (19.9%), Oceania (11.8%), Europe (11.1%), North America (7.6%), and South America (6.5%) (FAO, 2019). This reflects these regions' dietary patterns, availability, preferences, and traditions. Fish is especially important for food security and nutrition in many low- and middle-income countries, where it may be the only source of animal protein for some people. Therefore, water supply is a crucial factor for poverty reduction since it enhances food production and supports the growth of the food industry since it is a useful ingredient in food processing. Therefore, this study hypothesized that:

*H3*: *Water supply reduces poverty*.

# 3. Methodology

## 3.1. Variable Description and Data Source

The study relied on secondary data collected from the official World Bank's (WB) World Development Index Database (WDI), the Food and Agriculture Organisation (FAO), and Our World in Data (OWID) databases. The study targeted a population of the country in Asian countries regions. However, due to data constraints on the rural and urban setting measures, the study used a convenient sample of panel data over 20 years from 2000 to 2019 from three Asian countries: China from Eastern Asia, India from Southern Asia, and Indonesia from South-Eastern Asia.

### 3.1.1. Dependent Variables

The dependent variables are the poverty rates and the gap.

The *income gap* is often proxied by inequality measures such as poverty and income inequality, two interrelated aspects of income distribution in a society. Income inequality refers to how income is unevenly distributed among individuals or groups. It is commonly used to measure income inequality. However, reported Gini indices disseminated by the WB and FAO are at national levels. Thus, the analysis used poverty rates and income gaps as proxy income gaps.

*Poverty rates* refer to the percentage of the population that lives below the poverty line. The poverty line is usually defined as a proportion of the median household income of the total population. However, the poverty rate does not capture the intensity or depth of poverty, that is, how far the poor are from the poverty line. To address this limitation, the poverty gap, a ratio by which the mean income of the poor falls below the poverty line, shows how much income would be needed to lift all the poor out of poverty. The lower the poverty gap, the less severe the poverty situation (OECD, n.d.; OECD, 2021).

#### 3.1.2. Independent Variables

The predictors are the FEW resource metrics outlined as follows:

*Food insecurity:* The 1996 World Food Summit came to a consensus that food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. It has four crucial dimensions, namely: food availability, food access, utilization, and stability (Simon, 2012). Due to data access constraints, this study operationalized food insecurity using two metrics. First, the prevalence of undernourishment (% of the population) indicates the proportion of people who do not have enough food to meet their minimum dietary energy requirements over one year. It monitors progress towards SDG Target 2.1: ending hunger and ensuring access to safe, nutritious, and sufficient food for all households (UN, 2021). Second, the Food Insecurity Experience Scale (FIES) is a tool that measures the severity of food insecurity at the household or individual level based on people's own experiences and perceptions of not having enough food. It is also an indicator used to monitor progress toward SDG Target 2.1, specifically the prevalence of moderate or severe food insecurity (FAO, 2018).

*Access to electricity*: Access to electricity is a widely used and important metric to understand what share of the population has access to modern, clean energy seeking to decarbonize power systems rapidly. This study is operationalized dissertation using the World Bank's definition. According to the World Bank, access to electricity is the percentage of the population with access to electricity. In this study, data from rural and urban populations who have success with electricity was extracted from World Bank (n.d.-b).

*Access to clean fuels and technologies for cooking*: Access to clean fuels and technologies for cooking is a measure of how many people in a population have access to cooking methods that are not harmful to their health or the environment. According to the World Health Organization (WHO, 2020), clean fuels and technologies are those that attain the fine particulate matter (PM 2.5) and carbon monoxide (CO) levels recommended in the WHO global air quality guidelines. Clean fuels and technologies include solar, electric, biogas, natural gas, liquefied petroleum gas (LPG), and alcohol fuels, including ethanol.

Enhancement of clean fuel technologies mitigates concerns of global warming, diseases, and deaths arising from using air-polluting fuels and technologies, such as wood, coal, charcoal, dung, crop waste, and kerosene. The data helps assess whether the progress towards achieving universal access to clean cooking by 2030, one of the Sustainable Development Goal 7 targets on affordable and clean energy (WHO, 2020), is welfare-oriented. In this study, the proportion of the urban and rural population with access to clean fuels and technologies for cooking was extracted from World Bank (n.d.-b).

*Improved water access:* People using at least a basic improved drinking water source includes piped water on premises (piped household water connection located inside the user's dwelling, plot, or yard) and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection). The data for this series was extracted from OWID.

*Urban:* Binary urban identifier coded 1 if urban otherwise, 0.

#### 3.1.3. Control Variable

*Population* growth is controlled since high population outstrips agriculture's capacity to support the food production population according to Malthusian theory of population (Malthus, 1798) hence could be a potential delimiter of the influence of FEW on poverty and income gaps. The study variables' operationalization and data source are summarized in Table 1.

