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Poverty Reduction Effect of Infrastructure: A Cross Country Study of Developing Countries in Asia

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ABSTRACT

Poverty alleviation is the central theme of the decade and this paper investigates the poverty reduction effect of access to infrastructure using panel data from 1990-2015 for nine developing countries in Asia. The objective of the paper is to investigate the causality between poverty and access to infrastructure and to estimate the poverty reduction effect of infrastructure. Dependent variables are the poverty headcount ratio at USD 1.90 and USD 3.20 per day. A variable is created by using access to electricity, water and sanitation occupying principal component analysis (PCA). Causality test result indicates unidirectional causality running from access to infrastructure to poverty. The model estimated by using fixed effects and results find lack of access to electricity, water and sanitation are the major reasons to poverty. The poverty reduction effect of access to infrastructure is larger in the long-run. The results of the model speak to close infrastructure gap, make infrastructure accessible, make poor beneficiaries of education, to control persisting income inequality, controlling population growth, reduce unemployment and encourage remittance. Findings of the model guide policy makers to prioritize investment in infrastructure as infrastructure boosts human capital through better provisioning of electricity, sanitation and water and physical capital.

Keywords: *Electricity, Infrastructure, Poverty, Sanitation, Water.*

INTRODUCTION

Poverty alleviation is the central theme of Sustainable Development Goals (SDGs), and is the discussion of the decade. SDGs are closely connected with infrastructure as a source of reducing poverty through SDG Goal 9-Industry, Innovation, and Infrastructure, Goal 6-Clean water and sanitation, Goal 7-Affordable and clean energy, and Goal 11-Sustainable cities and communication connected to infrastructure (The Economist, 2019). The importance of infrastructure[1] in poverty[2] reduction is long cited relationship in the literature (UN, 2011). The percentage of poverty is 10.7%[3] out of the total world population, the total percentage of poor people dwelling in developing countries is 25% of the total population of developing countries. More than fifty percent of the extremely poor live in

[1] "Infrastructure includes all public services from law and order through education and public health to transportation, communication, power, water supply as well as agricultural overhead capital as irrigation and drainage systems" (Hirschman, 1958)

[2] "A condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education, and information. It depends not only on income but also on access to services" (UNDP, 2019).

[3] The percentage of people living under US$ 1.90 per day

Sub Saharan African continent while South Asia is sheltering 13.5% of poor in 2015 out of total people in South Asia. Poverty reduction is a common goal and a global issue for decades, kept challenging as its multidirectional nature as finds in (JBIC, 2004), and capabilities of the poor must strengthen by fulfilling human capabilities.

Poverty in developing countries is comparatively high as majority of the people are incapable of access to infrastructure, "such as access to good schools, health care, electricity, safe water, and other critical services remains elusive" (World Bank, 2019) resulted by obstructed supply in infrastructure followed by infrastructure gaps. The difference between the available amount of infrastructure and the required amount of infrastructure in each sector is defined as infrastructure gap. The required amount often set to be 100%. The reason for the infrastructure gaps is an inadequate supply of infrastructure due to budgetary constraints. Developing countries face tight budgets and must transfer public expenditure for the most required sectors. Tight budgets cannot afford huge infrastructure investment, and therefore the infrastructure often neglected to leave infrastructure gaps. "Infrastructure needs and financing is more severe in developing countries," as finds in (Akitoby, 2007).

Figure 1 and 2 explain the poverty trends in sample countries from 2005 to 2015 at USD 1.90 per day and USD 3.20 per day, respectively. The highest poverty rates represent in India, followed by Bangladesh, while in Malaysia and Thailand represents the lowest. The poverty headcount ratio per day is declining but remains high in 21.3% (USD 1.90) and 81.10% (USD 3.20) in India. Population living under USD 3.20 per day is more significant than that of the population living in USD 1.90 per day.

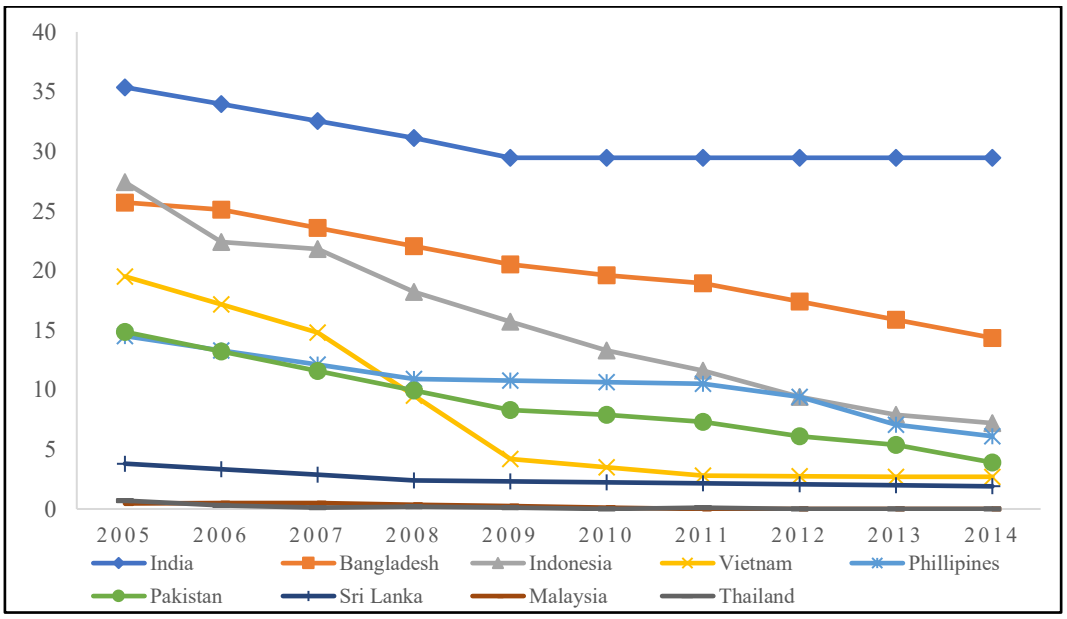


Figure 1 Percentage of people living under USD 1.90 per day in Sample Countries
Note: Extreme poverty level at USD1.90 is reducing during sample period.
Source: Author based on data from PovcalNet

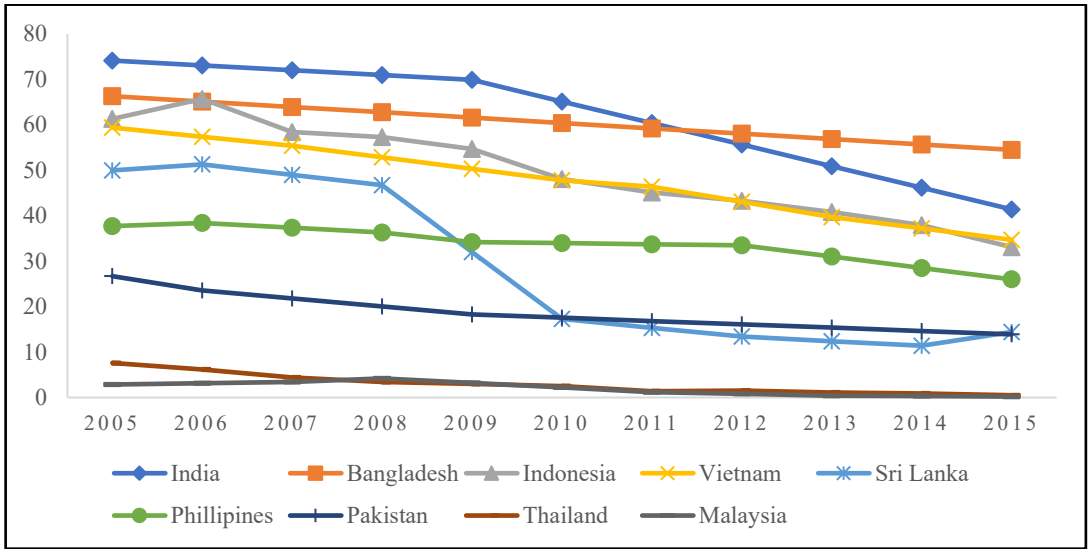


Figure 2 Percentage of people living under USD 3.20 per day in Sample Countries
Note: Extreme poverty level at USD3.20 is still remains at a high-level during sample period.
Source: Author based on data PovcalNet

This study aims to estimate the effect of access to infrastructure to reduce poverty in developing countries in Asia by using panel data from 1990-2015 in the sample of nine developing countries[4] according to availability of data. Lower access and poor quality of infrastructure leads to poverty. The sample countries are Bangladesh, India, Indonesia, Malaysia, Pakistan, Philippines, Sri Lanka, and Thailand (Appendix 1).

