Infrastructure and Growth and Poverty in Bangladesh

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I. INTRODUCTION

It is generally acknowledged that an efficient supply of infrastructure is conducive to economic development. Infrastructure is argued to be one of the critical factors for economic growth in the low income countries like Bangladesh. Efficient infrastructure can promote sustainable economic and social development. Infrastructure is the capital stock that provides public goods and services. It produces various effects, including those on production activities and quality of life for the households, which thus permeate the entire society. The development of infrastructure is likely to alleviate poverty if it improves the quality of life for the poor.

Infrastructure services are crucial to poverty reduction and the achievement of the Millennium Development Goals (MDGs) in Bangladesh. Access to better infrastructural services can improve health and education outcomes. For example, improved water and sanitation services reduce child mortality from waterborne diseases. They also support better education and health outcomes, for example by allowing more time for children to seek education and by improving access to health services. Reliable basic infrastructure services help small farmers market their crops, encourage the development of non-farm income opportunities for the poor, thus acting as a critical input into moving out of poverty.

Efficient and reliable infrastructure services are essential for economic growth and have a major impact on the investment climate in Bangladesh. Unreliable infrastructural services have led to substantial costs on the Bangladeshi economy and hindered growth. For example, power shortages reduce industrial output and GDP growth. Congestion in the nation’s ports leads to higher shipping costs, reducing the country’s competitiveness. Bangladesh lags behind other countries in the South Asia region in terms of providing access to modern infrastructure services.

National averages do not reveal important differences in access to services between urban and rural areas in power and telecommunications. Also, there are significant regional disparities in terms of infrastructural development, and regions in remote distance from the capital city are worse off.

Under the Sixth Five Year Plan (2010-2015) Bangladesh government aims to achieve 8 percent growth in real GDP by the end of the plan period. However, poor status of infrastructural development is acting as a serious binding constraint to realizing that growth target. Improving the country’s infrastructural system will thus be essential for achieving high economic growth which is important if poverty reduction is to accelerate.

Against this backdrop, this paper investigates the impacts of infrastructural development on growth and poverty in the context of Bangladesh economy. In this paper, three separate techniques are used to explore the linkage between infrastructure and growth and poverty in Bangladesh. The first technique involves the use of the Principal Component Analysis (PCA) to construct an Infrastructure Development Index (IDI) at the district level. A multi-variate cross-section regression model is used to link the constructed IDIs with the poverty status of the districts. The second technique involves the use of a SAM multiplier model to explore the economy-wide impacts of infrastructural investment in Bangladesh. A SAM is a square matrix with columns for expenditure and rows covering income accounts. It combines input-output data with national accounts data to reflect the circular flow of income at a particular point in time. In this context, its key use is to assess the economy wide effects of a particular exogenous impact that leads to different expenditure patterns. Finally, a CGE model is used to explore the macro, sectoral, welfare and poverty impacts of reduction in transport margins. CGE analysis allows for the assessment of the impacts of exogenous shocks within a constrained optimization framework (i.e. changes in quantity are restricted). At the core of the CGE model is a set of equations describing the behavior of various economic agents (such as firms and households) when faced with changes in relative prices.

II. INFRASTRUCTURE AND ECONOMIC GROWTH: REVIEW OF LITERATURE

There is a large volume of literature highlighting the significant role infrastructure plays for economic development. Canning and Pedroni (1999) emphasized on the long run relationship between physical infrastructure and per capita income of several countries using a panel data for the period of 1952-1992. The regression results suggest that countries, on average, were approximately at growth maximizing level in case of telecom sector. In this sector, long run effect exhibited positive sign for some countries and negative for the rest of others. That means, services of telecom was under-supplied in some countries, where in other countries, it was over-supplied. In case of electricity generating capacity, significant number of countries stood at below the growth maximizing level implying that improved capacity of electricity generation would bring higher income per capita in the long run which was a clear sign of being under-provided.

Fan *et al* (1999 and 2002) estimated and compared the impact of road investment on poverty reduction through four transmitted variables between China and India. The impact of road investment through increasing agricultural productivity accounted for 20 and 30 percent reduction in poverty level in India and China respectively. Compared to China, the effect of road development through labor market was higher by a large magnitude, as because India had surplus labour with subsequent number of landless and sub-marginal farmers. Thus, road investment activities would generate employment activities massively in India. On the contrary, the indirect effect of higher economic growth in reducing poverty was larger in China than that of in India. In the first half of the 1980s significant economic growth was observed in the coastal areas of China and improved infrastructure was the main reason behind it.

Yao (2003) suggested that poverty reduction strategy would need significant productivity in farm and non-farm sector so that poor people can get easy access in the market and produce efficient output. To enhance market productivity in case of farm and non-farm sector, substantial investment in infrastructure is mandatory. Lack of information, fluctuation in price level of input and output, geographical distances often play as barriers as these would hamper access to information, marketing goods, employment activities and thus causes serious market distortions. Rural investment in infrastructure would play a significant role by augmenting efficiency of market mechanism and alleviate poverty and boost economic growth.

Estache *et al* (2005) used growth model to relate economic growth with infrastructure in the context of 41 African countries with 25 year time span (1976-2001). The regression results showed a good linkage between infrastructural sub-sectors and growth in the African economies. Except sanitation, all the sub sectors (infrastructural) made significant impact on GDP per capita after controlling education and total investment. The result was highly significant and noteworthy for telecom and road followed by electricity which implied greater investment in these three sectors would promote higher economic growth.

The paper by Khandakar *et al* (2006) exposed how the rural road investment would make enormous positive impact on several agricultural indicators and socio-economic characteristics and hence reduce poverty in Bangladesh. Using household level panel data the paper estimated the income and consumption benefits of rural road investment through agricultural wage rate, input and output price, crop price, schooling rate of boys' and girls'. This paper also focused on some significant reduction in poverty due to road development projects.

The paper by Ogun (2010) demonstrated the needs for social and physical infrastructural development to reduce ever escalating poverty rate in Nigeria. A structural autoregressive model was adopted for the Nigerian economy and the analysis showed long run effects of higher consumption per capita as a result of increasing investment in infrastructure. The analysis further revealed that investment in education and health (considered as social infrastructure) would make significant and positive impact on poverty reduction than that of physical infrastructure in Nigeria.

Raihan and Khondker (2011), using SAM multiplier model and CGE model, examined the potential economy-wide impacts of Padma Bridge (a very large bridge to be constructed over river Padma) in Bangladesh which will connect the South-West part to the rest of the country. The study indicated significant impact on GDP growth and poverty reduction out of the construction of this bridge.

III. DISTRICT LEVEL INFRASTRUCTURE DEVELOPMENT INDEX (IDI) AND POVERTY IN BANGLADESH

This paper develops a composite index called the Infrastructure Development Index (IDI) in Bangladesh. The IDI can be an analytical tool for measuring the infrastructural development at different administrative levels, such as, Upazilas, Districts and Divisions, of the country. The instrument will facilitate inter-temporal as well as cross-sectional analysis of the levels of attainment in physical and social infrastructure among different regions of Bangladesh and will draw policy attention to crucial parameters which need to be dealt with effectively.

The method of Principal Component Analysis (PCA) has been used to construct district level IDI in Bangladesh. The objective of PCA is to reduce the dimensionality (number of indicators) of the data set but retain most of the original variability in the data. This involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible. Thus using PCA one can reduce the whole set of indicators into few *factors* (underlying dimensions) and also can construct *dimension* index using factor-loading values as the weight of the particular variable.

The task under PCA is to extracting the Principal Components (factors). This depends upon the Eigen value of the factors. The Eigen value of a Principal Component (PC) explains the amount of variation extracted by the PC and hence gives an indication of the importance or significance of the PC. According to Kaiser's Criterion only PCs having Eigen values greater than one should be considered as essential and should be retained in the analysis. Weight for each variable is calculated from the product of factor loadings of the principal components with their corresponding Eigen values. At first step all factor loadings are considered in absolute term. Then the principal components, which are higher than one, are considered and their factor loadings are multiplied with the corresponding Eigen values for each variable. In the next step, the weight for each variable is calculated as the share of the aforementioned product for each variable in the sum of such product. The index is then calculated using the following formula

$$Index = \frac{\sum V_i \sum F_{ij} E_j}{\sum F_{ij} E_j}$$

Where I is the Index, V_i is the i^{th} Indicator ; F_{ij} is the factor loading value of the i^{th} variable on the j^{th} principal component; E_j is the Eigen value of the j^{th} principal component

Table 1 presents the list of indicators used to construct district wise IDIs in Bangladesh. The indicators covers both physical and social infrastructure. The physical infrastructure includes electricity, water, road, telephone and gas, and the social infrastructure includes education and health. It should however be mentioned that there are 64 districts in Bangladesh, and for the current analysis four districts in the hill-tracts, namely Bandarban, Khagrachari, Rangamati and Cox's Bazar are not included because of lack of data.