### 3.2. Pooled Ordinary Least Square (OLS) Regression Analysis

Pooled ordinary least square (OLS) regression analysis was used to test the study objective. Let $Y_i$ be the welfare measure $i$, the study seeks to fit two OLS linear regression models in the form represented in Equation (1).

$$Y_{isct} = \alpha + \sum_{i=1}^{1} \beta_i \Delta X_{icst} + \sum_{i=k=1}^{4} \tau_i \Delta X_{icst} \Delta X_{kcst} + \varphi_i postcrisis + \omega_i urbn + \phi_c country + \pi_i \Delta \ln pop_{isct} + \varepsilon_i \quad (1)$$

where $Y_i$ are predict poverty rates and gap, $X_{i,k}$ is a vector of FEW resources' measures; $\Delta$ is the differential operator whose order is dependent on the stationarity of the data; $\alpha$ is the interaction effect between treatment and time, $\beta_s$ are the regression coefficients of each of the four FEW metrics; namely, the prevalence of severe food insecurity, access to electricity, clean fuels and technologies for cooking, and water;$\tau$ denotes the interaction effect of the FEW resources that help identify the nexus between FEW in influencing in urban and rural income gap; $\varphi$ is the crisis effect ( $postcrs$ ) which is a crisis dummy variable, labeled *post-crisis,* will be created that takes the value "0" for each $i^{th}$ observation for the years between 2000 and 2009 and takes the value "1" for each observation $i^{th}$ from the year 2010 to 2020, $\omega$ is the urban ( $urbn$ ) premium/loss; is $urbn$ is the urban dummy variable which takes the value "1" for each $i^{th}$ observation in a rural setting and takes the value "0" for the urban setting; $\theta$ is the interaction effect crisis and urban setting ( $crs * urbn$ ); $\Delta lnpop$ is natural of population size, $\pi_i$ is the population effect; and $\phi$ captures the country effect premium/loss; $i$ is the observation index, $s$ is the observation index, $c$ is the country index, and $t$ is the time index; and $\varepsilon_i$ is the error term capturing the variation in outcome measures not accounted for by the model.

## 3.3. Diagnostic Tests

### 3.3.1. Stationary Test

Several tests for unit roots in panel data have been postulated, such as the Levin-Lin-Chu test, the Im-Pesaran-Shin test, and the Fisher-type tests (Maddala & Wu, 1999; StataCorp, 2019). To test for stationarity in panel data using Fisher's type ADF test entails the following steps. An augmented Dickey-Fuller (ADF) regression accounting for possible serial correlation in the error term is fitted for each time series, as represented in Equation (2).

$$\Delta x_{it} = \alpha_i + \beta_i t + \gamma_i x_{it-1} + \sum_{j=2}^{p} \delta_{ij} \Delta x_{it-j} + \epsilon_{it} \tag{2}$$

where $x_{it}$ is the variable $i$ at time $t$, $\Delta$ is the first-difference operator, $\alpha_i$ is a constant term, $\beta_i$ is a coefficient for a linear time trend, $\gamma_i$ is the coefficient for the lagged level of the variable, $p$ is the number of lags to be included, $\delta_{ij}$ are the coefficients for the lagged differences of the variable, and $\epsilon_{it}$ is the error term. The null hypothesis of the ADF test is that. $\gamma_i = 0$, which implies that $x_{it}$ has a unit root or is non-stationary. The alternative hypothesis is that $\gamma_i < 0$ implies that $x_{it}$ is stationary. Unlike the standard $p$-values for each ADF test, Fisher's method combines independent tests of the same null hypothesis by transforming the $p$-values into chi-squared statistics and summing them up (StataCorp, 2019). The Equation (3) represents the Fisher's $F$ statistic.

$$F = -2\sum_{i=1}^{N} \ln\left(p_i\right) \tag{3}$$

where $F$ is the Fisher statistic, $N$ is the number of time series in your panel data; ln is the natural log operator, and $p_i$ is the p-value from the ADF test for unit $i$. The null hypothesis of Fisher's method is that all panels contain a unit root. The alternative hypothesis is that at least one panel is stationary. The distribution of the Fisher statistic is chi-squared with 2N degrees of freedom. If Fisher's p-value is less than 0.05, the null hypothesis is rejected, indicating evidence of stationarity in at least one panel. A $p$-value greater than or equal to 0.05 indicates no evidence of stationarity in any panel.

### 3.3.2. Multicollinearity

Multicollinearity occurs when there is a high correlation among the predictor variables. Multicollinearity can adversely affect the regression results, such as inconsistent coefficient estimates, and reduced precision of the coefficient estimates, hence the unreliability of the findings. The variance inflation factor (VIF) was used to detect multicollinearity. A VIF of 1 means no correlation between a given predictor variable and any other predictor variables in the model. A VIF between 1 and 5 indicates moderate correlation, while a VIF exceeding 10 indicates severe multicollinearity.