Previous research on infrastructure and poverty are mainly based either on qualitative approach or case studies and mainly country specific studies. The selection criteria of the type of poverty reduction infrastructure is doubtful. The research gap is the lack of quantitative studies in terms of access to infrastructure and poverty reduction in existing literature and no studies have estimated long run effects of access to infrastructure. This paper contributes addressing this gap in the literature, estimating the effect of access to infrastructure to reduce poverty developing countries in Asia in the short run and long run. A variable is created by combining access to electricity, water and sanitation to capture the importance of infrastructure to reduce poverty according to the income groups. At this point, this paper contributes to quantitatively modern discussion of infrastructure and poverty at the regional level. The second contribution is in terms of filling the gap in the literature. Poverty reduction through the estimation of access to infrastructure has hardly been researched area yet very important in terms of developing countries. Developing countries face investment bottlenecks and policy makers have to prioritize scarce investment between physical capital and human capital. Results of this study contributes policy makers to prioritize physical investment in developing countries.

Table 1 describes the percentage of people with access to electricity, water, and sanitation from the year 2000 to 2015 and the population living under the poverty line of USD1.90 per day. Malaysia records 100% of access to electricity,98.2% of access to water, and 96% of sanitation and eradicated poverty at USD1.90 in the period concerned proceeded by Thailand. Both countries shifted to the next level of economic growth and labeled as upper-middle-income countries.
.

[4] World Bank classification (2017)

Table 1: Nexus between Access to Infrastructure and Poverty Reduction (2000 -2015)

Country	Access to Infrastructure as a Percentage of People						Poverty Head Count Ratio USD1.90 per Day	
	Electricity		Water		Sanitation			
	2000	2015	2000	2015	2000	2015	2000	2015
Bangladesh	32.0	68.2	76.0	86.9	45.4	60.6	34.8	12.7
India	59.4	88.0	80.6	94.1	25.6	39.6	40.6	29.5
Indonesia	86.3	97.5	77.9	87.4	47.1	60.8	39.3	7.2
Malaysia	97.0	100.0	94.1	98.2	91.2	96.0	0.4	0.0
Pakistan	75.3	93.5	88.5	91.4	36.9	63.5	26.0	3.9
Philippines	73.5	89.1	87.1	91.8	63.8	73.9	13.9	6.1
Sri Lanka	69.6	93.9	79.7	95.6	81.2	95.1	12.4	1.9
Thailand	82.1	99.6	91.9	97.8	91.3	93.0	2.5	0.0
Vietnam	86.2	100.0	77.4	97.6	52.9	78.0	36.7	2.7

Note: Access to electricity, water and sanitation has improved from year 2000-2015 lowering poverty head count ratio

Source: Author database on WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation. Private Participation in Infrastructure Database, World Bank (2017), Sustainable Energy for All (SE4ALL) database, PovcalNet

The lowest access to electricity and water is recorded by Bangladesh while India records the lowest access to sanitation, housing the highest percentage of poor people living in poverty under USD 1.90 in 2015. Countries with a higher percentage of access to infrastructure records the lowest poverty and lower access to infrastructure records higher poverty percentage denoting access to infrastructure is a reason to reduce poverty in developing countries.

Infrastructure poverty linkage is explained in various aspects as poverty itself alone is a multidimensional concept, while infrastructure has both socio-economic impacts of poverty. Infrastructure development is recognized as the key element of poverty alleviation as infrastructure serves as multifaceted miens. This paper structures as introduction, literature review; data and methodology, discussion of results, and conclusion of the study.

LITERATURE REVIEW

Theoretical Approach: Theory of Development and Poverty

Infrastructure has growth effect through different channels and increase in public investment leads to economic growth followed by poverty reduction. Huge investment in infrastructure leads to economic growth specially in developing countries according to the "Big Push", by (Rosenstein-Rodan,1943). Infrastructure services of electricity, sanitation and water has a strong health and education impact leading improvement of human capital. Theory of development considers infrastructure is essential for the growth (Agenor,2006) where infrastructure, health and savings are interconnected and these three factors jointly decide the growth rate. Health services of the economy are decided by the infrastructure, and better health services promote healthy work force followed by increased productivity and large output. Better health reduces medical expenses and increase savings. According to the theory of development, infrastructure reduces poverty enhancing the quality of human capital and saving medical expenses. Public investment reduces poverty according to empirical studies. Since poverty is multidimensional, it is technical to look at poverty in terms of public investment as the effects are multifaceted. Both public investment and private investments are important as public investment mainly focuses on (Construction on roads, power plants, ports, etc.), and private investment focuses on private goods such as

buildings. It is impossible to focus on poverty reduction leaving behind economic growth. The ultimate effect of economic growth trickles down to reduce poverty as the overall impact has direct and indirect effects on poverty. Economic growth generates by the amount of public investment and existing stock of public investment. Keynesian economists suggest public investment boost aggregate demand, which will trickle down to reduce poverty. Public investment leads to crowd in effects where public and private investment is complementary to each other. According to Barro, the crowd in effect takes place according to the level of growth in the economy, whereas at the beginning, positive returns to scale on private investment what we call as "crowd in effect" and later converts to diminishing returns to scale (Barro, 1990) .

Existing literature proves poverty reduction effects of infrastructure, provision of quality infrastructure and make them accessible, and policy gaps in infrastructure in terms of developing countries. These studies incorporate with one particular kind of infrastructure or combination according to the availability of data. Research gap includes lack of estimation of causality and no studies yet considered the type of poverty reduction infrastructure particularly followed by quantitative analysis. Country specific studies find public investment reduces poverty (Sasmal & Sasmal,2016) and investment in infrastructure reduces poverty (Chotia & Rao,2017b) in Indian context. Both of these studies focus on investment and poverty. Access to infrastructure connects to reduce poverty more than the investment (Timilsina, Hochman, & Song, 2020).The effects of infrastructure and poverty reduction have long run effects and estimation of long run effects of infrastructure hardly seen in the literature.

Nexus between Infrastructure and Poverty Reduction

South Asia is a region with complex characteristics of both chronicle and transient poverty. Infrastructure helps to reduce many channels having trickledown effect on the grass-root level, reducing not only the poverty incident but also chronicle poverty (Calderón, 2014) .The linkage between infrastructure and poverty is not directly addressed in literature and a few studies investigate the relationship using either qualitative approach or case studies (Timilsina, Hochman, & Song, 2020).

Poverty is a multidimensional concept and commonly viewed in infrastructure literature as inaccessibility of basic human needs of health, education, drinking water, sanitation, and electricity services by the poor which is closely associated with poverty in developing countries. "Lack of access to basic services is closely linked to poverty," and *access* to clean water and sanitation of the people in rural areas, and especially people in low-income countries fall into the category of poverty (Andres, 2013). Disparity in access to electricity is widely pronounced in the rural-urban sense in most of the low-income countries. Poverty is an outcome of policy gaps in infrastructure policies (Dappe, 2015) and addresses this gap between policy planning and the actual requirement of "infrastructure, especially in the South Asian region." Poor people in developing countries demand infrastructure facilities either due to the inability to access core infrastructure or cannot afford the available infrastructure (Antonio, 2012).Estache sums up the direct and indirect effects of improving infrastructure and poverty reduction (Estache, 2010). More investment in infrastructure provides more opportunities to access infrastructure to the poor - especially in terms of education, health, and income generation. Developing infrastructure is combatting persisting poverty in developing countries according to (Kirkpatrick, 2008). The finding keeps consistent with (Calderón and Servén, 2008) as cited in his paper, "Infrastructure development is a win-win ingredient of poverty reduction." Poverty is an outcome of a lack of proper quantity of infrastructure combined with the inaccessibility of infrastructure (Pouliquen, 2000) . Brenneman and Pouliquen specifically conclude poverty reduction infrastructure as found in works of (Brenneman, 2002) (Pouliquen, 2000). Brenneman considers the improvement of electricity, energy, education, health, and transport helps to alleviate poverty (Brenneman, 2002).