Table 1: Indicators used to construct IDI

Indicator	Description	Sources of Data
Education	District-wise number of schools per thousand population (age between 5 and 14)	Bangladesh Bureau of Statistics
Health	District-wise number of health facilities per thousand population	Bangladesh Bureau of Statistics
Electricity	District-wise % of households having electricity	Household Income and Expenditure Survey 2005
Water	District-wise % of households having access to arsenic free tube-well	Household Income and Expenditure Survey 2005
Road	District-wise length of paved and semi-paved road per Sq Km	Bangladesh Bureau of Statistics
Telephone	District-wise % of households having telephone (land or mobile)	Household Income and Expenditure Survey 2005
Gas	District-wise % of households having access to gas for household use	Household Income and Expenditure Survey 2005

Using the PCA, the respective weights of the indicators under consideration for the construction of IDI can be derived. Table 2 provides such calculated weights. It seems that 'electricity' indicator constitutes the highest weight (19.74 percent) in the construction of IDI, whereas the 'health' indicator corresponds to the lowest weight (7.61 percent).

Table 2: Derived weights of Indicators from PCA

Indicator	Weight (%)
Education	11.03
Health	7.61
Electricity	19.74
Water	10.05
Road	13.14
Telephone	19.27
Gas	19.16
Total	**100.00**

Source: Author's calculation using PCA

The weights reported in Table 2 are used to calculate the IDIs at the district level in Bangladesh. The calculated district-wise IDIs are reported in Table 3. Dhaka appears to have the highest index value whereas Sherpur has the lowest value. Among the top ten ranked districts 6 districts are from Dhaka division. In contrast, among the lowest ten ranked districts 5 are from Rangpur division. This suggests some significant regional disparities in terms of infrastructural development in Bangladesh.

Table 3: District-wise IDI in Bangladesh

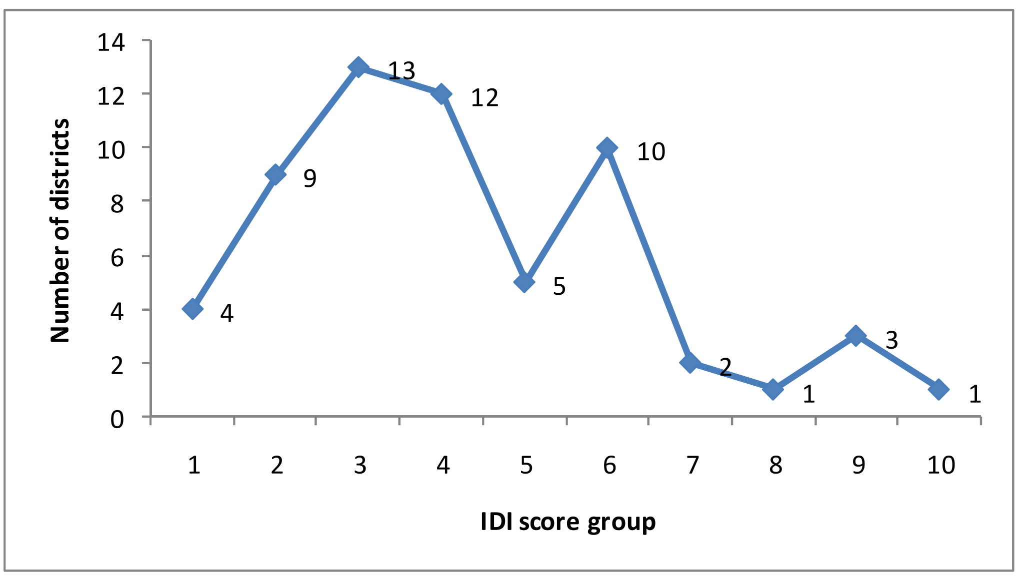
District	Infrastructure Development Index (IDI)	Rank
Dhaka	0.694875	1
Sylhet	0.625758	2
Narayanganj	0.591155	3
Narshingdi	0.583049	4
Munshiganj	0.533181	5
Mymensingh	0.47239	6
Feni	0.466903	7
Narail	0.455279	8
Manikganj	0.451611	9
Comilla	0.435298	10
Kustia	0.431994	11
Gazipur	0.421155	12
Rajshahi	0.418778	13
Barisal	0.412171	14
Gopalganj	0.411386	15
Noakhali	0.410257	16
Chittagong	0.407559	17
Pirojpur	0.386097	18
Jhenaidaha	0.366994	19
Brahmanbaria	0.365588	20
Meherpur	0.361573	21
Chandpur	0.359318	22
Moulovibazar	0.349181	23
Faridpur	0.343698	24
Nawabganj	0.338847	25
Jessore	0.338084	26
Habiganj	0.333445	27
Barguna	0.328367	28
Gaibandha	0.317615	29
Kishoreganj	0.315898	30
Khulna	0.31048	31
Pabna	0.302613	32
Madaripur	0.299536	33
Tangail	0.299388	34
Sunamganj	0.288533	35
Magura	0.28467	36
Satkhira	0.284498	37
Bhola	0.27813	38
Rajbari	0.27687	39
Joypurhat	0.27646	40
Shariatpur	0.263488	41
Chuadanga	0.260901	42

District	Infrastructure Development Index (IDI)	Rank
Lakshmipur	0.258985	43
Sirajganj	0.258351	44
Bagerhat	0.256095	45
Jamalpur	0.255	46
Jhallokathi	0.253314	47
Rangpur	0.231607	48
Panchagarah	0.228724	49
Bogra	0.224687	50
Netrokona	0.223622	51
Kurigram	0.203444	52
Dinajpur	0.19652	53
Naogaon	0.185889	54
Thakurgaon	0.182361	55
Patuakhali	0.177837	56
Natore	0.171983	57
Nilphamari	0.146361	58
Lalmonirhat	0.121232	59
Sherpur	0.119218	60

Source: Author's calculation

Figure 1 suggests that in terms of overall ranking majority of the districts are below mediocre. Figure 1 shows the distribution of the districts according to the overall IDI score. About 72 percent of the districts fall between 1st and 5th deciles.

Figure 1: Distribution of Districts around the Score



Note: 1=lowest; 10 highest

A motivating fact is that the current analysis finds negative correlations between head-count ratio and the infrastructural indicators suggesting that lower level of infrastructural development is associated with higher poverty ratio at the district level (Table 4). This result supports the argument that poverty alleviation requires better physical and social infrastructure.

Table 4: Correlation between Individual Indices

	poverty ratio	Education	Health	Electricity	Water	Road	Telephone	Gas
poverty ratio	1							
Education	-0.0903	1						
Health	-0.0675	0.3094	1					
Electricity	-0.1006	-0.2673	-0.1269	1				
Water	-0.1364	-0.1079	-0.0825	0.1254	1			
Road	-0.0521	-0.0488	-0.0141	0.2938	0.1755	1		
Telephone	-0.1264	-0.2161	-0.0976	0.7516	0.0667	0.2445	1	
Gas	-0.1766	-0.2458	-0.1271	0.7297	-0.0201	0.2626	0.7885	1

Source: Author's calculation

Now, a more sophisticated cross-section regression is conducted with a view to exploring whether district-wise variation in the head-count poverty can be explained by the variation in the infrastructural index at the district level in Bangladesh. For this regression few control variables are also considered. All variables are expressed in natural loga. The regression equation takes the following form:

$$POV = \beta_0 + \beta_1 PCGDP + \beta_2 PHLAND + \beta_3 LLESS + \beta_4 IDI + \varepsilon$$

Where POV = head-count poverty at the district level calculated from the Household Income and Expenditure Survey (HIES) 2005

PCGDP = Per capita GDP of the districts of year 2004 obtained from Bangladesh Bureau of Statistics

PHLAND = Per household land size in the districts calculated from the Household Income and Expenditure Survey (HIES) 2005

LLESS = proportion of landless households in the districts calculated from the Household Income and Expenditure Survey (HIES) 2005

IDI = district level infrastructure development index

The regression results are reported in Table 5. It appears that the coefficient on per capita GDP is significant and negatively associated with head-count poverty indicating that districts with higher per capita GDP are associated with lower head-count poverty. The coefficient on per household land ownership is also significant and negative, which suggests that the districts with higher land per households are associated with lower head-count poverty. The coefficient on proportion of landless household is positive and significant implying that the districts with higher proportion of landless households are also having higher head-count poverty. Finally, the variable of our interest is the infrastructure development index and the coefficient of this variable is negative and significant. This suggests that the districts with higher index value of IDI are associated with lower level of head-count poverty.

Table 5: Result of the Regression

Variable	Coefficient
PCGDP	-0.035 (0.025)*
PHLAND	-0.185 (0.109)**
LLESS	0.046 (0.009)*
IDI	-0.204 (0.093)**
Number of observations	60
Adjusted R^2	0.21
Functional Form [$\chi^2(1)$]	1.054
Normality [$\chi^2(2)$]	2.685
Heteroscedasticity [$\chi^2(1)$]	0.636

Note: The regressions are based on data for 60 districts. ** and * indicate statistical significance at the 5 and 10 percent levels respectively. The figures in parentheses are the standard errors. For diagnostics, Ramsey's (1969) RESET test for functional form, Jarque-Bera test for normality of residuals and White's (1980) test for heterescedasticity are performed. The critical values for $\chi^2(1)$ and $\chi^2(2)$ at the 95 percent level are 3.84 and 5.99, which are used to test the null hypothesis of no functional form problem, normality of regression residuals and homoscedastic errors.