### 3.3.3. Heteroskedasticity

The Breusch-Pagan/Cook-Weisberg test was used to detect heteroskedasticity.

Table 1. Variables, units, and sources.

| Abbreviation | Name | Description | Units | Source |
|---|---|---|---|---|
| *pv_rate* | Poverty rate | Poverty headcount ratio (% of the population living below $2.15) | % | World Bank (n.d.-a) |
| *pv_gap* | poverty gap | The ratio by which the mean income of the poor falls below the poverty line ($2.15) | % | World Bank (n.d.-a) |
| *foodins* | prevalence of severe food insecurity food insecurity | China and India: Food Insecurity Experience Scale (FIES). This indicator measures the proportion of people uncertain of having or unable to acquire enough food because they have insufficient money or other resources.<br>Indonesia; Prevalence of undernourishment (% of population) | % | FAO (2019) |
| *elcacc* | Access to electricity | % of the cohort (urban/rural) population who have success with electricity | % | World Bank (n.d.-b) |
| *cleanf* | Access to clean fuels and technologies for cooking | % of the cohort population who have access to clean fuels and technologies for cooking | % | World Bank (n.d.-b) |
| *impwacc* | Improved water access | People using at least a basic improved drinking water source includes piped water on premises (piped household water connection located inside the user's dwelling, plot, or yard) and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection). | % | OWID: Our World in Data (n.d.-c) |
| *urban* | Urban | Binary urban identifier coded 1 if urban otherwise, 0 | NA | Author |
| *pop* | Population growth | Annual population growth of the cohort | % | World Bank (n.d.-b) |

Note. The data for *foodins* by urban and rural areas were incomplete were imputed using MA (3) and empirical studies depicting the rural-urban gap on food insecurity.

Heteroskedasticity means that the variance of the error term is not constant across the values of the independent variables. This can violate the assumption of homoskedasticity, which is required for the OLS estimator to be efficient and unbiased. The Breusch-Pagan/Cook-Weisberg test is based on the following steps:

1) Fitting an OLS regression model to the data and obtaining the residuals, denoted by $\hat{\epsilon}_i$.

2) Calculate the squared residuals, denoted by $\hat{\epsilon}_i^2$, and divide them by the estimated variance of the error term, denoted by $\hat{\sigma}^2$.

3) The scaled squared residuals are then regressed on the independent variables using the OLS regression model. The equation for this auxiliary regression is represented in Equation (4):

$$\frac{\hat{\epsilon}_i^2}{\hat{\sigma}^2} = \gamma_0 + \gamma_1 x_{i1} + \gamma_2 x_{i2} + \cdots + \gamma_2 x_{ik} + u_i \tag{4}$$

4) The ultimate Lagrange multiplier (LM) test statistic is computed using Eq-

uation (5).

$$LM = n \times R^2 \quad (5)$$

where n is the sample size and $R^2$ is the coefficient of determination of the auxiliary regression. The test statistic follows a Chi-square distribution with k degrees of freedom, where k is the number of independent variables. The null hypothesis is that there is no heteroskedasticity, and the alternative hypothesis is that there is heteroskedasticity. If the p-value of the test statistic is less than a significance level, preset at 0.05, the null hypothesis is rejected, indicating evidence of heteroskedasticity. BP test was preferred since it detects linear forms of heteroskedasticity and assumes that the error term follows a normal distribution, another OLS regression assumption unlike alternative tests, such as White's test or Koenker's test

#### 3.3.4. Normality Test

A normality test evaluates whether a time series model's residuals follow a normal distribution. If the residuals are not normally distributed, it may indicate that the model is mis specified or that the data has outliers or nonlinearities. In this study, a graphical method used a histogram of model residuals to inspect their shape and symmetry visually. The model residuals should be symmetrical around zero to satisfy the linearity assumption. All the data analysis will be conducted using Stata Version 17.0.

## 4. Empirical Findings

### 4.1. Poverty Gaps/Rates Trends

The analysis is based on panel data from three ASEAN countries: China, India, and Indonesia, over 20 years between 2000 and 2021. In all three countries, there is declining poverty gaps and rates in both rural and urban (**Figure 1** and **Figure 2**). The declining rates can be associated with diverse and accessible food, water, and energy sources in urban areas, creating immense job opportunities than in rural areas. However, the notable low poverty gap in urban areas can be attributed to evident FEW resource margins between rural and urban areas. There is adequate power supply in urban areas, unlike rural areas, which do not have access to hydroelectric power in most developing countries. The energy sector substantially multiplies job creation in energy-dependent sectors such as transport, trade, hospitality, and telecommunication. Thus, rising income from direct and indirect water and energy distribution employment in urban areas widens income gaps.