Education is one of the significant determinants of reducing poverty according to (World Bank, 2018) and reflects that educated households usually engage with high income-generating jobs allowing them to reach out of poverty. Global poverty can be lessened by 55% if the adults' population has fulfilled primary and secondary education (UNESCO, 2017). Importance of primary and secondary education, reducing global poverty documents in (UN, 2019). Personal remittance has an impact on reducing poverty, and remittance increases consumption as poor people first try to fulfill their basic needs. Studies regarding personal remittance and poverty conclude poverty reduction effect of remittances received and decrease inequality (Pekovic, 2017) (Acharya & Leon-Gonzalez, 2012) (World Bank,2006). Population growth rate and poverty has a strong linkage, and this link has been explained by different approaches by different schools of thought, as availability of human capital depends on population growth (Makkik, Ghani, and Sultan, 2005). Poverty influences population dynamics, according to (UNFPA, 2014). Population growth rate and poverty have a positive relationship in developing countries as a small amount of wealth is shared among many people, denoting large level of income inequality. Gini coefficient explains the inequality of a country ranging from zero to one (0 – 1); graphically, this is the area between the Lorenz curve and the equality line. This gap is wider in sample countries representing the high level of inequality. Inequality and poverty have a positive relationship representing poor people receive a lower share of GDP or national wealth, and a higher share of GDP is shared among a few rich people. Unemployment and poverty have a positive significance. Unemployment makes poor people vulnerable to risk making poorer. The findings of the link between unemployment and poverty are inconclusive as poverty in the developing countries and the developed countries do not share the same characteristics (Saunders, 2002) (Visaria, 1981). Figure 3 is the conceptual framework of the study. Economic and social infrastructure differentiated according to (Fourie, 2006).

Access to Infrastructure and Poverty Nexus (2000-2015)

Figures 4 and 5 explain inaccessibility to each infrastructure and poverty linkage at USD 1.90 and USD 3.20 per day from the year 2000 to 2015- poverty is described as a reason for lack of access to electricity, water, and sanitation. Accessibility to each infrastructure has been increased and extreme poverty has reduced in sample countries. This idea disclosed in the figures by reducing the area of poverty. People living without access to electricity and sanitation were high in Bangladesh in the year 2000 and therefore poverty in both USD 1.90 per day and 3.20 per day was high. In the year 2015, Bangladesh inaccessibility to electricity and water was reduced; therefore, poverty at both poverty lines reduced. The poverty rate is still high, as inaccessibility of sanitation is remaining as a challenge to Bangladesh. India has the challenge of inaccessibility to sanitation that makes the poverty range larger and inaccessibility to electricity has been reduced, leaving a huge level of the gap in sanitation yet. According to the figure, a lack of sanitation is a challenge to reduce extreme poverty in India.

The area of poverty was large in both Indonesia and Pakistan in the year 2000 and reduced by 2015, improving access to electricity and water. In Indonesia, reducing inaccessibility in electricity and water leads to reduce poverty. Lack of access to sanitation is remaining as a challenge leaving the scope of poverty large in Malaysia. Poverty in Pakistan has reduced as a result of improving access to electricity and sanitation. The area denoting poverty has shrunk in the Philippines by the year 2015, denoting reduced inaccessibility to electricity, water, and sanitation. Sri Lanka has reduced poverty largely in the period concerned by improving access to electricity, water, and sanitation. Vietnam and Malaysia improved access to electricity, water, and sanitation, and poverty in the period concerned is reduced dramatically. Lack of sanitation is a challenge to both countries, leaving poverty scope large. Sri Lanka, Vietnam, Malaysia, and Thailand disclose smaller poverty areas in comparison to other sample countries by reducing inaccessibility to infrastructure during the period of 2000 – 2015. Thailand has reduced inaccessibility to electricity and water,

leading to poverty reduction at both poverty lines.

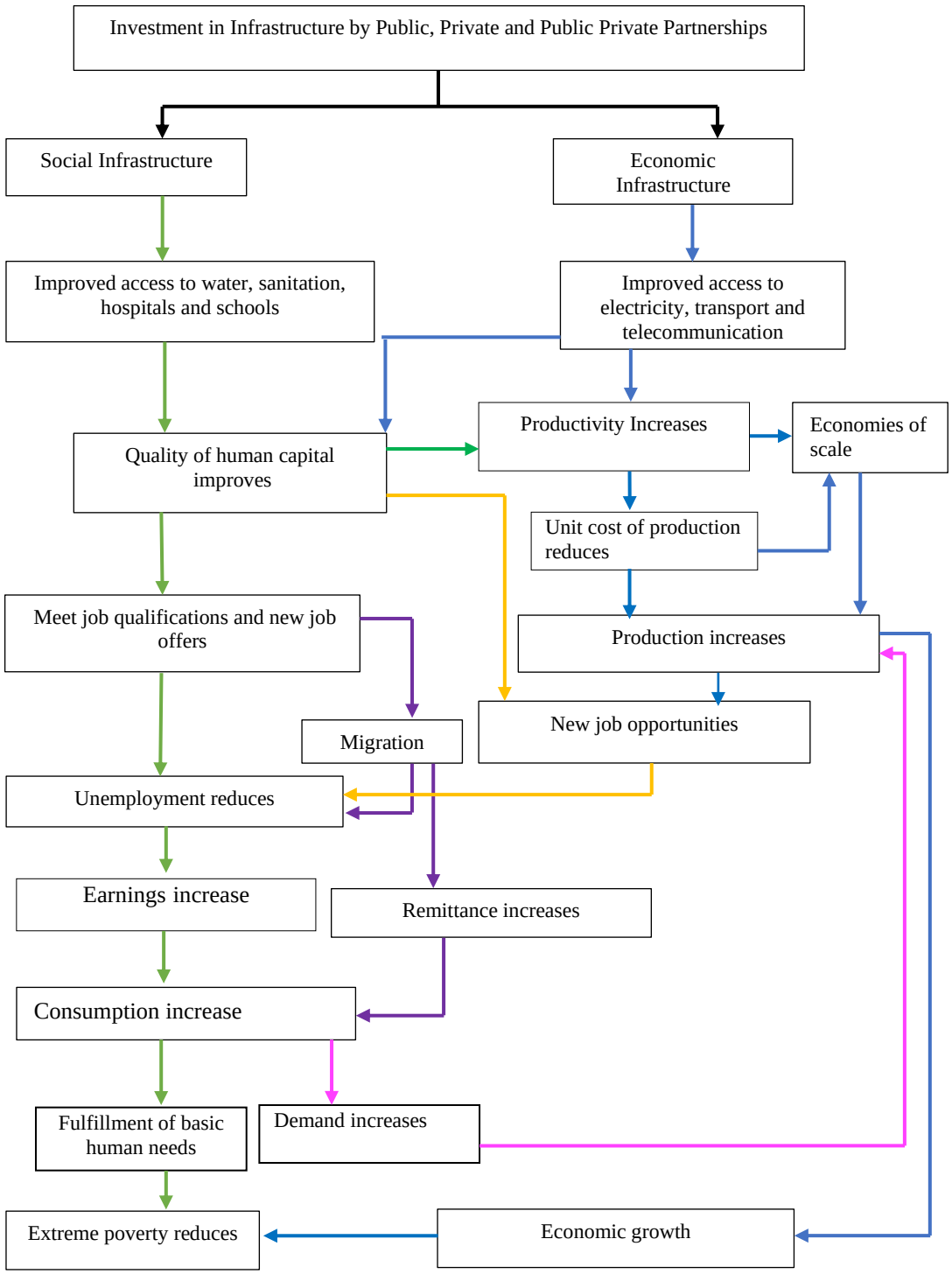
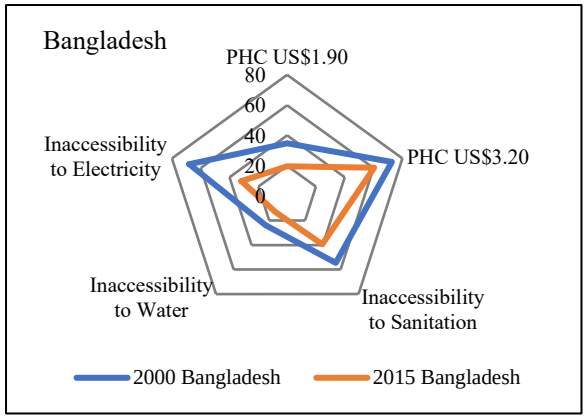
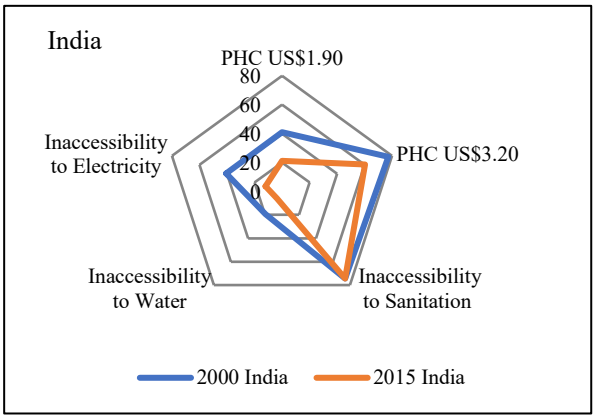
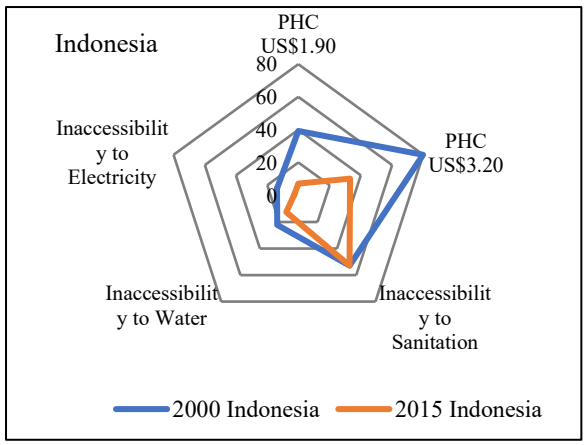