IV. THE SAM MULTIPLIER MODEL AND INFRASTRUCTURAL INVESTMENT IN BANGLADESH

This section uses a SAM multiplier model to understand the impacts of increase in infrastructural investment in Bangladesh economy. The advantage of using the SAM multiplier model is that it shows linkages among different sectors and actors in the economy, and thus it is able to capture the economy-wide effects of any exogenous shock. Therefore, *ex ante* assessment of various infrastructural investments can be conducted using this model.

4.1. Bangladesh Social Accounting Matrix 2007

In a narrower sense, a SAM is a systematic database and an organized, consistent classification system. As a data framework, the SAM is a snapshot, which explicitly incorporates various crucial transaction links among variables, such as the mapping of factorial income distribution from the structure of production and the mapping of the household income distribution from the factorial income distribution, among others. In a broader sense, in addition to providing a consistent classification scheme, it can be conceived as a modular analytical framework for a set of interconnected subsystems which specifies the major relationships among variables within and among these systems (see Pyatt and Thorbecke, 1976).

For the purpose of this exercise, a SAM for 2007 for Bangladesh has been constructed. SAM 2006/07 is composed of 109 accounts. The distributions of 109 accounts are: (i) 41 activities;

(ii) 41 commodities; (iii) 4 factors of production; (iv) 11 current institutions; and (v) 2 capital institutions. Data on various components of the demand side have been collected from Bangladesh Bureau of Statistics (BBS). In particular, data on public consumption by 41 commodities, gross fixed capital formation by 41 commodities, and private consumption by 41 commodities have been obtained from BBS. The vector of private consumption data is further distributed among the eight representative household groups using the unit record data of Household Income and Expenditure Survey (HIES) of 2005. Data on exports of goods and services are collected from the Export Promotion Bureau and Bangladesh Bank (i.e. the central bank of Bangladesh). Supply side composed of value added and imports of goods and services. We used disaggregated BBS data to derive the value added vector for the 41 activities. Data on imports of goods and services are collected from Bangladesh Bank and National Board of Revenue. Information on direct and indirect taxes and subsidies has been collected from National Board of Revenue and the Finance division, Ministry of Finance. Input-output flow matrix for 2006/07 has been derived by using newly conducted surveys for few selected activities and updating the previous technology vectors using secondary information. More specifically, out of the 41 activities, technology vectors of five important activities such as paddy, livestock, poultry, pharmaceuticals and information technology (ICT) have been derived using the field survey data. The technology vectors of the remaining 36 activities are updated using secondary information.

The 2007 SAM identifies the economic relations through *four types of accounts*: (i) production activity and commodity accounts for 41 sectors; (ii) 4 factors of productions with 2 different types of labour and 2 types of capital; (iii) current account transactions between 4 main institutional agents; household-members and unincorporated capital, corporation, government and the rest of the world; and (iv) two consolidated capital accounts distinguished by public and private origins to capture the flows of savings and investment. The disaggregation of activities, commodities, factors and institutions in the SAM is given in Table 6.

Table 6: Disaggregation and Description of Bangladesh SAM Accounts

Accounts	Description of Elements
Activities (41)	
Agriculture (12)	Paddy Cultivation, Grains, Jute Cultivation, Sugarcane Cultivation, Vegetables, Commercial Crops, Other Crop Cultivation, Livestock Rearing, Poultry Rearing, Shrimp Farming, Fishing, and Forestry
Manufacturing (20)	Rice Milling, Grain Milling, Fish Process, Oil Industry, Sweetener Industry, Food, Leather, Jute, Clothing, RMG, Tobacco, Wood, Chemical, Fertilizer, Petroleum, Clay Products, Cement, Steel, Machinery, and Miscellaneous
Construction (1)	Construction
Services (8)	Utility, Trade, Transport, Social Services, Financial services, Public Administration and Defense, Professional Services, and Other Services
Commodities (41)	
Agriculture (12)	Paddy Cultivation, Grains, Jute Cultivation, Sugarcane Cultivation, Vegetables,

Accounts	Description of Elements
	Commercial Crops, Other Crop Cultivation, Livestock Rearing, Poultry Rearing, Shrimp Farming, Fishing, and Forestry
Manufacturing (20)	Rice Milling, Grain Milling, Fish Process, Oil Industry, Sweetener Industry, Food, Leather, Jute, Clothing, RMG, Tobacco, Wood, Chemical, Fertilizer, Petroleum, Clay Products, Cement, Steel, Machinery, and Miscellaneous
Construction (1)	Construction
Services (8)	Utility, Trade, Transport, Social Services, Financial services, Public Administration and Defense, Professional Services, and Other Services
Factors of Production (4)	
Labour (2)	Labour Unskilled, and Labour Skilled
Capital (2)	Capital and Land
Current Institutions (11)	
Households (8)	Rural: landless, Agricultural marginal, Agricultural small, Agricultural large, Non-farm poor and Non-farm non poor Urban: Households with low educated heads, and households with high educated heads
Others (3)	Government, Corporation and Rest of the World
Capital Institutions (2)	
Public Capital	Public Capital
Private Capital	Private Capital

Source: SAM 2007 of Bangladesh

Therefore, the Bangladesh SAM 2007 captures:

- The sources of income and expenditure destination of all accounts.
- Breakdown of sectoral GDP (value addition) by labour and capital factors.
- Income generation and distribution of the institutions in general and household groups in particular.
- Patterns of expenditure by institutions including Household groups.
- The inter-dependence between activities and institutions with respect to income generation and final demand creation.
- Inter-dependence among institutions regarding transfer receipts and transfer payments.
- Role of institutions in capital formation.
- Relationship of the domestic economy with the Rest of the World or external sector.

4.2. Derivation of the SAM Multiplier[3]

The move from a SAM data framework to a SAM model or multiplier framework requires decomposing the SAM accounts into "exogenous" and "endogenous" as well as to introduce a set of assumptions pertaining to the Generalized Leontief Model (Alarcon, 2002).

[3] Further analysis is provided in Annex 1.

Generally accounts intended to be used as policy instruments (e.g. government expenditure, investment, exports) are made exogenous and accounts a priory specified as objectives or targets must be made endogenous (e.g. activity, commodity demand, factor return and household income).

For any given injection into the exogenous accounts (i.e. instruments) of the SAM, influence is transmitted through the interdependent SAM system among the endogenous accounts. The interwoven nature of the system implies that the incomes of factors, households and production are all derived from exogenous injections into the economy via a multiplier process. The multiplier process is developed here on the assumption that when an endogenous income account receives an exogenous expenditure injection, it spends it in the same proportions as shown in the matrix of average propensities to spend (APS). The elements of the APS matrix is calculated by dividing each cell by its corresponding column sum totals.

The multiplier analysis using the SAM framework helps to understand the linkages between the different sectors and the institutional agents at work within the economy. Accounting multipliers have been calculated according to the standard formula for accounting (impact) multipliers, as follows:

$$\mathbf{Y} = A\,Y + \mathbf{X} = (I - A)^{-1}\,\mathbf{X} = M_a\,\mathbf{X}$$

Where:

Y is a vector of incomes of endogenous variables

X is a vector of expenditures of exogenous variables

A is the matrix of average expenditure propensities for endogenous accounts

$M_a = (I - A)^{-1}$ is a matrix of aggregate accounting multipliers (generalized Leontief inverse).

Variations in any one of the exogenous account (i.e. in this case ΔX) will produce total impacts (ΔY) of endogenous entries via the multipliers. More specifically they are expressed as:

$$\Delta Y = M_a \times \Delta X.$$

The economy wide effect is thus equal to $\Delta Y = M_a \times \Delta X$. Thus ΔY captures the economy wide impacts on the four endogenous accounts namely: (i) gross output; (ii) commodity demand; (iii) factor returns and (iv) household. Table 7 provides the description of the endogenous and exogenous accounts and multiplier effects.

Table 7: Description of the Endogenous and Exogenous Accounts and Multiplier Affects

Endogenous (y)	Exogenous (x)
The activity (gross output multipliers), indicates the total effect on the sectoral gross output of a unit-income increase in a given account *i* in the SAM, and is obtained via the association with the commodity production activity account *i*.	
The consumption commodity multipliers, which indicates the total effect on the sectoral commodity output of a unit-income increase in a given account *i* in the SAM, is obtained by adding the associated commodity elements in the matrix along the column for account *i*.	Intervention into through activities (x = i + g + e), where i= GFC + ST (GFCF) Exports (e) Government Expenditure (g) Investment Demand (i) Inventory Demand (i)
The value added or GDP multiplier, giving the total increase in GDP resulting from the same unit-income injection, is derived by summing up the factor-payment elements along account *i*'s column.	
Household income multiplier shows the total effect on household and enterprise income, and is obtained by adding the elements for the household groups along the account i column.	Intervention via households (x = r + gt + ct), where Remittance (r) Government Transfers (gt) Corporation Transfers (ct)

The economy-wide impacts of the infrastructural investment are examined by changing the total exogenous injection vector, especially Government Expenditure (g), and Investment demand (investment in construction, infrastructure, machinery and equipment). More specifically, the total exogenous account is manipulated to estimate their effects on output (through an output multiplier), value-added or GDP (through the GDP multiplier), and household income (through household income multiplier) and commodity demand (via commodity multipliers). The calculated multipliers are provided in Annex 2.