Declining food insecurity can also be linked with declining poverty. According to the Global Hunger Index (GHI), India's GHI score decreased from 38.8 in 2000 to 29.1 in 2022, indicating a significant improvement in food security. Among the three countries investigated, China had the least level of food insecurity than India and Indonesia. The prevalence of severe food insecurity in China was 2.5% in 2019, implying that 2.5% of the population experienced

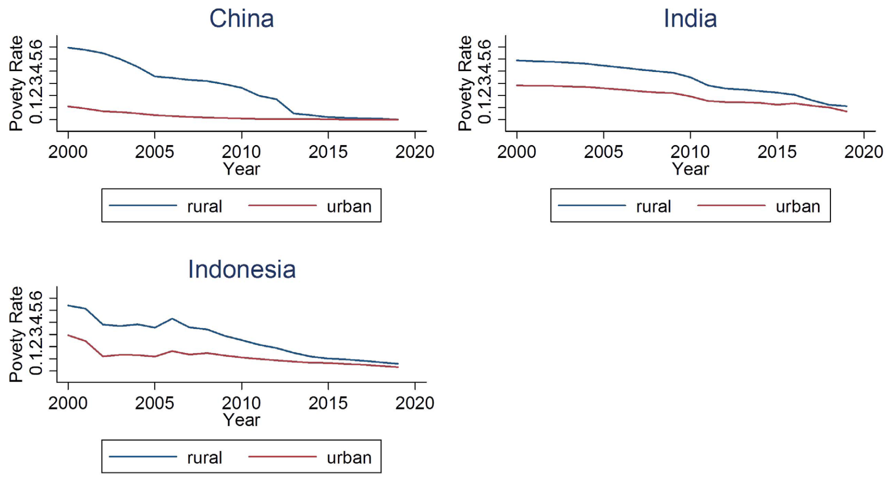


**Figure 1.** Poverty rates trend in rural and urban areas in China, India, and Indonesia between 2000 and 2021.

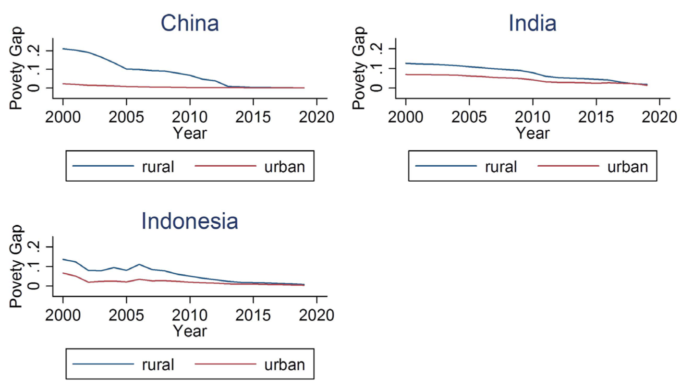


**Figure 2.** Poverty rates trend in rural and urban areas in China, India, and Indonesia between 2000 and 2021.

hunger and went without food for a whole day or more (World Bank, n.d.-c). Comparatively, the prevalence of food insecurity in India and Indonesia was 9.7% and 8.3% in 2019 (World Bank, n.d.-c). The poverty gaps/rates reflect this disparity, as **Figure 1** and **Figure 2** indicate. China had the least poverty gaps/rates than India and Indonesia. Thus, examining the statistical significance of these nexus between FEW resources as enablers of poverty reduction through direct and indirect employment is essential.

## 4.2. Diagnostics Test

### 4.2.1. Stationarity Test

Based on augmented Dickey-Fuller tests, the stationarity test was done using Fisher-type unit-root test since it does not require a strongly balanced one. The null hypothesis being tested is that all panels contain a unit root. For a finite number of panels, the alternative is that at least one panel is stationary. The method combines the p-values from the panel-specific unit-root tests using either the inverse $\chi^2$ normal or logit transformation of $p$-values alongside their modifications suitable for when N tends to infinity, as proposed by Choi (2001). The study reports the inverse-normal transformations statistics. Given the panel setting design stacked by urban-rural setting, the stationary test was done separately for urban and rural data. All the variables provide sufficient evidence that the urban first differenced data is stationary at a 10% significance level. See **Table 2**.

Besides, all the variables provide sufficient evidence that the rural first differenced data is stationary at a 10% significance level. See **Table 3**. Therefore, the first differenced series of continuous data was used in regression analysis.

#### 4.2.2. Multicollinearity

The analysis examines multicollinearity in each of the parent models without interactions. Since the average VIF is less than 5, multicollinearity is not a severe problem. The VIF of water access is slightly above 10; hence the variables were not removed. See **Table 4**.