Figure 3 Conceptual Framework of Infrastructure and Poverty Reduction

Note: The importance of infrastructure to reduce poverty


Bangladesh
PHC US$1.90
80
60
40
20
0
PHC US$3.20
Inaccessibility to Sanitation
Inaccessibility to Water
Inaccessibility to Electricity
2000 Bangladesh
2015 Bangladesh


India
PHC US$1.90
80
60
40
20
0
PHC US$3.20
Inaccessibility to Sanitation
Inaccessibility to Water
Inaccessibility to Electricity
2000 India
2015 India


Indonesia
PHC US$1.90
80
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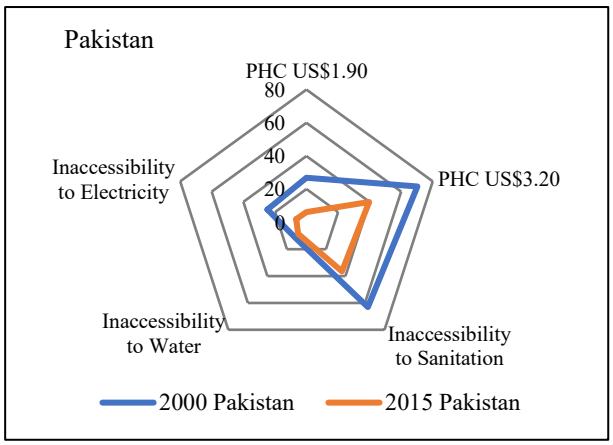
PHC US$3.20
Inaccessibility to Sanitation
Inaccessibility to Water
Inaccessibility to Electricity
2000 Indonesia
2015 Indonesia


Pakistan
PHC US$1.90
80
60
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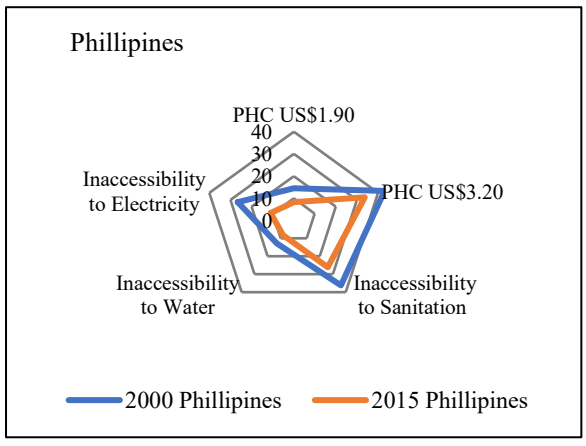
PHC US$3.20
Inaccessibility to Sanitation
Inaccessibility to Water
Inaccessibility to Electricity
2000 Pakistan
2015 Pakistan


Phillipines
PHC US$1.90
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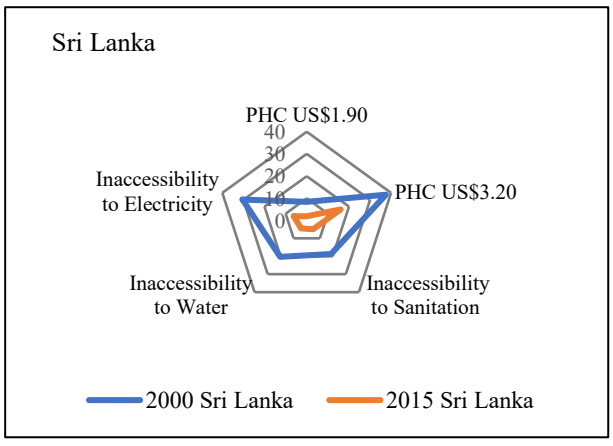
Inaccessibility to Sanitation
Inaccessibility to Water
Inaccessibility to Electricity
2000 Phillipines
2015 Phillipines


Sri Lanka
PHC US$1.90
40
30
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PHC US$3.20
Inaccessibility to Sanitation
Inaccessibility to Water
Inaccessibility to Electricity
2000 Sri Lanka
2015 Sri Lanka

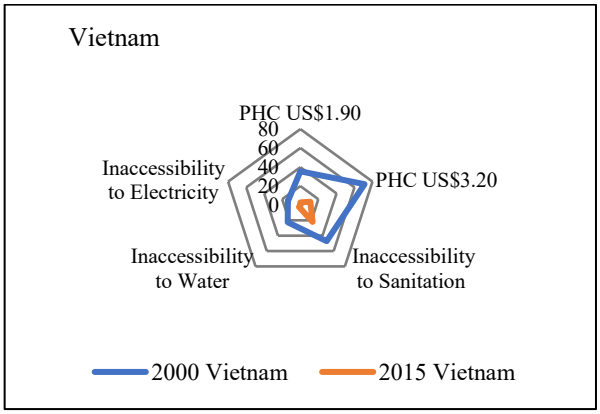
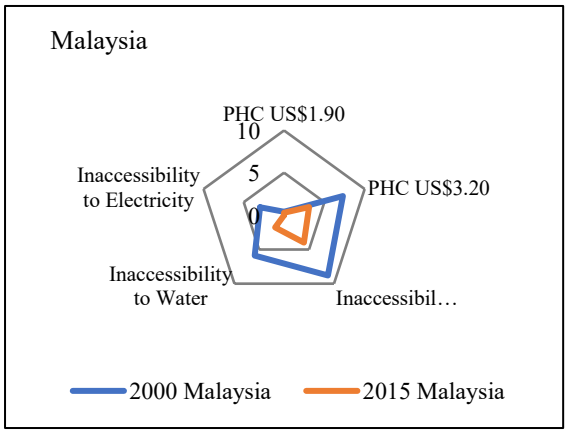


Figure 4 Infrastructure and Poverty in Lower Middle-Income Countries
Note: Access to electricity and water has improved leading reduction in extreme poverty. Access to sanitation is still a challenge in lower middle-income countries.
PHC US$1.90 = Poverty headcount ratio at US$1.90 perday,2011 Purchasing power Parity (% of population);
PHC US$3.20 = Poverty headcount ratio at US$1.90 perday,2011 Purchasing power Parity (% of population)
Source: Author based on WHO/UNICEF Joint Monitoring Programme (JMP) for Water supply and Sanitation World Bank, Sustainable Energy for All (SE4ALL) Database