4.3. Simulation and Results

In order to explore the economy-wide effects of infrastructural investment, in this paper we assume a scenario where the investment demands in construction, utility, transportation and social services are increased by 20 percent.

Simulated outcomes by four endogenous accounts are reported in Table 8. As a result of the 20 percent rise in investment in four infrastructural sectors, the gross output of the economy would increase by 8.17 percent compared to the base year value. The largest increase of 19.8 percent has been reported for the construction activity followed by linked activities such as forestry, utility, cement and steel. The effects on other sectors are determined by the sectoral interlinkages as can be understood from the estimates of the SAM multipliers reported in Annex 2.

Table 8: Economy Wide Benefit of Infrastructural Intervention

(In million taka unless otherwise specified)

	Endogenous SAM Accounts	Base Value	Simulation	% Change over Base
1	Paddy Cultivation	576443.08	576443.08	7.10
2	Grains	37765.603	37765.603	7.22
3	Jute Cultivation	28012.72	28012.72	1.96
4	Sugarcane Cultivation	18204.355	18204.355	7.07
5	Vegetables	130094.6	130094.6	7.02
6	Commercial Crops	153594.08	153594.08	5.50
7	Other Crop Cultivation	29588.601	29588.601	6.75
8	Livestock Rearing	178661.27	178661.27	7.00
9	Poultry Rearing	128409.57	128409.57	7.73
10	Shrimp Farming	121612.13	121612.13	3.09
11	Fishing	335527.94	335527.94	7.06
12	Forestry	210295.16	210295.16	13.58
13	Rice Millling	709737.66	709737.66	7.18
14	Grain Milling	103630.88	103630.88	7.14
15	Fish Process	15089.612	15089.612	4.04
16	Oil Industry	68308.21	68308.21	6.90
17	Sweetener Industry	25870.79	25870.79	7.24
18	Food	234142.81	234142.81	7.21
19	Leather	64680.427	64680.427	3.15
20	Jute	27054.165	27054.165	0.12
21	Clothing	247190.71	247190.71	4.14
22	RMG	734635.29	734635.29	0.79
23	Tobacco	89903.84	89903.84	7.14
24	Wood	34908.028	34908.028	8.57
25	Chemical	89544.984	89544.984	8.56
26	Fertilizer	6505.3177	6505.3177	5.48
27	Petroleum	45848.78	45848.78	7.33
28	Clay Products	27886.066	27886.066	13.49
29	Cement	74892.908	74892.908	19.57
30	Steel	197985.53	197985.53	14.55
31	Machinery	140414.79	140414.79	2.39
32	Miscellaneous	91347.215	91347.215	4.95
33	Construction	895118.93	895118.93	19.80
34	Utility	200009.98	200009.98	13.34
35	Trade	889467.64	889467.64	6.63
36	Transport	556136.63	556136.63	6.80
37	Social Services	789725.76	789725.76	9.08
38	Financial services	114316	114316	9.79
39	Public Administration and Defense	209290.97	209290.97	0.76
40	Professional Services	125122.91	125122.91	7.06
41	Other Services	618194.5	618194.5	8.42
	Gross Output	**9375170**	**766005**	**8.17**
42	Paddy Cultivation	576443.08	576443.08	7.10
43	Grains	71030.163	71030.163	7.22
44	Jute Cultivation	28012.72	28012.72	1.96

	Endogenous SAM Accounts	Base Value	Simulation	% Change over Base
45	Sugarcane Cultivation	18204.355	18204.355	7.07
46	Vegetables	147316.17	147316.17	7.02
47	Commercial Crops	235245.81	235245.81	5.50
48	Other Crop Cultivation	31488.89	31488.89	6.75
49	Livestock Rearing	183592.63	183592.63	7.00
50	Poultry Rearing	129011.69	129011.69	7.73
51	Shrimp Farming	121612.13	121612.13	3.09
52	Fishing	335527.94	335527.94	7.06
53	Forestry	210295.16	210295.16	13.58
54	Rice Millling	720616.59	720616.59	7.18
55	Grain Milling	104745.02	104745.02	7.14
56	Fish Process	15486.35	15486.35	4.04
57	Oil Industry	151435.16	151435.16	6.90
58	Sweetener Industry	61484.274	61484.274	7.24
59	Food	248619.2	248619.2	7.21
60	Leather	65166.821	65166.821	3.15
61	Jute	27276.377	27276.377	0.12
62	Clothing	330071.84	330071.84	4.14
63	RMG	748044.19	748044.19	0.79
64	Tobacco	90015.502	90015.502	7.14
65	Wood	44950.497	44950.497	8.57
66	Chemical	192118.29	192118.29	8.56
67	Fertilizer	28390.992	28390.992	5.48
68	Petroleum	247631.34	247631.34	7.33
69	Clay Products	29721.919	29721.919	13.49
70	Cement	97804.82	97804.82	19.57
71	Steel	283011.81	283011.81	14.55
72	Machinery	393920.57	393920.57	2.39
73	Miscellaneous	276760.53	276760.53	4.95
74	Construction	895118.93	895118.93	19.80
75	Utility	208034.39	208034.39	13.34
76	Trade	889467.64	889467.64	6.63
77	Transport	654328.56	654328.56	6.80
78	Social Services	789725.76	789725.76	9.08
79	Financial services	126433	126433	9.79
80	Public Administration and Defense	228924.97	228924.97	0.76
81	Professional Services	138127.98	138127.98	7.06
82	Other Services	618210.5	618210.5	8.42
	Total Commodity Demand	**10793425**	**856403**	**7.93**
83	VA Labour Unskilled	1107767.4	1107767.4	7.97
84	VA Labour Skilled	1130935.9	1130935.9	6.95
85	VA Capital	1941426.6	1941426.6	8.99
86	VA Land	288419.2	288419.2	6.58
	Value added	**4468549**	**360481**	**8.07**
87	Landless	300255.94	300255.94	7.22
88	Marginal	283096.92	283096.92	7.15

	Endogenous SAM Accounts	Base Value	Simulation	% Change over Base
89	Small	549960.56	549960.56	6.79
90	Large	341537.69	341537.69	6.67
91	RNFP	433473.45	433473.45	6.50
92	RNFNP	1156861.5	1156861.5	7.88
93	LowEdu	490267.05	490267.05	6.75
94	HighEdu	1168683	1168683	7.01
	Household income	**4724136**	**336377**	**7.12**

Source: SAM Multiplier Simulation Results

Value-added or gross domestic product of the Bangladesh is expected to increase by more than 8 percent compared to the base case. Largest return would accrue to the capital factor (8.99 percent) followed closely by unskilled labour (7.97 percent).

Due to leakages of different types (e.g. savings and direct taxes), increase in household consumption is 0.95 percentage point less than the increase in value-added or GDP. More specifically, total household consumption would increase by 7.12 percent compared to the base case. Among the household groups, largest increase is found for the non-farm non poor household group (7.88 percent) followed by landless (7.22 percent) and marginal farmers (7.15 percent).

V. THE IMPACTS OF INFRASTRUCTURAL DEVELOPMENT: A COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

One of the major effects of the development of physical infrastructure would be the reduction in the transport margin across the sectors. This study undertakes a simulation exercise considering a cut in the transport margins. A useful method of undertaking this exercise is to run this simulation in a Computable General Equilibrium (CGE) framework, whose advantage is that it traces the price effects of the exogenous shock. In an increasingly market oriented economy, the variations in prices may be the most important sources of re-allocation of resources among competing activities which then may alter the factorial income and hence personal income distribution. Changes in personal income distribution of household groups and consumer price indices may have different implications on the welfare and poverty situations of the distinct household groups. Application of computable general equilibrium analysis allows us to assess the impacts of exogenous shocks primarily through changing prices. A SAM prepared for the year 2007 serves as the consistent and comprehensive database for the above-mentioned exercises.

The variations in the sectoral prices will reallocate resources across the producing activities, thereby altering factoral income generation. As a consequence, the personal income of the household group will also be altered. Implied price, income and consumption effects will have implications for the household welfare situation and poverty incidence. Welfare situation is measured by the well-known equivalent variation.

5.1. The CGE Model for Bangladesh Economy

A CGE model examines the consequences of policy reforms within a constrained optimization framework. Computable general equilibrium models capture the detailed accounts of the circular flows of receipts and outlays in an economy. It satisfies general equilibrium conditions in various markets simultaneously. Such models are useful to analyse associations between various agents of the economy.