#### 4.2.3. Heteroskedasticity

Breusch-Pagan/Cook-Weisberg test for heteroskedasticity was used to test for heteroskedasticity. The results provide strong evidence of violation constant variance at a 5% significance level in the poverty rates, $\chi^2(1) = 27.4$, $p = 0.001$ and the poverty gap model, $\chi^2(1) = 14.86$, $p < 0.001$. Thus, heteroskedasticity robust standard errors were used to correct for heteroscedasticity. See **Table 5**.

#### 4.2.4. Normality Test

As indicated in **Figure 3**, the residuals for the poverty rates and poverty gap models are approximately normally distributed. Thus, both models satisfy the linearity assumption; hence the models are correctly specified.

### 4.3. Regression Results

#### 4.3.1. Poverty Rates

The regression results indicate no significant rural-urban disparity in poverty rates ($\beta = 0.006$, $p > 0.05$). See **Table 6**.

Improved electricity supply is the only resource that contributes to increasing poverty gaps ($\beta = 0.543$, $p < 0.05$). The significant crisis effect across all the panels indicates that poverty rates were significantly lower in the post-crisis period (before 2010). No significant interactions between FEW resources were established. Further, China has significantly lower poverty rates than Indonesia and India ($\beta = -0.191$, $p < 0.05$). Besides, India has significantly higher poverty rates than China and Indonesia ($\beta = 0.140$, $p < 0.05$).

#### 4.3.2. Poverty Gaps

On poverty gaps, there is a significant rural-urban disparity ($\beta = -1.236$, $p < 0.05$) (**Table 7**).

The results imply that the poverty gap is 123.6% lower in urban than rural areas. None of the FEW resources has significantly lowered poverty gaps. Improved electricity supply is the only resource that contributes to increasing poverty

**Table 2.** Stationarity test for urban data.

| Variable | Level | | | First difference | | |
|---|---|---|---|---|---|---|
| | *df* | *Inverse chi-squared* | *p-value* | *df* | *Inverse Chi-squared* | *p-value* |
| Poverty rate | 6 | 5.172 | 0.522 | | 26.109*** | 0.0002 |
| poverty gap | 6 | 6.821 | 0.338 | 6 | 23.766*** | 0.0006 |
| food insecurity | 6 | 21.878*** | 0.001 | 6 | 10.979* | 0.0890 |
| Access to electricity | 6 | 12.665* | 0.049 | 6 | 43.934*** | 0.0000 |
| Access to clean fuels and technologies for cooking | 6 | 42.113*** | 0.000 | 6 | 23.078*** | 0.0008 |
| Improved water access | 6 | 38.876 | 0.000 | 6 | 16.634** | 0.0107 |
| Population growth | 6 | 8.797 | 0.185 | 6 | 11.351* | 0.0781 |

Note. Note. The drift option was specified since all the series' means are nonzero. Two lags in the ADF regressions and cross-sectional means were removed using demean.; *: $p < 0.1$; **: $p < 0.1$; ***: $p < 0.01$.

**Table 3.** Stationarity test for rural data.

| Variable | Level | | | First difference | | |
|---|---|---|---|---|---|---|
| | *df* | *Inverse chi-squared* | *p-value* | *df* | *Inverse Chi-squared* | *p-value* |
| Poverty rate | 6 | 0.7908 | 0.9923 | 6 | 16.663* | 0.011 |
| poverty gap | 6 | 2.6923 | 0.8464 | 6 | 24.044*** | 0.001 |
| food insecurity | 6 | 21.816*** | 0.0013 | 6 | 10.637* | 0.100 |
| Access to electricity | 6 | 6.8518 | 0.3348 | 6 | 29.855*** | 0.000 |
| Access to clean fuels and technologies for cooking | 6 | 37.667*** | 0.0000 | 6 | 11.587* | 0.072 |
| Improved water access | 6 | 73.669*** | 0.0000 | 6 | 11.271* | 0.080 |
| Population growth | 6 | 9.9203 | 0.1280 | 6 | 16.932** | 0.010 |

Note. The drift option was specified since all the series' means are nonzero. Two lags in the ADF regressions and cross-sectional means were removed using demean.; *: $p < 0.1$; **: $p < 0.1$; ***: $p < 0.01$.