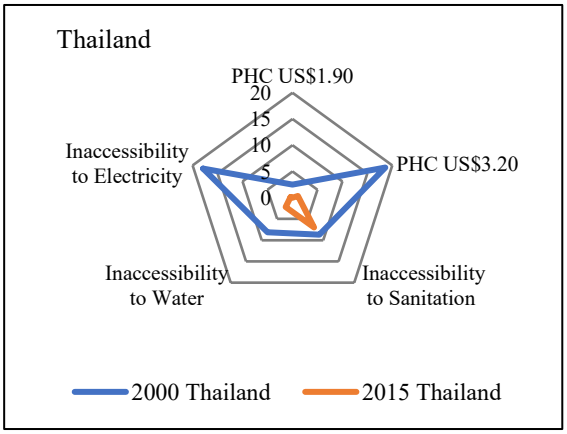


Figure 5 Infrastructure and Poverty in Upper Middle-Income Countries

Note: Access to infrastructure has improved leading reduction in extreme poverty in upper middle-income countries.
PHC US$1.90 = Poverty headcount ratio at US$1.90 perday,2011 Purchasing power Parity (% of population);
PHC US$3.20 = Poverty headcount ratio at US$1.90 perday,2011 Purchasing power Parity (% of population)
Source: Author based on WHO/UNICEF Joint Monitoring Programme (JMP) for Water supply and Sanitation, World Bank, Sustainable Energy for All (SE4ALL) Database

Poverty in Thailand was high in the year 2000 and reduced largely by 2015, denoting reduced inaccessibility in electricity and water. Lack of access to water still remains as a challenge. Inaccessibility to infrastructure and poverty has a positive relationship showing lower level of access to electricity, water, and sanitation is a reason to poverty. Multidimensional Poverty Index captures the importance of access to these three sectors.

Multidimensional Poverty Index (MPI)

Poverty is multidimensional, and multidimensionality of poverty is captured by Multidimensional Poverty Index (MPI) recently by Oxford Poverty and Human Development Initiative (2018) equally prioritizing the areas of education, health, and living standard weighing 1/3 each (UNDP, 2019), disclosing lack of education, lack of health and lack of good living standard are reasons to poverty. The living standard is subcategorized under six topics and three sub-topics related to infrastructure, namely electricity, sanitation, and water. MPI is to capture the multidimensionality of poverty and considered as an internationally comparable index. The index based on ten indicators, out of which three indicators represent infrastructure. The index ranges from one to zero, where higher values denote a larger scale of poverty vice versa.

To combat poverty, the good living standard should be ensured, which is measured by weighing non-monetary units of "cooking fuel, sanitation, drinking water, electricity, housing, and assets". Provision of Sanitation, drinking water, and electricity are considered as parts of infrastructure. Health and education have an indirect relationship in terms of supplying buildings and access roads. The methodology of the paper develops upon access to infrastructure variable, which is a combination of access to sanitation, access to clean water, and access to electricity being shed light components of MPI as they are recognized as effects of poverty (Bandre,2015) (Andres, Biller & Dappe, 2013) (Zaure,2007) and can be categorized as components of infrastructure.

METHODOLOGY AND DATA

Access to Infrastructure variable and Principal Component Analysis

Access to infrastructure variable is created by using the data of access to electricity, access to water and access to sanitation by using principal component analysis (PCA), which can be introduced as a "dimension reduction tool," and "an analysis of identification of the pattern of data". It largely uses to condense a large set of variables into a small number of variables keeping proportional weight of the variables (Jolliffe and Cadima,2016). The PCA is based on independency of the variables considering the variance of the components which is the deviation from the mean point leaving vectors to minimize interdependency. Covariance measures the amount of each vector varies from the mean value with respect to other vectors. This analysis creates a new de-correlated set of data without changing the direction and maximizing the covariance. The direction of the analysis is confirmed by eigenvectors under linear transformation. The change of the dimension is denoted by eigenvalues. Therefore, PCA minimizes correlation when transforming variables into a new variable while weighing each component accordingly. High correlation leads to flaws in methodology and spurious estimated results which is misleading. The correlation is high in this study and therefore PCA is used following previous literature to control the issue of high correlation (Calderon & Serven,2010). Correlation between (i) GDP per capita income and access to sanitation (0.75), (ii) access to water and electricity (0.73), and (iii) GDP per capita and access to water (0.72) are high as finds in table 2. The second reason is (b) Upward trend of access to water, access to sanitation, and access to electricity in sample countries, and they can be condensed into one variable.

Poverty data, personal remittance, population growth rate, literacy rate of age 15 and above, Gini and unemployment data are obtained from World Bank Development Research Group data while access to water and sanitation data is from WHO/UNICEF Joint

Monitoring Programme (JMP) for Water Supply and Sanitation data set. Access to electricity data is from the World Bank, Sustainable Energy for All (SE4ALL) database. Access to electricity, Access to Water and sanitation, unemployment, personal remittance, population growth rates, literacy rate, and poverty data are in percentage. (Appendix 2). This analysis meets missing data. Missing data is treated by using the interpolation technique when the data is missing between known values.

The methodology of the paper is developed on (Marinho, 2017),where poverty is a function of infrastructure and analyzed for the states of Brazil for 2000-2009. Marinho (2017) is a country-specific study and the equation designed to capture country-specific features. Country characteristics are different, and tailor-made model specification cannot capture the features in each country since this study is a country specific study. The population growth rate is another reason to persisting a high level of poverty in developing countries as small amount of wealth is shared among large population due to high income inequality (Makkik,Ghani,and Sultan, 2005). Therefore, the population growth rate is added to the original equation. Government budget revenue data is not available in some countries. Therefore, government budget revenue is not considered in the study. Average years of schooling are replaced with literacy rate as the years of schooling reflect the length of the period of study. The period unable to capture the literacy rate of the population.

Low level of access to infrastructure is another reason for poverty, as finds in literature. The infrastructure variable in the original equation revised introducing access to infrastructure variable by the percentage of people. At this point, the infrastructure selected to calculate the multidimensional poverty index (MPI) was used as they are recognized as infrastructure reasoning, mostly to poverty. Therefore, access to electricity, access to sanitation, and access to water by 100 people were used to create access to infrastructure variable. Personal remittance is introduced to the equation as the majority of poor people in developing countries work low skilled jobs in developed countries, and as a result, the share of personal remittance in GDP is increasing. The other reason is personal remittances in developing countries mainly used to consumption (Christian and Jean-Louis, 2010) (Karine, 2014). Therefore, equation (1) can be written as follows introducing access to electricity (*ae*), access to improved sanitation (*as*), access to clean water (*aw*), personal remittance (*rem*), and population growth rate (*pgr*).

$$p_{it} = \beta_0 + \beta_1 p_{it-1} + \beta_2 inf_{it} + \beta_3 pib_{it} + \beta_4 aem_{it} + \beta_5 gini_{it} + \beta_6 regov_{it} + \beta_7\, des_{it} \text{-------- (1)}$$

Whereas,

p_{it} = poverty index
p_{it-1} = Poverty index of the previous year
inf_{it} = Infrastructure Index
pib_{it} = GDP per capita
aem_{it} = Average years of schooling for the people of 25 years old
$gini_{it}$ = Gini index
$regov_{it}$ = Government budget revenue
des_{it} = Unemployment rate of the country "*i*" th state of Brazil and "*t*" th time.

$$p_{it} = \beta_0 + \beta_1 ae_{it} + \beta_2 as_{it} + \beta_3 aw_{it} + \beta_4\, p_{it-1} + \beta_5 gdpc_{it} + \beta_6 rem_{it} + \beta_7 pgr_{it} + \beta_8 lit_{it} + \beta_9 unem_{it} + \beta_{10} gini_{it} \text{ ---------- (2)}$$

Equation 3 is the equation with the access to infrastructure variable *(infin)* combining access to electricity (*ae*), access to improved sanitation (*as*), access to clean water (*aw*),

$$p_{it} = \beta_0 + \beta_1\, infin_{it} + \beta_2 p_{it-1} + \beta_3\, gdpc_{it} + \beta_4\, rem_{it} + \beta_5\, pgr_{it} + \beta_6\, lit_{it} + \beta_7\, unem_{it} + \beta_8\, gini_{it} \text{----------(3)}$$

Poverty reduction effect of infrastructure is a long-run process, and this paper estimated the long-run effect of each variable using the lag effect of the dependent variable. In equation (4), "*b*" is the short-run effect of the "x" variable at a time "*t.*"

$$Y_t = a + bx_t + cy_{t-1} \text{ ----------(4)}$$

The long-run equation can be written as,

$Y_t = Y_{t-1}$ where Y_∞ . The long-run effect can be derived, following the below steps.

$$Y = a + bx + cy$$

$$(1-c)y = a + bx$$

$Y = \frac{a}{1-c} + \frac{b}{1-c}x$ where long run effect will be $\frac{b}{1-c}$. Following $\frac{b}{1-c}$ long-run effect of each variable on poverty is estimated

.