In line with most of CGE models, the model has been solved in comparative static mode and provides an instrument for controlled policy simulations and experiments. Solution of each simulation presents complete sets of socio-economic, meso and macro level indicators such as activity/commodity prices, household incomes and expenditures, factor demand and supplies, gross domestic products, exports and imports, and household poverty situation. The model is calibrated to the SAM to exactly reproduce the base year values[4]. The equations of the CGE model are presented in Annex 3.

Activities

On the production side it is assumed that in each sector there is a representative firm that generates value added by combining labour and capital. A nested structure for production is adopted. Sectoral output is a Leontief function of value added and total intermediate consumption. Value added is in turn represented by a CES function of capital and composite labour. The latter is also represented by a CES function of two labour categories: skilled labour and unskilled labour. Both labour categories are assumed to be fully mobile in the model. In the different production activities we assume that a representative firm remunerates factors of production and pays dividends to households.

Households

Households earn their income from production factors: labour, land and capital. They also receive dividends, government transfers and remittances. They pay direct income tax to the government. Household savings are a fixed proportion of total disposable income. Household demand is derived from a Cobb-Douglas (C-D) utility function.

Foreign Trade

It is assumed that foreign and domestic goods are imperfect substitutes. This geographical differentiation is introduced by the standard Armington assumption with a constant elasticity of substitution function (CES) between imports and domestic goods. On the supply

[4] In calibration procedure, most of the model parameters are estimated endogenously keeping the various elasticity values fixed.

side, producers make an optimal distribution of their production between exports and domestic sales according to a constant elasticity of transformation (CET) function. Furthermore, a finite elasticity export demand function is assumed. Even if it is assumed that the international terms of trade are given, the small country assumption for Bangladesh is rejected, and assumed that foreign demand for Bangladeshi exports is less than infinite. In order to increase their exports, local producers must decrease their free on board (FOB) prices.

Government

The government receives direct tax revenue from households and firms and indirect tax revenue on domestic and imported goods. Its expenditure is allocated between the consumption of goods and services (including public wages) and transfers. The model accounts for indirect or direct tax compensation in the case of a tariff cut.

System Constraints and Equilibrium Conditions

There are four constraints in the system. The real constraint refers to domestic commodity and factor market; the nominal constraint represents two macro balances: the current account balance of the rest of the world and the savings-investment balance.

Sectoral supply is a composite of imports and output sold in the domestic market. Composite demand, on the other hand, includes final demands (i.e. private and public consumption expenditure and investment) and intermediate input demand. Variations in the sectoral prices assure equilibrium between sectoral supply and demand.

In the case of factor market, it is assumed that total quantities of factors supply are fixed. This specification also implies full mobility of labour factors across producing activities and variations in their returns (e.g. wages) assures equilibrium in the factor market.

The inflows (transfers to and from domestic institutions) are fixed but imports and exports are determined endogenously in the model. Foreign savings is fixed in this model and nominal exchange rate acts as numeraire.

Finally, for the savings-investment equilibrium, the model treats the investment decision as given and hence savings has to adjust to ensure the equality to the fixed value of investment. The basic approach is to allow the savings propensity of one of the domestic institution to vary.

5.2. Simulation and Results

In CGE exercise a simulation is conducted where sectoral transport margins are reduced and its impacts on resource re-allocation, sectoral output and consumption, poverty and income distribution situation of the representative household groups are examined. In this simulation base values of the sectoral transport margin rates are reduced by 25 percent[5]. The base values of all other parameters are retained.

In order to capture the effects of changes in transport margins on sectoral prices and volumes of output, as well as on the household's welfare and poverty situation, the transport margins paid by each of the producing activities are deducted from their transaction values valued at purchaser prices. The derived sectoral transport margins are then added as a component in the formation of the domestic sales price. Variations in the transport margins affect the domestic sales price first and subsequently the changed domestic sales price will influence all other prices due to their interdependence. The base and simulation values of transport margin rates are presented in Table 9.

Table 9: Rates of Transport Margin by Sectors under Base and Simulation Scenario

	Sectors	Base rate	New rate
1	Paddy Cultivation	3.69	2.77
2	Grains	4.16	3.12
3	Jute Cultivation	4.71	3.53
4	Sugarcane Cultivation	3.74	2.81
5	Vegetables	4.93	3.70
6	Commercial Crops	3.07	2.30
7	Other Crop Cultivation	1.22	0.92
8	Livestock Rearing	1.14	0.86
9	Poultry Rearing	1.12	0.84
10	Shrimp Farming	1.33	1.00
11	Fishing	1.18	0.89
12	Forestry	1.03	0.77
13	Rice Milling	1.25	0.94
14	Grain Milling	1.46	1.10
15	Fish Process	1.49	1.12
16	Oil Industry	1.13	0.85
17	Sweetener Industry	1.40	1.05

Note: The mapping of 17 sectors in Table 6 to the 41 sectors in Bangladesh 2007 SAM is reported in Annex 4

5.2.1. Macroeconomic Effects

The macro impacts of the fall in transport margins on major macro variables are reported in Table 10. It is observed that the effects of the transport margin rate reduction on macro variables are positive. Under this simulation, real GDP rises by 0.57 percent. The general price index falls by 1.43 percent. Both exports and imports rise by 0.83 and 0.95 percent respectively. Domestic sales and consumption expenditure also rise by 1.03 percent and 0.48 percent respectively. The positive growth of the economy and moderate fall of general

[5] The sectoral transport rates are derived as proportions of sectoral total domestic sales values.

price index led to the enhancement of national welfare by 0.39 percent of base value of household income.

Table 10: Macroeconomic Effects (% change from base value)

Macro variables	% change
Real Gross Domestic Product	0.57
General Price Index	-1.43
Imports	0.95
Exports	0.83
Domestic Goods	1.03
Consumption Expenditure	0.48
Equivalent Variation	0.39

Source: CGE Simulation Results

5.2.2. Price Effects

The fall of transport margin rates affects the sectoral domestic sales price first. The changes in domestic sales prices then influence other prices, allocation of resources, incomes and consumption expenditures. The price effects of reduction in transport margin rate for 17 sectors are presented in Table 11.

Under this simulation, the fall in prices of domestic sales in general is higher for the agricultural sectors compared to the manufacturing and services sector. Since the base of rates of transport margins for agriculture are higher than manufacturing and services, these sectors would experience the larger price fall. The fall in the price of domestic sales is the highest for forestry sector. The fall in consumer and producer prices help reduce the general price index. The fall in FOB export prices results in rise in the competitiveness of the sectors. As a result of the fall in domestic sales prices (which dominates the consumer price formation), the prices faced by final consumers are also reduced. The reduction in the domestic price of manufacturing product imports led to a further decline of consumer prices of manufacturing commodities. Due to the interdependence of price formation, imports-exports and producer prices have also been affected by the fall of domestic sales prices.

Table 11: Sectoral Price Effects (Percentage change from base value)

	Sectors	Domestic Sales	Consumer	Producer	Export_ FOB
1	Cereal Crops	-1.19	-1.14	-1.12	0.00
2	Commercial Crops	-1.39	-1.37	-1.33	-0.88
3	Livestock-Poultry-fishing	-1.22	-1.13	-1.25	-1.36
4	Forestry	-1.46	-1.31	-1.25	0.00
5	Other Agriculture	-1.23	-1.14	-1.09	-1.01
6	Other Food	-1.17	-1.16	-1.10	-0.71
7	Leather Products	-0.48	-0.46	-0.44	-0.40
8	Cloth	-0.71	-0.68	-0.62	-0.52

	Sectors	Domestic Sales	Consumer	Producer	Export_ FOB
9	Readymade Garments	-0.63	-0.63	-0.62	-0.62
10	Chemical-Fertilizer	-0.75	-0.68	-0.62	-0.62
11	Machinery	-0.71	-0.85	-0.80	-0.82
12	Petroleum Products	-0.74	-0.66	-0.59	-0.51
13	Other Industries	-0.73	-0.71	-0.71	-0.61
14	Construction	-0.84	-0.65	-0.96	0.00
15	Transport	-0.67	-0.64	-0.60	-0.54
16	Utility	-0.55	-0.88	-0.73	0.00
17	Other Services	-0.62	-0.56	-0.83	-0.67

Source: CGE Simulation Results

5.2.3. Volume Effects

Under this simulation, the decline in sectoral prices leads to rise in sectoral domestic sales, consumption, imports, exports and outputs (Table 12). Consistent with the price decline pattern, the gains are found to be the highest for agricultural sectors. Livestock-poultry-fishing sector would experience the largest rise in output.