**Table 4.** Variance inflation factors of the predictor variables.

| | VIF | 1/VIF |
|---|---|---|
| *lnwat_imp_access_d1* | 10.627 | .094 |
| *lnpop_d1* | 9.509 | .105 |
| *urban* | 6.106 | .164 |
| *lncln_fuel_tch_ck_d1* | 2.288 | .437 |
| *postcrisis* | 1.457 | .686 |
| *lnfoodins_d1* | 1.391 | .719 |
| *lnelectr_acc_d1* | 1.078 | .927 |
| Mean VIF | 4.636 | . |

**Table 5.** Breusch-Pagan/Cook-Weisberg test for heteroskedasticity.

| Model | Degrees of freedom | Chi-square Statistic | *p*-value |
|---|---|---|---|
| Poverty rate model | 1 | 27.43 | 0.000 |
| Poverty gap model | 1 | 14.86 | 0.0001 |

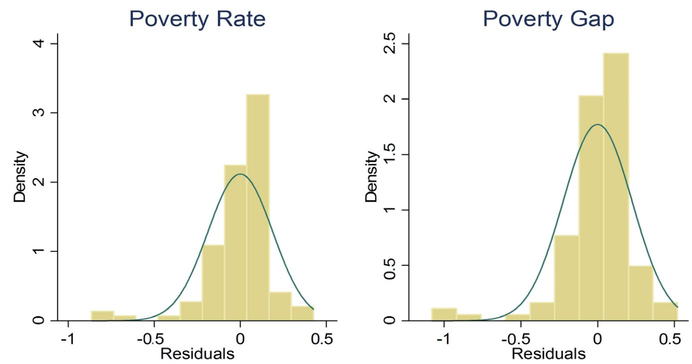


**Figure 3.** Histogram the residuals for the poverty rates and poverty gap models.

**Table 6.** POLS predicting poverty rates based on FEW resources and their nexus.

| *Variables* | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | *Ln Poverty rates_D1* | *Ln Poverty rates_D1* | *Ln Poverty rates_D1* | *Ln Poverty rates_D1* | *Ln Poverty rates_D1* | *Ln Poverty rates_D1* |
| lnfoodins_d1 | | 0.0424 | −0.0663 | 0.254 | −0.0326 | −0.0349 |
| | | (0.280) | (0.554) | (0.547) | (0.614) | (0.540) |
| lncln_fuel_tch_ck_d1 | | 0.123 | 0.632 | −0.192 | 0.366 | 0.579 |
| | | (0.254) | (0.789) | (0.862) | (0.829) | (0.772) |
| lnelectr_acc_rural_d1 | | 0.543*** | 0.516 | −0.668 | −0.810 | 0.587 |
| | | (0.187) | (1.213) | (0.961) | (0.975) | (1.219) |
| lnwat_imp_access_d1 | | 12.03 | 13.24 | 0.303 | 18.70 | 10.90 |
| | | (12.64) | (13.95) | (10.84) | (18.00) | (18.27) |
| foodins_fuel | | | −0.800 | −4.560 | −1.694 | −1.091 |
| | | | (6.387) | (6.637) | (6.629) | (6.389) |
| foodins_electricity | | | 3.231 | 7.940 | 10.83 | 2.586 |
| | | | (14.16) | (13.06) | (13.93) | (13.91) |
| foodins_water | | | 24.20 | 51.31 | 9.653 | 29.58 |
| | | | (105.4) | (105.0) | (105.3) | (105.5) |
| fuel_electricity | | | 4.345 | 1.336 | 0.283 | 4.633 |
| | | | (5.479) | (5.216) | (5.239) | (5.538) |
| fuel_water | | | −45.78 | −7.993 | −17.82 | −45.80 |
| | | | (52.62) | (55.54) | (55.29) | (52.99) |
| electricity_water | | | −67.45 | 89.38 | 122.5 | −79.07 |
| | | | (181.7) | (146.1) | (151.7) | (183.1) |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| urban | 0.00617 | −0.0815 | −0.0954 | −0.0503 | 0.0428 | −0.112 |
| | (0.0394) | (0.0726) | (0.0750) | (0.0658) | (0.0869) | (0.110) |
| postcrisis | | −0.0895** | −0.0918** | −0.123*** | −0.0987** | −0.0944** |
| | | (0.0369) | (0.0410) | (0.0386) | (0.0450) | (0.0465) |
| lnpop_d1 | | 6.828* | 6.690 | 1.215 | 4.919 | 6.338 |
| | | (4.075) | (4.415) | (3.612) | (4.643) | (4.645) |
| China | | | | −0.191*** | | |
| | | | | (0.0471) | | |
| India | | | | | 0.140*** | |
| | | | | | (0.0416) | |
| Indonesia | | | | | | 0.0219 |
| | | | | | | (0.0796) |
| Constant | −0.160*** | −0.246* | −0.249* | 0.00458 | −0.378* | −0.221 |
| | (0.0279) | (0.136) | (0.147) | (0.119) | (0.203) | (0.199) |
| Observations | 114 | 114 | 114 | 114 | 114 | 114 |
| R-squared | 0.000 | 0.191 | 0.201 | 0.293 | 0.264 | 0.202 |