The percentage of population in extreme poverty is determined by access to infrastructure, personal remittance, population growth rate, literacy rate, unemployment, and income disparity. This paper estimates equation (3) using the fixed effect model. At this point, this paper divides the group of countries into two depending on the income level following (World Bank, 2017) as Lower Middle-income developing countries (LMI) and Upper Middle-Income developing countries (UMI). Dependent variable is poverty headcount ratio at USD 1.90 per day and USD 3.20 per day. Then, this paper estimated the individual impact of access to infrastructure in country groups and finds each of the infrastructure variables contributes to reducing poverty (Appendix 3), having significant results of poverty reduction effect of access to infrastructure individually, the paper composed access to infrastructure variables. The theoretical literature on determinants of poverty provides an inconsistency in the findings. Therefore, this paper tested the causality to observe the direction of the relationship between access to infrastructure and poverty reduction (Appendix 5). At this point, the unidirectional causality is investigated, running from access to infrastructure to both lines of poverty representing lower access to electricity, sanitation, and water is a reason to extreme poverty in sample countries and poverty is not a reason for lack of infrastructure. Since the causality is unidirectional, running from infrastructure to poverty, the paper estimates the effect of access to infrastructure to poverty. Equation 3 is estimated under three models.

Ordinary least square method is used at this stage to control unknown parameters, and the model is to be unbiased. This paper occupies panel data and both fixed effects (FE) and random effects (RE) models are estimated. Fixed effects models control country-specific effects and time-specific effects, and therefore, results are not correlated. Therefore, the results generated by the model are not biased. The RE model uncorrelated with the independent variable and assumes time-specific and country-specific variations are random. The Hauseman test[5] results used to define the better model. In the sample of UMI, the sample size is small, and the number of years is large. The fixed effect model is recommended by Gujarati (Gujarati and Dawn, 2011:291) when the sample size is smaller than the number of years. The maximum lags are used in the model is one. Table 2 explains correlation matrix and the correlation between PHC1.90 and PHC3.20 is 0.93, which are dependent variables in this study as poverty is analyzed under two poverty lines.

[5] Hauseman test helps to select a better model between fixed effects and random effects, having the null hypothesis of preference to the random effect model. An alternative hypothesis is the preference of the fixed effect model. Hauseman test detects the correlation between the errors and the regressors.

Table 2 Correlation Matrix with Original Data

variable	*phc190*	*phc320*	*ae*	*as*	*aw*	*gdpc*	*gini*	*lit*	*pgr*	*prem*	*unem*
phc190	1										
phc320	0.9398	1									
ae	-0.6743	-0.6693	1								
as	-0.8926	-0.9474	0.5825	1							
aw	-0.7918	-0.8256	0.7337	0.6620	1						
gdpc	-0.6804	-0.8039	0.5924	0.7578	0.7230	1					
gini	-0.4568	-0.5586	0.3366	0.5568	0.3757	0.4960	1				
lit	-0.5111	-0.6164	0.6659	0.6690	0.3730	0.4591	0.6387	1			
pgr	0.2718	0.3634	-0.2232	-0.4786	-0.0988	-0.1653	0.0296	-0.5612	1		
prem	0.0847	0.1886	-0.3091	-0.1243	-0.2653	-0.5553	0.2179	0.0137	0.0393	1	
unem	0.0509	0.0835	-0.1958	0.0831	-0.4353	-0.0116	0.2786	0.2255	-0.1725	0.2056	1

Note: Variables are explained in Appendix 2
Source: Author

Table 3 Composition of access to Infrastructure Variable

Eigenvalues:(sum =3, Average =1)					
Variable	Value	Difference	Proportion	Cumulative value	Cumulative Proportion
Access to electricity	2.2722	1.8362	0.7574	2.2722	0.7574
Access to sanitation	0.4359	0.1441	0.1453	2.7081	0.9027
Access to water	0.2918		0.0973	3	1

Note: Proportion of electricity weights most followed by sanitation and water
Source: Author

Table 3 explains the proportional composition of access to infrastructure variable. Eigen values explain the variance of each component of the infrastructure variable that composites access to electricity, sanitation and water. Since this study occupies three variables the total value of Eigenvalues is 3 and average is 1. The system generates relative importance of each component where the first component carries largest variance. The factor loading of electricity amounts to 0.76, water 0.15, and sanitation is 0.09 denoting electricity amounts more than 75% of the variable and water 15% and sanitation 9%. Correlation within the access to infrastructure variable is comparatively low after introducing access to infrastructure variable composed by using PCA. The highest correlation is between water and electricity, which is 0.70 (Appendix 4). These values are for access to infrastructure variables for all countries in the sample. Access to infrastructure variable is created separately for each model by using the same method. Data for each factor is the percentage of the population with access to each infrastructure. The paper estimates three models using each of access infrastructure factor and found significance in reducing poverty at USD 1.90 and USD 3.20 (Appendix 3). Table 4 sums up descriptive statistics of the model variables, and the total number of observations is 234. The highest mean and medium value are represented by *gdpc*, and the lowest is *pgr*.

Table 4 Descriptive Statistics of Infrastructure and Poverty

Variable	*ae*	*as*	*aw*	*gdpc*	*gini*	*lit*	*pgr*	*phc190*	*phc320*	*prem*	*unem*
Mean	77.54	63.44	86.13	7047.89	36.92	1.87	1.54	17.59	43.64	3.91	3.52
Median	83.52	63.25	87.90	5080.46	35.55	1.96	1.50	13.19	42.30	3.05	3.07
Maximum	100.00	96.00	98.20	25390.44	49.10	1.98	2.87	66.70	90.20	13.32	14.66
Minimum	13.45	19.80	68.90	1340.26	27.60	1.56	0.13	0.00	0.20	0.11	0.40
Std. Dev.	20.63	23.27	7.67	5349.80	5.57	0.13	0.64	16.37	27.62	3.38	2.71
Skewness	-1.18	-0.11	-0.45	1.46	0.79	-0.94	0.13	0.77	-0.13	0.84	1.80
Kurtosis	3.93	1.71	2.23	4.49	2.46	2.22	2.20	2.62	1.64	2.76	6.94
Jarque-Bera	49.97	13.18	10.83	83.38	21.50	31.86	5.55	19.58	14.82	22.37	220.61

Note: The highest mean value is represented by *gdpc* followed by access to water.
Source: Author

Table 5 Unit Root Test of the Variables of Access to Infrastructure and Poverty Reduction

Test	LLC		IPS		ADF	
	Level	FD	Level	FD	Level	FD
Gdpc	7.9483	-10.0434	10.2146	-10.6482	0.3196	127.939
probability	*1.0000*	*0.0000*	*1.0000*	*0.0000*	*1.0000*	*0.0000*
Gini	-0.8351	-4.9094	-1.2996	-4.6097	36.0743	55.9928
probability	*0.2018*	*0.0000*	*0.0969*	*0.0000*	*0.0069*	*0.0000*
Infin	-3.2318	-1.5554	0.3255	-8.1430	19.236	112.203
probability	*0.0006*	*0.0499*	*0.6276*	*0.0000*	*35.218*	*0.0000*
lit	-8.0737		-2.5450		49.3745	
probability	*0.0000*		*0.0055*		*0.0001*	
pgr	-4.0309	-14.4557	-0.3653	-16.2537	32.0811	200.455
probability	*0.0000*	*0.0000*	*0.3575*	*0.0000*	*0.0215*	*0.0000*
phc190	-1.5890	-4.3425	0.7711	-4.1908	17.5146	51.3587
probability	*0.0560*	*0.0000*	*0.7797*	*0.0000*	*0.4880*	*0.0000*
phc320	0.6038	-1.3259	4.2172	-1.7418	5.9950	36.9258
probability	*0.7270*	*0.0424*	*1.0000*	*0.0408*	*0.9962*	*0.0054*
prem	-1.8431	-5.0665	-0.4138	-6.3756	16.8276	74.1400
probability	*0.0327*	*0.0000*	*0.3395*	*0.0000*	*0.5350*	*0.0000*
unem	-1.4714	-4.6329	-0.5276	-5.7559	23.811	68.0666
probability	*0.0706*	*0.0000*	*0.2989*	*0.0000*	*0.1613*	*0.0000*

Note: Level – Level Form, FD – First difference, LLC - Levin, Lin & Chu t*, IPS - Im, Pesaran and Shin W-stat, ADF - Fisher Chi-square
Source: Author

Table 5 represents the unit root test of the variables in the analysis. Unit root test is used to detected stationarity of the series using Levin, Lin & Chu (LLC), IM, Pesaran and Shin W- (IPS), and Augmented Dicky- Fuller (ADF) tests. Null hypothesis of the unit root test is the existence of the unit root of the data series. All the variables, except the literacy rate, are stationary at the first difference, meaning the variables are non-stationary at the level form- null hypothesis is accepted at level form as probabilities are greater than 0.05. Literacy rate is stationary at level form denoting no unit root at the level form, and probability is lower than 0.05, meaning a rejection of null hypothesis at level form.