Table 12: Sectoral Effects of Simulation (Percentage change from base value)

	Sectors	Output	Imports	Exports	Domestic Sales	Consum-ption
1	Cereal Crops	1.29	0.95	0.00	1.23	0.00
2	Commercial Crops	1.78	1.02	1.04	1.59	0.77
3	Livestock-Poultry-fishing	2.22	1.14	1.67	2.12	0.95
4	Forestry	1.76	0.00	0.00	1.88	0.74
5	Other Agriculture	2.31	1.25	2.64	2.19	0.96
6	Other Food	1.93	1.11	1.68	1.74	0.80
7	Leather Products	0.92	0.50	1.19	0.85	0.38
8	Cloth	1.24	0.74	0.05	1.25	0.57
9	Readymade Garments	0.27	0.15	0.30	0.23	0.11
10	Chemical-Fertilizer	1.53	1.48	2.16	1.78	0.76
11	Machinery	1.38	0.57	0.93	1.19	0.39
12	Petroleum Products	2.33	1.26	1.82	1.71	0.97
13	Other Industries	1.92	1.03	1.87	2.32	0.79
14	Construction	1.69	0.00	0.00	1.83	0.57
15	Transport	1.77	1.22	1.52	1.58	0.69
16	Utility	1.46	1.14	0.00	1.14	0.66
17	Other Services	2.10	0.88	0.71	1.87	0.79

5.2.4. Factor Movements and Value-Added Effects

Under a general equilibrium framework, any shock into the system would lead to reallocation of resources from existing less productive sectors to relatively more productive sectors. The resultant primary factor movements and changes in value added are reported in Table 13. Under this simulation, in general, resources move out of some manufacturing and services activities and are absorbed in the agricultural and some manufacturing leading to the positive value added growth of agriculture and manufacturing activities. On the other hand, reduced availability of primary factors manifested in negative value added growth for many services activities.

Table 13: Effects on Value Added and Factor Movements (Percentage change from base value)

	Sectors	Value-Added	Labour unskilled	Labor skilled	Capital	Land
1	Cereal Crops	0.52	0.44	0.42	0.00	0.54
2	Commercial Crops	0.71	0.56	0.55	0.00	0.75
3	Livestock-Poultry-fishing	0.89	0.76	0.74	0.98	0.00
4	Forestry	0.71	0.60	0.58	0.78	0.00
5	Other Agriculture	0.93	0.79	0.76	0.00	0.96
6	Other Food	0.76	0.80	0.81	0.72	0.00
7	Leather Products	0.37	0.38	0.39	0.33	0.00
8	Cloth	0.49	0.52	0.53	0.47	0.00
9	Readymade Garments	0.11	0.11	0.12	0.10	0.00
10	Chemical-Fertilizer	-0.50	-0.56	-0.57	-0.43	0.00
11	Machinery	-0.18	-0.15	-0.15	-0.18	0.00
12	Petroleum Products	-0.93	-1.00	-1.02	-0.84	0.00
13	Other Industries	-0.36	-0.45	-0.46	-0.28	0.00
14	Construction	0.88	0.76	0.78	0.79	0.00
15	Transport	0.46	0.43	0.44	0.41	0.00
16	Utility	-0.38	-0.33	-0.34	-0.35	0.00
17	Other Services	0.29	-0.12	0.14	0.42	0.00

Source: CGE Simulation Results

5.2.5. Welfare Effects

While it is quite straightforward to measure impacts on aggregate nominal production and consumption levels, relative prices, nominal income and savings, it is less obvious to quantitatively evaluate how much better or worse off the households are. As direct and indirect utility functions are purely ordinal in nature, we can only analyse the direction of change. An interesting alternative is provided by using the money metric utility function, which measures the nominal income the consumer needs at one set of prices in order to be as well of at an alternative set of prices and nominal income. As such, it can be used to obtain monetary measures of the welfare effects of different policy scenarios. The most common of these measures is equivalent variations (EV).

Table 14 presets the change in consumer price index, income and EV of the eight representative households in the model. Under both the scenarios, all the households experience fall in CPIs and rise in income which leads to rise in real consumption and welfare of the households. The largest rise in EV is for the small and marginal farmers. In general the rural households experience larger rise in real consumption and welfare.

Table 14: Welfare effects (Percentage change from base value)

Households	CPI	Income	EV
Landless	-1.33	0.60	0.43
Marginal farmers	-1.34	0.73	0.45
Small farmers	-1.29	0.84	0.45
Large farmers	-1.28	0.57	0.38
Rural non-farm poor	-1.26	0.63	0.36
Rural non-farm non poor	-1.11	0.57	0.34
Urban low education	-1.24	0.60	0.39
Urban high education	-1.18	0.56	0.33

Source: CGE Simulation Results

5.2.6. Poverty effects

Under the CGE framework, there is an initial distribution of income for different representative household groups. Now, for any policy shock, the incomes of different household groups change. Also, the poverty line income is adjusted for the change in consumer price index. Now, the simulated income of the household is compared with the new adjusted poverty line income. If the income is above the poverty line income, the household is non-poor and if it is below the household is poor. Using the Foster-Greer-Thorbecke (FGT) class of poverty measures (Foster, et al, 1984) we can also derive other two measures of poverty: poverty gap index and squared poverty gap index for different household categories under different simulations. The poverty gap index, measures the depth of poverty, and it estimates the average distance separating the income of the poor from the poverty line as a proportion of the income indicated by the line. The squared poverty gap index, also measures the severity of poverty, quantifies the aversion of the society towards poverty. Table 15 provides the estimates of impact on poverty indices for different household groups under this simulation. It appears that under this simulation the national head-count poverty would fall by 1.24 percent. The poorer household groups are likely to experience higher reduction in poverty indices compared to their non-poor counterparts.

Table 15: Impacts on Poverty Indices for different Household Groups (% change from base value)

Households	Head-count (P0)	Poverty gap (P1)	Squared poverty gap (P2)
Landless	-1.55	-1.86	-2.48
Marginal farmers	-1.24	-1.86	-2.17
Small farmers	-1.55	-2.17	-2.48
Large farmers	-0.93	-1.24	-1.55
Rural non-farm poor	-0.62	-0.93	-1.24
Rural non-farm non-poor	-0.62	-0.62	-0.93
Urban low education	-1.55	-1.86	-2.48
Urban high education	-0.93	-1.55	-1.24
National	-1.24	-1.55	-1.86

Source: CGE Simulation Results

VI. CONCLUDING OBSERVATIONS

This paper has explored the relationship between infrastructure and growth and poverty in the context of the Bangladesh economy and in this context the paper has used three different techniques. The general conclusion is that infrastructure plays extremely significant role in promoting growth and alleviating poverty in Bangladesh.

The construction of the district-wise Infrastructure Development Index (IDI) and ranking of the districts on IDI suggest that the districts which are close to the capital city are having higher IDIs than the districts which are far from the capital city. The cross-section regression results suggest that the district-wise variation in head-count poverty is well explained by the variation in the IDI and the district with higher IDIs are associated with lower head-count poverty.

The SAM multiplier model indicates significant rise in gross output, household consumption and value-addition because investment in physical and social infrastructure. A 20 percent increase in infrastructural investment demand would lead to 8.17 percent rise in gross output, 8.07 percent rise in value-added or gross domestic product, and 7.12 percent rise in household consumption.

The exercise using the CGE model suggests that 25 percent reduction in the transport margin in the sectors would lead to rise in the real GDP by 0.57 percent, fall in the general price index by 1.43 percent, rise in exports and imports by 0.83 and 0.95 percent, and rise in national welfare by 0.39 percent. Also, the national head-count poverty would fall by 1.24 percent. The poorer household groups are likely to experience higher reduction in poverty indices compared to their non-poor

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Annex 1: SAM Multiplier Modules

The shift from a 'data' SAM structure to a SAM Multiplier Module requires the introduction of assumptions and the separation of the SAM accounts into 'exogenous' and 'endogenous' components.

Table A1: General SAM Modular Structure

		1a-PA	**1b-CM**	**2-FP**	**3a-HH-OI**	**4-KHH-OI**	**5-ROW**	**TDD**
1a	PA		$T_{1a, 1b}$		0			$\mathbf{Y_{1a}}$
1b	CM	$T_{1b, 1a}$			$T_{1b, 3}$	$T_{1b, 4}$	$T_{1b, 5}$	$\mathbf{Y_{1b}}$
2	FP	$T_{2, 1a}$					$T_{2, 5}$	$\mathbf{Y_{2}}$
3	HH-IO	$T_{3, 1a}$	$T_{3, 1b}$	$T_{3, 2}$	$T_{3, 3}$		$T_{3, 5}$	$\mathbf{Y_{3}}$
4	KHH-OI	$T_{4, 1a}$			$T_{4, 3a}$		$T_{4, 5}$	$\mathbf{Y_{4}}$
5	ROW		$T_{5, 1b}$	$T_{5\ 2}$	$T_{5, 3}$	0	0	$\mathbf{Y_{5}}$
	TSS	$\mathbf{E_{1a}}$	$\mathbf{E_{1b}}$	$\mathbf{E_{2}}$	$\mathbf{E_{3}}$	$\mathbf{E_{4}}$	$\mathbf{E_{5}}$	

Where: by definition Y_i= E_j and **1 Production (1a PA** = Production Activities and **1b CM** = Commodities); **2 FP** = Factors of Production; **3 HH-IO** = Households and Other Institutions (incl. Government); **4 KHH-OI** = Capital Account Households and Other Institutions (incl. government); **5 ROW** = Rest of the World (Current and capital account). **Blank entries** indicate that there are no transactions by definition.