Note. Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

**Table 7.** POLS predicting poverty gaps based on FEW resources and their nexus.

| *Variables* | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | *Ln Poverty Gap_D1* | *Ln Poverty Gap_D1* | *Ln Poverty Gap_D1* | *Ln Poverty Gap_D1* | *Ln Poverty Gap_D1* | *Ln Poverty Gap_D1* |
| lnfoodins_d1 | | 0.0596 | −0.337 | −0.0374 | −0.303 | −0.343 |
| | | (0.347) | (0.725) | (0.735) | (0.772) | (0.735) |
| lncln_fuel_tch_ck _d1 | | 0.201 | 0.842 | 0.0684 | 0.572 | 0.852 |
| | | (0.336) | (1.037) | (1.149) | (1.092) | (1.014) |
| lnelectr_acc_rural_d1 | | 0.712** | −0.170 | −1.281 | −1.511 | −0.183 |
| | | (0.279) | (1.431) | (1.251) | (1.291) | (1.427) |
| lnwat_imp_access_d1 | | 6.730 | 6.248 | −5.886 | 11.77 | 6.680 |
| | | (12.88) | (13.94) | (11.62) | (17.34) | (18.19) |
| foodins_fuel | | | 5.325 | 1.798 | 4.421 | 5.379 |
| | | | (7.517) | (8.018) | (7.755) | (7.490) |
| foodins_electricity | | | 6.191 | 10.61 | 13.88 | 6.310 |
| | | | (16.15) | (15.10) | (16.08) | (16.21) |
| foodins_water | | | −36.63 | −11.20 | −51.34 | −37.62 |
| | | | (123.2) | (126.1) | (122.5) | (121.9) |
| fuel_electricity | | | 7.545 | 4.723 | 3.438 | 7.492 |
| | | | (6.348) | (6.057) | (6.124) | (6.369) |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| fuel_water | | | −47.47 | −12.03 | −19.20 | −47.46 |
| | | | (70.11) | (74.52) | (74.60) | (70.47) |
| electricity_water | | | −20.21 | 126.9 | 171.8 | −18.06 |
| | | | (215.6) | (188.7) | (196.7) | (215.5) |
| urban | 0.0222 | −0.0862 | −0.106 | −0.0639 | 0.0335 | −0.103 |
| | (0.0463) | (0.0883) | (0.0893) | (0.0819) | (0.0911) | (0.120) |
| postcrisis | | −0.109*** | −0.121*** | −0.150*** | −0.128*** | −0.120** |
| | | (0.0384) | (0.0427) | (0.0428) | (0.0461) | (0.0497) |
| lnpop_d1 | | 6.069 | 5.811 | 0.676 | 4.021 | 5.876 |
| | | (4.368) | (4.727) | (3.883) | (4.904) | (4.906) |
| China | | | | −0.179*** | | |
| | | | | (0.0546) | | |
| India | | | | | 0.142*** | |
| | | | | | (0.0464) | |
| Indonesia | | | | | | −0.00405 |
| | | | | | | (0.0863) |
| Constant | −0.188*** | −0.217 | −0.207 | 0.0303 | −0.338* | −0.212 |
| | (0.0327) | (0.137) | (0.145) | (0.127) | (0.192) | (0.196) |
| Observations | 114 | 114 | 114 | 114 | 114 | 114 |
| R-squared | 0.002 | 0.164 | 0.179 | 0.237 | 0.226 | 0.179 |

Note. Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

gaps (β = 0.172, $p < 0.05$). The significant crisis effect across all the panels indicates that poverty gaps were significantly lower in the post-crisis period (before 2010). No significant interactions between FEW resources were established. Additionally, China has significantly lower poverty gaps than Indonesia and India (β = −0.191, $p < 0.05$). Lastly, the results indicated that India has significantly higher poverty gaps than China and Indonesia (β = 0.142, $p < 0.05$).

### 4.4. Discussion

FEW are the essential resources that support human well-being, poverty reduction, and sustainable development. These resources are interrelated and form a nexus that influences the sustainability of human activities. From the factor approach, the productive capacity of a country is limited by the available factors of production, which are labor, capital, technical knowledge, and land. Thus, FEW resources can help reduce the income gap between rural and urban areas since it enhances mobility factors of production and creates employment for households. Using empirical evidence from three countries: China from Eastern Asia, India from Southern Asia, and Indonesia from South-Eastern Asia, the study findings indicate significant rural-urban discrimination in the use of FEW resources in lowering poverty. While the results indicated no significant rural-urban disparity in poverty rates, a significant rural-urban disparity in poverty gaps was established. The results imply that urban households have lower poverty gaps. Further, the results indicated that poverty gaps in urban areas are 1.23 times less in urban areas than in rural areas. Contrary to the study hypothesis, FEW supply has not achieved its tentative outcomes of reducing income inequality.