RESULTS DISCUSSION

Table 6 records the results of fixed-effect models. In all countries' sample, access to infrastructure, GDP per capita income, unemployment, literacy rate and population growth rate are significant to reduce poverty. Poverty in the previous year is responsible for the poverty of the current year. The reason for the poverty in Asia is chronical and results keeps consistent with the findings of (Dowling, 2009). Access to infrastructure and poverty has a negative relationship where more access to infrastructure causes to reduce poverty. The expected sign is negative, and results speak a lack of access to infrastructure is a reason for poverty where elasticity of access to infrastructure is -2.74 and -6.40 of poverty at USD 1.90 and 3.20 respectively. This finding is consistent with the idea of (Bandre, 2015) (Zaure, 2007) explaining reasons to poverty as lack of electricity, clean water and sanitation and provisioning them is a strategy for pro poor growth as finds in (OECD, 2007). Population growth rate is another reason for poverty having a positive relationship making conditions worse. Elasticity of population growth to poverty is 1.32 and 0.88 in USD 1.90 and USD 3.20 respectively. Literacy rate and poverty have a negative relationship explaining lack of literacy leads to poverty where 1% increase in literacy rate reduces poverty by 8% and 14% in USD 1.90 and USD 3.20 poverty lines respectively. The relationship between personal remittance and poverty is also negative denoting lack of income is another reason for poverty.

Lower middle-income countries denote the same results as all sample countries with different coefficients. Major reason for poverty is lack of infrastructure showing elasticities of 6 and 2.2 followed by unemployment 0.67 and 0.33 at USD 1.90 and USD 3.20 poverty lines respectively. The results of this study incorporate with higher population growth rate causing poverty. 1% increase in literacy rate can reduce poverty by 32% and 30% at USD 1.90 and USD 3.20 poverty lines respectively. These countries show wider income disparity, and the relationship between income disparity and poverty is positive depends on the transition level. Results of upper-middle-income countries keep consistency with lower-middle-income countries. Lack of access to infrastructure, poverty of the previous year, GDP per capita income, population growth rate are the reasons to poverty. Gini coefficient is not significant in upper middle-income countries which consists of Malaysia and Thailand. Malaysia enjoys reduction in income disparity in inter and intra-ethnic groups (Ravallion, 2019) and Thailand curbs at policy level (World Bank, 2019).

The effect of access to infrastructure to reduce poverty is a long-term process. Therefore, the long-term effect of access to electricity, sanitation, and water on poverty is estimated, and results are presented in Table 7 while the long-term effect of each individual variable in equation (3), following equation (4). The results suggest with respect to infrastructure, long run poverty reduction effect of each variable is lager denoting poverty reduction is a long run process.

Long run poverty reduction effect of infrastructure is larger than the other variables. Theoretically contribution of infrastructure trickles down to poorest group indirectly and consumes times. The results explain large effect of infrastructure reducing poverty of negative 13.8 and negative 30.9 in USD 1.90 and 3.20 poverty lines followed by GDP per capita and population growth. Sample countries report higher poverty level of 29.5(India),12.7(Bangladesh) followed by 7.2(Indonesia) at USD 1.90. Results of the paper speaks the causes of persisting higher poverty level. Population growth rate and poverty have a positive sign showing the developing countries are poor as a result of a higher population growth rate. Unemployment is another positively significant variable, denoting a higher level of unemployment leads to a larger magnitude of poverty incident. Gini coefficient explains both poverty lines are affected by inequality; where larger the inequality, the bigger the poverty effect. Lower GGP per capita, higher population growth rate, larger inequality followed by lack of access to infrastructure explains the nature of poverty in sample countries, and theoretically, the findings support the vicious circle of poverty.

Personal remittance has a negative significant effect reflecting the ability of poverty reduction. Literacy has a negative significance; denoting education has a larger impact on poverty reduction in the long run. These findings suggest countries with a lower level of access to infrastructure suffer more poverty, and the effect of poverty will be larger in the long run.

Table 6 Results of Access to Infrastructure and Poverty Reduction

Model	AC		LMIC		UMIC	
Poverty Line / Variable	PHC190	PHC320	PHC190	PHC320	PHC190	PHC320
Infin	-2.7427***	-6.3931***	-5.9957***	-2.2510**	-2.2853***	-6.5925***
	(-2.95)	(-4.86)	(-3.61)	(-1.93)	(-2.08)	(-3.94)
$Pov_{(it-1)}$	0.8008***	0.7928***	0.3760***	0.7925***	0.6060***	0.3678***
	(14.49)	(15.46)	(6.25)	(7.98)	(6.32)	(2.48)
gdpc	-0.6852**	-0.3402**	-0.1635**	-0.1413**	-0.1369***	-0.3213***
	(-2.12)	(-2.17)	(-2.11)	(-2.07)	(-2.69)	(-2.74)
unem	0.1710**	0.7447*	0.6677**	0.3333**	0.0411	0.3240*
	(1.70)	(1.94)	(2.00)	(1.95)	(0.78)	(2.49)
lit	-0.0870**	-0.1454**	-0.3209***	-0.2964***	-0.0348*	-0.8412*
	(-2.04)	(-2.04)	(-4.75)	(-3.48)	(-1.91)	(-2.45)
gini	0.2808**	0.5845***	0.6133***	0.0651*	0.0121	0.0676
	(2.60)	(3.62)	(3.75)	(1.46)	(0.58)	(0.21)
pgr	1.3250*	0.8820**	0.7592***	0.1322**	0.2723*	0.1814*
	(1.90)	(2.41)	(2.63)	(2.07)	(1.87)	(2.52)
prem	-0.1530	-0.2514	-0.0085	-0.0544	-0.2862	-0.7777*
	(-0.87)	(-0.94)	(-0.02)	(-0.27)	(-0.31)	(-2.52)
R^2	0.97	0.93	0.97	0.98	0.94	0.95
Number of Observations	125	125	89	89	32	32
Number of Cross-sections	9	9	7	7	2	2

Note: AC- All developing countries in the Asia; LMIC- Lower middle-income countries in Asia; UMIC- Upper middle-income countries in Asia; PHC190- Poverty headcount ratio at USD 1.90 per day; PHC320- Poverty headcount ratio at USD 3.20 per day; T values are in parenthesis *** significance level at 1%; ** significance level at 5%; *significance level at 10%

Source: Author

Table 7 Long Term Effect of Infrastructure in Poverty Reduction

Model	Developing Countries in Asia				Lower Middle-Income Countries				Upper Middle-Income Countries			
Poverty Line	PHC190		PHC320		PHC190		PHC320		PHC190		PHC320	
Variable	SR	**LR**	SR	**LR**	SR	**LR**	SR	**LR**	SR	**LR**	SR	**LR**
Infin	-2.74	**-13.77**	-6.39	**-30.85**	-5.99	**-9.61**	-2.25	**-10.85**	-2.28	**-5.80**	-6.59	**-10.43**
gdpc	-0.69	**-3.44**	-0.34	**-1.64**	-0.16	**-0.26**	-0.14	**-0.68**	-0.13	**-0.35**	-0.32	**-0.51**
unem	0.17	**0.86**	0.74	**3.59**	0.66	**1.07**	0.33	**1.61**	0.04	**0.10**	0.32	**0.51**
lit	-0.09	**-0.44**	-0.15	**-0.70**	-0.32	**-0.51**	-0.29	**-1.43**	-0.03	**-0.09**	-0.84	**-1.33**
gini	0.28	**1.41**	0.58	**2.82**	0.61	**0.98**	0.06	**0.31**	0.01	**0.03**	0.06	**0.11**
pgr	1.33	**6.65**	0.88	**4.26**	0.75	**1.22**	0.13	**0.64**	0.27	**0.69**	0.18	**0.29**
prem	-0.15	**-0.77**	-0.25	**-1.21**	-0.08	**-0.14**	-0.05	**-0.26**	-0.28	**-0.73**	-0.77	**-1.23**

Note: PHC190- Poverty headcount ratio at USD 1.90 per day; PHC320- Poverty headcount ratio at USD3.20 per day; SR– Short Run, LR- Long Run
Source: Author

CONCLUSION AND LIMITATIONS

Poverty alleviation is the central theme of the discussion of the decade, and countries follow different strategies to eradicate poverty as it is a critical issue. Infrastructure development is one of the identified sources of reducing poverty in developing countries, it contributes directly through access and indirectly through education and health to reduce poverty improving human capital. Developing countries face investment bottlenecks and policy makers have to decide prioritizing options between physical capital and human capital. Findings of the study guides to prioritize physical capital as human capital can be improved through physical capital and poverty reduction effect is larger in long run.