The separation is needed to gain entry into the system, allowing some variables within the SAM structure to be manipulated exogenously (via injection instruments) to assess the subsequent impacts on the endogenous accounts as well as on the exogenous accounts.

Generally, accounts intended to be used as policy instruments are classified as exogenous and accounts specified *a priory* as objectives (or targets) are classified as endogenous.

Three accounts are designated as endogenous accounts: *(1) Production (Production Activities and Commodities) account, (2) Factors of Production account, (3a) Households and Other Institutions (excl. the Government)*.

The exogenous accounts comprises *3a Government (expenditure, transfer, remittances); 4 Capital account of institutions (savings and demand for houses, investment demand, infrastructure and machinery and equipment); and* 5 ROW *transfers, remittances, export demand and capital.* The SAM Flows and the categorization into endogenous and exogenous accounts are shown below.

Table A2: Endogenous and Exogenous Accounts

		1a-PA	1b-CM	2-FP	3a-HH-OI	3b-Gov	4-KHH-OI	5-ROW	TDD
1a	PA		$T_{1a, 1b}$		0				$\mathbf{Y_{1a}}$
1b	CM	$T_{1b, 1a}$			$T_{1b, 3a}$	$T_{1b, 3b}$	$T_{1b, 4}$	$T_{1b,5}$	$\mathbf{Y_{1b}}$
2	FP	$T_{2, 1a}$						$T_{2, 5}$	$\mathbf{Y_2}$
3a	HH-OI			$T_{3a, 2}$	$T_{3a, 3a}$	$T_{3a, 3b}$		$T_{2, 5}$	$\mathbf{Y_3}$
3b	Gov	$T_{3b, 1a}$	$T_{3b, 1b}$		$T_{3b, 3a}$	$T_{3b, 3b}$		$T_{3a, 5}$	
4	KHH-OI	$T_{4, 1a}$			$T_{4, 3}$			$T_{4, 5}$	$\mathbf{Y_4}$
5	ROW		$T_{5, 1b}$	$T_{5, 2}$	$T_{5, 3a}$	$T_{5, 3b}$	$T_{5, 4}$	0	$\mathbf{Y_5}$
	TSS	$\mathbf{E_{1a}}$	$\mathbf{E_{1b}}$	$\mathbf{E_2}$	$\mathbf{E_{3a}}$	$\mathbf{E_{3b}}$	$\mathbf{E_4}$	$\mathbf{E_5}$	

Where Endogenous: **1 Production (1a PA** = Production Activities and **1b CM** = Commodities); **2 FP** = Factors of Production; **3a HH** = Households and Other Institutions (excl. Government); Where Exogenous: **3b** Government; **4 KHH-OI** = Capital Account of Households and of Other Institutions (incl. government); **5 ROW** = Rest of the World (Current and capital account). **Blank** entries indicate that there are no transactions by definition.

Table A3: Endogenous and Components of Exogenous Accounts

	PA	CM	FP	3a HH&OI	EXO	INCOME	Exogenous Accounts (EXO) used as injections Column Vectors
1a PA		$T_{1a\ 1b}$		0	X_{1a}	$\mathbf{Y_{1a}}$	$X_{1a} = 0$
1b CM	$T_{1b\ 1a}$			$T_{1b\ 3a}$	X_{1b}	$\mathbf{Y_{1b}}$	X_{1b} = Government Consumption Subsidies -Taxes + Exports + Gov. Investment (capital formation in infrastructure and machinery and equipment) + Gross Capital Stock formation
2 FP	$T_{2\ 1a}$				X_2	$\mathbf{Y_2}$	X_2 =Factor Remittances from ROW
3a HH&OI			$T_{3a\ 2}$	$T_{3a\ 3a}$	X_{3a}	$\mathbf{Y_{3a}}$	X_{3a} = Factor Remittances from ROW
3b-5 Leaks	L_{1a}	L_{1b}	L_2	L_{3a}	$L_{3b-5} = X_{3b-5}$	Y_{3b-5}	3b =Aid to Government from ROW
EXPN	$\mathbf{E_{1a}}$	$\mathbf{E_{1b}}$	$\mathbf{E_2}$	$\mathbf{E_{3a}}$	$\mathbf{E_{3b-5}}$		Where $\mathbf{E_i = Y_j}$

L_{1a} = Activity Tax	L_{3a} = Income Tax + Household Savings + Corporate Savings
L_{1b} = Commodity Tax + Import Duty + Imports	L_{3b-5} X_{3b-5} and Y_{3b-5} falls out of the model
L_2 = Factor Remittances to ROW	Blank entries indicate that there are no transactions by definition.

<u>*Note on Injection*</u>*: For any given injection into the exogenous accounts X_i (i.e. instruments) of the SAM, influence is transmitted through the interdependent SAM system among the endogenous accounts. The interwoven nature of the system implies that the incomes of factors, institutions and production are all derived from exogenous injections into the economy via a multiplier process. Multiplier models may also be built on the input-output frameworks. The main shortcoming of the IO model is that the feedback between factor income generation (value added) and demand by private institutions (households) does not exist. In this case the circular economic flow is truncated. The problem can be partly tackled*

by endogenising household consumption within the I-O framework; this is typically referred to as a 'closed I-O model'. In this case, the circular economic flow is only partially truncated. A better solution is to extend the I-O to a SAM framework which captures the full circular economic flow.

SAM coefficient (Aij) are derived from payments flows by endogenous accounts to themselves (Tij) and other endogenous accounts as to the corresponding outlays (Ei = Yj); similarly, the leak coefficients (Bij) derived from flows reflecting payments from endogenous accounts to exogenous accounts. They are derived below.

Table A4: Coefficient Matrices and Vectors of the SAM Model

Account	1a - PA	1b – CM	2 – FP	3a - HH&OI	3b … 5 EXO	Income
1a – PA		$A_{1a,1b} = T_{1a,1b} / \mathbf{Y_{1b}}$			X_{1a}	$\mathbf{Y_{1a}}$
1b – CM	$A_{1b,1a} = T_{1b,1a} / \mathbf{Y_{1a}}$			$A_{1b,3a} = T_{1b,3a} / \mathbf{Y_{3a}}$	X_{1b}	$\mathbf{Y_{1b}}$
2 – FP	$A_{2,1a} = T_{2,1a} / \mathbf{Y_{1a}}$				X_2	$\mathbf{Y_2}$
3a - HH&OI			$A_{3a,2} = T_{3a,2} / \mathbf{Y_2}$	$A_{3a,3a} = T_{3a,3a} / \mathbf{Y_{3a}}$	X_{3a}	$\mathbf{Y_{3a}}$
3b … 5 Leaks	$B_{1a} = L_{1a} / \mathbf{Y_{1a}}$	$B_{1b} = L_{1b} / \mathbf{Y_{1b}}$	$B_2 = L_2 / \mathbf{Y_2}$	$B_{3a} = L_{3a} / \mathbf{Y_{3a}}$		
Expenditure	$\mathbf{E_{1a} = Y_{1a}}$	$\mathbf{E_{1b} = Y_{1b}}$	$\mathbf{E_2 = Y_2}$	$\mathbf{E_3 = Y_{3a}}$		

The multiplier analysis using the SAM framework helps to understand the linkages between the different sectors and the institutional agents at work within the economy. Accounting multipliers have been calculated according to the standard formula for accounting (impact) multipliers, as follows:

$\mathbf{Y} = A\,Y + \mathbf{X} = (I - A)^{-1}\,\mathbf{X} = M_a\,\mathbf{X}$

Where:

- **Y** is a vector of incomes of endogenous variables
- **X** is a vector of expenditures of exogenous variables
- **A** is the matrix of average expenditure propensities for endogenous accounts
- $M_a = (I - A)^{-1}$ is a matrix of aggregate accounting multipliers (generalized Leontief inverse).

Variations in any one of the exogenous account (i.e. in this case ΔX) will produce total impacts (ΔY) of endogenous entries via the multipliers. The total impact will be decomposed by direct and induced impacts for capturing the strengths of the transmission channel.

Annex 2: Multipliers of the SAM Modules

The multipliers derived using the National and Regional SAMs are reported here.