Natural resource endowments regarding water supply, energy access, physical spatial use, and socio-economic activity disparity shape the rural-urban disparity. In this study, improved electricity supply is the only resource that contributes to increasing poverty rates and gaps. According to Wu et al. (2021), insufficient energy supply in rural households and the utilization structure are unreasonable, making it difficult to eliminate the low-income dilemma since rural households' expenditures, including water, electricity, and gas, are substantially lower than in urban areas. Besides, urban households may have more opportunities and choices for economic activities that require or benefit from electricity, such as manufacturing, services, trade, and education. The demand for these activities is high due to urban agglomeration and is associated with higher wages.

Contrarily, rural households may have fewer options and resources for economic activities that use electricity, such as agriculture, processing, storage, and marketing. Solar power is predominantly used for household consumption in lighting and water heating, irrigation, and colling in agricultural greenhouses (Hassanien, Li, & Lin, 2016; Rahman et al., 2022). Rural electrification has predominantly improved rural people's quality of life and well-being by enabling them to access modern appliances and devices, such as fans, TVs, radios, mobile phones, computers, and the Internet. Yet, these developments are liabilities, not assets that enhance income generation.

This study's findings elucidate the need to move from supply statistical to a structural adjustment that ensures that the rural population benefits from the increasing energy supply. Renewable energy can support rural development by enhancing agricultural productivity, irrigation, food processing, storage, and marketing (OECD, 2012). Productive uses of electricity in rural areas can include milling, husking of cones and rice, water pumping for irrigation, welding, carpentry, and refrigeration. These economic activities create new opportunities for income generation and employment in rural areas. They also save time and labor for rural households, especially women, and increase their income and productivity (Lee, 2018). Thus, national and local governments should ensure that rural households are empowered in income-generating activities that optimize electricity and increases their income levels. This is in line with the UN's Alliance for Rural Electrification (ARE) seeks to enable the private sector to expand at least 5 million green jobs ranging from direct green jobs in manufacturing, assembly, distribution and sales, operations, and maintenance, as well as derived jobs in related sectors that are dependent on electricity, for example, agricultural industries and fisheries by 2030 (UN, 2022d). Such activities contribute to lowering rural-urban income since most of the rural residents, especially in LDCs, are predominantly agricultural.

High labour force heterogeneity in rural areas could also confound the positive contribution of electricity supply on poverty rates and gaps. In China, Wu et al. (2021) established that the rural labor force is heterogeneous, with a majority being low-skilled. As a result, a few residents utilize the electricity supply for income generation while a majority use it for domestic purposes such as non-productive lighting.

Lastly, the study findings indicated that China has significantly lower poverty rates and gaps than India and Indonesia. China plays an increasingly immense role in the large-scale photovoltaic electricity supply, with solar and wind power being the primary sources (Zhang et al., 2020). According to the International Energy Agency (IEA, 2022), the global installed PV capacity reached 773 gigawatts (GW) at the end of 2020, of which nearly 40% was in China. China's cumulative solar PV capacity was 307.1 GW, followed by the United States with 122.1 GW, Japan with 77.6 GW, India with 60.2 GW, and Germany with 59.2 GW (Statista, 2023). Indonesia's cumulative solar PV capacity was much lower, at only 0.3 GW in 2020 (Our World in Data, n.d.-a, n.d.-b). Therefore, China leads in solar PV installation among the three countries. Indonesia, however, still lags in terms of solar PV development. As a result, households in China, mostly in rural areas, given that China has attained 100% electricity supply in major urban areas, benefit from direct and indirect employment associated with power generation and distribution.

While the study was centred on the impact of FEW resources on poverty and income inequality alleviation, China's structural and fiscal adjustments over the past four decades have immensely contributed to poverty alleviation. A recent World Bank (2022) report indicates that China has made a remarkable achievement over the past 40 years, lifting about 800 million people out of poverty, accounting for more than 75% of global poverty reduction in the same period. Among the measures that have sustained poverty reduction in China include endogenous development, particularly the rural revitalization strategy on fundamental areas such as industrial development, agricultural productivity, human capital investment through education, skill development, and enhanced labour mobility, which has enhanced rural-urban migration. Besides, China's governance is founded on China's tradition built on a People-Centered Philosophy. The culture of communism has carried forward the tradition of working together, offering mutual support, and a strong will among the citizens, leaders, and volunteers working with diligence and a spirit of dedication towards achieving national goals such as poverty alleviation and eradiation among the poor (State Council Information Office of the People's Republic of China (SCIO), 2021). Besides, other institutional and structural adjustments to alleviate poverty include social land reforms such as ownership, contracting rights, and management rights, and rural collective property rights for contracted rural land and repealing agricultural taxes, which have contributed to rural development and increased farmers' incomes (SCIO, 2021).

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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