Investment in infrastructure increases access to better standard infrastructure and better provision of infrastructure enables improving access to clean water, sanitation, electricity, health, and education. Therefore, infrastructure provision is important in reducing poverty, both socially and economically. Access to infrastructure and poverty has a unidirectional causality running from infrastructure to poverty. The link between access to infrastructure and poverty is no longer inconclusive. The reason for poverty in developing countries is not only monetary but also lack of access to infrastructure facilities which is termed as social infrastructure in literature and making living standard lower. Dynamic policies are important in reducing to make poor people capable of breaking the poverty such as making capable of poor people to access to electricity, improved water, sanitation, and education.

The study concludes the importance of access infrastructure reducing poverty occupying data from 1990-2015 samples of 9 developing countries in Asia. Infrastructure poverty linkage is measured under fixed effect and keep consistency with theoretical evidence, and the long-run effect is much larger than that of short-run effect. The finding will be interesting to policymakers as the aim of SDGs is to reduce all forms of poverty by 2030.

Closing down infrastructure gap, making infrastructure accessible and affordable, make

poor beneficiaries of education, attacking persisting income inequality, controlling population growth, reduce unemployment and encourage remittance will encourage to reduce poverty in the sample countries. The limitation of the study is the unavailability of data and previous literature in terms of access to infrastructure and poverty reduction. This study focuses on developing countries in Asia only. In future studies, I suggest to increase the sample size to make a cross comparison of the developing countries in Asia and Africa as the largest proportion of poverty owned by Africa. It is noteworthy to remember investing in one particular type of infrastructure unable to generate large poverty reduction effects when a country undergoes huge infrastructure gaps.

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Appendix

Appendix 1 Classification of Economies in the Study

Code	Long Name	Income Group	Region
BGD	People's Republic of Bangladesh	Lower middle income	South Asia
IND	Republic of India	Lower middle income	South Asia
IDN	Republic of Indonesia	Lower middle income	East Asia & Pacific
PAK	Islamic Republic of Pakistan	Lower middle income	South Asia
PHL	Republic of the Philippines	Lower middle income	East Asia & Pacific
LKA	Democratic Socialist Republic of Sri Lanka	Lower middle income	South Asia
THA	Kingdom of Thailand	Upper middle income	East Asia & Pacific
MYS	Malaysia	Upper middle income	East Asia & Pacific
VNM	Vietnam	Lower middle income	East Asia & Pacific

Note: Lower middle-income economies are those with a GNI per capita between USD 996 and USD 3,895; Upper middle-income economies are those with a GNI per capita between USD 3,896 and USD 12,055; Source: World Bank List of Economies (2017).

Appendix 2 Variables Description and Data Source

Variable	Description	Source
Access to Electricity *(ae)*	Access to electricity (% of the population with access)	World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.
Access to Sanitation *(as)*	Improved sanitation facilities (% of the population with access)	WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation http://www.wssinfo.org
Access to Water *(aw)*	Improved water source (% of the population with access)	WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation http://www.wssinfo.org

Personal Remittance *(prem)*	Personal remittances received (% of GDP)	World Bank staff estimates based on IMF balance of payments data, and World Bank and OECD GDP estimate.
Unemployment *(unem)*	Unemployment, total (% of the total labor force) (modeled ILO estimate)	International Labor Organization, ILOSTAT database
Population Growth Rate *(pgr)*	Population growth (annual %)	Derived from the total population. Population source: (1) United Nations Population Division. World Population Prospects: 2017 Revision, (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme.
Gini Coefficient *(gini)*	GINI index (World Bank estimate)	World Bank, Development Research Group http://iresearch.worldbank.org/PovcalNet/index.htm
Literacy Rate *(lit)*	Literacy rate, adult total (% of people ages 15 +)	United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics.
GDP per capita *(gdpc)*	GDP per capita, PPP (constant 2011 international $)	World Bank, International Comparison Program database.
PHC $ 190 *(phc190)*	Poverty headcount ratio at $1.90 a day (2011 PPP) (% of the population)	World Bank, Development Research Group. http://iresearch.worldbank.org/PovcalNet/index.htm
PHC $ 320 *(phc320)*	Poverty headcount ratio at $3.20 a day (2011 PPP) (% of the population)	World Bank, Development Research Group. http://iresearch.worldbank.org/PovcalNet/index.htm

Source: Author

Appendix 3 Access to Infrastructure and Poverty Reduction

Variable	All Countries		LMIC		UMIC	
	Phc190	Phc320	Phc190	Phc320	Phc190	Phc320
Access to Electricity	-0.5074***	-0.9090***	-0.3691***	-0.5268***	-0.2353***	-1.1362***
t-Statistic	(-10.74)	(-12.39)	(-6.62)	(-7.36)	(-11.66)	(-18.27)
R^2	0.35	0.64	0.21	0.26	0.74	0.87
Access to Sanitation	-0.6275***	-1.1140***	-0.6613***	-0.9731***	-0.5378***	-2.6571***
t-Statistic	(-25.04)	(-37.78)	(-16.69)	(-22.39)	(-6.75)	(-8.54)
R^2	0.74	0.87	0.63	0.76	0.48	0.60

Access to Water	-1.5312***	-2.6510***	-1.3082***	-1.7092***	-0.5313***	-2.6571***
t-Statistic	(-15.86)	(-17.73)	(-10.00)	(-9.30)	(-9.83)	(-8.54)
R^2	0.54	0.61	0.38	0.36	0.66	0.60
Periods Included	26	26	26	26	26	26
Cross-sections included	9	9	7	7	2	2
(unbalanced) observations	215	215	165	165	50	50

Note: LMIC- Lower middle-income countries, UMIC- Upper Middle-income countries *** significant at 1%, Phc190-Poverty headcount ratio at $1.90 a day (2011PPP) (% of population), Phc320- Poverty headcount ratio at $3.20 a day (2011PPP) (% of population)

Source: Author

Appendix 4 Correlation Matrix of the Access to Infrastructure Variable

	Electricity	Sanitation	Water
Electricity	1		
Sanitation	0.5922	1	
Water	0.7076	0.6062	1

Source: Author

Appendix 5 Results of Causality Test of Access to Infrastructure and Poverty Reduction

Null hypothesis	F statistic	Probability
INDAC does not granger cause phc190	5.0062	0.0076*
Phc190 does not granger cause INDAC	0.7399	0.4785
INDAC does not granger cause phc320	8.0351	0.0005*
Phc320 does not granger cause INDAC	0.9929	0.3725
INDLMI does not granger cause phc190	5.3129	0.0059*
Phc190 does not granger cause INDLMI	0.7204	0.4882
INDLMI does not granger cause phc320	5.8963	0.0035*
Phc320 does not granger cause INDLMI	0.2492	0.7798
INDUMI does not granger cause phc190	2.5087	0.0938*
Phc190 does not granger cause INDUMI	0.9574	0.3923
INDUMI does not granger cause phc320	11.2597	0.0001*
Phc320 does not granger cause INDUMI	0.1199	0.8873

Note: INDAC-Access to Infrastructure Index of all sample countries
INDLMI-Access to Infrastructure Index of lower middle-income countries
INDUMI-Access to Infrastructure Index of upper middle-income countries
Phc190-Poverty headcount ratio at $1.90 a day (2011PPP) (% of population)
Phc320- Poverty headcount ratio at $3.20 a day (2011PPP) (% of population)
Source: Author