Table A5: Multipliers of the National and Regional SAMs

		National SAM	Regional SAM SW
1	a_Paddy Cultivation	11.66	11.33
2	a_Grains	9.55	11.85
3	a_Jute Cultivation	11.57	10.89
4	a_Sugarcane Cultivation	11.31	11.65
5	a_Vegetables	11.13	11.00
6	a_Commercial Crops	10.84	10.85
7	a_Other Crop Cultivation	11.82	11.98
8	a_Livestock Rearing	11.29	11.67
9	a_Poultry Rearing	10.92	13.95
10	a_Shrimp Farming	12.85	12.21
11	a_Fishing	11.08	10.79
12	a_Forestry	11.37	11.35
13	a_Rice Millling	12.53	11.96
14	a_Grain Milling	9.56	11.71
15	a_Fish Process	13.53	12.70
16	a_Oil Industry	8.56	11.27
17	a_Sweetener Industry	11.72	11.43
18	a_Food	9.88	11.53
19	a_Leather	12.02	11.77
20	a_Jute	12.53	11.45
21	a_Clothing	10.91	11.00
22	a_RMG	10.67	10.68
23	a_Tobacco	6.50	10.95
24	a_Wood	10.75	11.49
25	a_Chemical	9.07	11.01
26	a_Fertilizer	10.79	10.25
27	a_Petroleum	4.09	12.63
28	a_Clay Products	10.44	10.65
29	a_Cement	10.60	11.80
30	a_Steel	10.36	11.27
31	a_Machinery	9.98	10.39
32	a_Miscellaneous	10.38	10.27
33	a_Construction	10.50	11.12
34	a_Utility	10.11	9.99
35	a_Trade	9.93	9.27
36	a_Transport	10.20	9.58
37	a_Social Servcies	10.22	9.12
38	a_Financial servcies	10.29	9.20
39	a_Public Administration and Defense	10.47	9.36
40	a_Professional Servcies	9.15	8.92
41	a_Other Services	10.80	10.50

		National SAM	Regional SAM SW
42	c_Paddy	12.66	12.33
43	c_Grains	6.08	12.62
44	c_Jute	12.57	11.89
45	c_Sugarcane	12.31	12.65
46	c_Vegetables	10.83	11.87
47	c_Commercial Crops	8.08	11.13
48	c_Other Crop	12.11	12.96
49	c_Livestock Rearing	11.99	12.65
50	c_Poultry Rearing	11.87	14.94
51	c_Shrimp Farming	13.85	13.21
52	c_Fishing	12.08	11.79
53	c_Forestry	12.37	12.35
54	c_Rice	13.34	12.92
55	c_Grain	10.46	12.71
56	c_Fish Process	14.19	13.70
57	c_Oil Industry	4.86	11.88
58	c_Sweetener Industry	5.93	12.25
59	c_Food	10.30	12.50
60	c_Leather	12.93	12.77
61	c_Jute	13.43	12.45
62	c_Clothing	9.17	11.62
63	c_RMG	11.48	11.60
64	c_Tobacco	7.49	11.95
65	c_Wood	9.35	12.44
66	c_Chemical	5.23	11.60
67	c_Fertilizer	3.47	11.14
68	c_Petroleum	1.76	13.32
69	c_Clay Products	10.79	11.64
70	c_Cement	9.12	12.75
71	c_Steel	8.25	11.95
72	c_Machinery	4.56	10.02
73	c_Miscellaneous	4.43	10.22
74	c_Construction	11.50	12.12
75	c_Utility	10.72	10.92
76	c_Trade	10.93	10.27
77	c_Transport	9.67	9.58
78	c_Social Servcies	11.22	10.12
79	c_Financial servcies	10.30	10.09
80	c_Public Administration and Defense	10.57	10.19
81	c_Professional Servcies	9.28	9.80
82	c_Other Services	11.80	11.50
83	VA Labour Unskilled	10.62	9.68
84	VA Labour Skilled	8.82	6.46
85	VA Capital	8.97	7.26
86	VA Land	9.75	9.25
87	Landless	11.34	8.81

		National SAM	Regional SAM SW
88	Marginal	10.15	9.82
89	Small	9.92	9.17
90	Large	7.29	8.85
91	Rural Non Farm Poor	8.63	6.22
92	Rural Non Farm Non Poor	10.80	9.05
93	Low Education	9.60	9.44
94	High Education	5.98	2.44
	Total	**100.0**	**100.0**

Annex 3: Equations of the CGE Model

	Equations	Description
1.	*Price Block*	
2.	$PM_i = \overline{PWM_i} \cdot ER \cdot (1 + tm_i + tv_i)$	Import Price
3.	$PE_i = PE\_FOB_i \cdot ER / (1 + te)$	Export Price
4.	$P_i \cdot Q_i = PD_i \cdot D_i + PM_i \cdot M_i$	Composite Price
5.	$PX_i \cdot X_i = PD_i \cdot (1 - td_i - tv_i) \cdot D_i + PE_i \cdot E_i$	Activity Price
6.	$PN_i = \sum_j \tau_{ji} \cdot P_j$	Input price
7.	$PV_i \cdot V_i = PX_i \cdot X_i - PN_i \cdot INT_i$	Value added price
8.	$PK_i = \sum_j \kappa_{ij} \cdot P_j$	Capital Price
	Production and Supply Block	
9.	$X_i = AX_i \cdot [\eta_i \cdot V_i^{-\phi_i} + (1 - \eta_i) \cdot N_i^{-\phi_i}]^{-1/\phi_i}$	Gross Output (CES aggregate of value-added and intermediate input)
10.	$N_i = V_i \cdot \frac{PN_i \cdot (1 - \eta_i)}{PV_i \cdot \eta_i}]^{\frac{1}{1+\phi_i}}$	Composite Intermediate
11.	$V_i = AV_i \cdot [\sum_f \alpha_{if} \cdot FD_{if}^{-\mu_i}]^{-\frac{1}{\mu_i}}$	Value added function
12.	$FD_{if} = V_i \cdot \left[\frac{\alpha_{if} \cdot PV_i}{AV_i^{\mu_i} \cdot W_f \cdot \varpi_{if}} \right]^{\frac{1}{1+\mu_i}}$	Factor Demand
13.	$FY_f = \sum_i W_f \cdot \varpi_{if} \cdot FD_{if}$	Factor Income
14.	$Q_i = AQ_i \cdot [\delta_i \cdot M_i^{-\rho_i} + (1 - \delta_i) \cdot D_i^{-\rho_i}]^{-1/\rho_i}$	Composite Supply (Armington Function)
15.	$M_i = D_i \cdot [\frac{PD_i \cdot \delta_i}{PM_i \cdot (1 - \delta_i)}]^{\frac{1}{1+\sigma_i}}$	Import-Domestic Demand Ratio
16.	$Q_i = M_i + D_i$	Composite commodity aggregation for perfect substitutes
17.	$Q_i = D_i$	Composite supply for Non-imported commodities
18.	$Q_i = M_i$	Composite supply for Non-produced imports

	Equations	Description
19.	$X_i = AT_i \cdot [\gamma_i \cdot E_i^{-\phi_i} + (1-\gamma_i) \cdot D_i^{-\phi_i}]^{1/\phi_i}$	Composite supply function
20.	$E_i = D_i \cdot [\frac{PE_i \cdot (1-\gamma_i)}{PD_i \cdot (1-td_i)}]^{\varphi_i}$	Export Supply
21.	$E_i = E_i^0 \cdot \left[\frac{PWE_i}{\overline{PE\_FOB_i}} \right]^{e_i}$	Export Demand
	Institutional Income	
22.	$YF_h = \sum_f \varepsilon_{h,f} \cdot FY_f$	Household Factor Income
23.	$Y_h = \left[YF_h + \overline{RM_h}\right] \cdot (1 - th_h - s_h)$	Household Income
24.	$YG = \sum_h th_h \cdot Y_h + \sum_i tm_i \cdot \overline{PWM_i} \cdot M_i \cdot ER + \sum_i td_i \cdot X_i \cdot PD_i$	Government Income
25.	$CD_{ih} \cdot P_i = \beta_{ih} \cdot Y_h$	Consumption Demand
26.	$\overline{GD_i} = \beta_i^g \cdot \overline{GTOT}$	Government Demand
27.	$PK_i \cdot DK_i = \xi_i \cdot I$	Investment by Destination
28.	$ID_i = \sum_j \kappa_{ij} \cdot DK_j$	Investment by Origin
29.	$INT_i = \sum_j \tau_{ij} \cdot N_j$	Intermediate Demand
	Equilibrium Condition	
30.	$S = \sum_h SH_h + SG + SF$	Total Savings by Institutions
31.	$Q_i = INT_i + \sum_h CD_{ih} + GD_i + ID_i$	Product Market Balance: Supply equals Demand
32.	$\sum_i FD_{if} = FS_f$	Factor Market Balance: Demand plus unemployed factor equals Supply. (capital is fully employed, but labour is not)
33.	$\sum_i \overline{PWM_i} \cdot M_i - \sum_i PWE_i \cdot E_i - \sum_h \overline{RM_h} - SF = 0$	Current Account Balance: Receipts equal to Outlays
34.	$I = S = \sum_h SH_h + SG + SF$	Macro Balance: Investment equals Savings

Annex 4: Mapping and Classification Scheme

Table A6: Mapping

Activity-Commodity 17	Activity-Commodity 41
1. Cereal Crops	Paddy Cultivation and Grains Cultivation
2. Commercial Crops	Jute cultivation, Sugarcane Cultivation and Commercial Crops
3. Livestock-Poultry-fishing	Livestock Rearing, Poultry Rearing, Shrimp Farming and Fishing
4. Forestry	Forestry
5. Other Agriculture	Vegetable and Other Crop Cultivation
6. Other Food	Rice Milling, Grain Milling, Fish Process, Oil Industry, Sweetener Industry and Food
7. Leather Products	Leather
8. Cloth	Jute and Clothing
9. Readymade Garments	Ready Made Garment
10. Chemical-Fertilizer	Chemical and Fertilizer
11. Machinery	Steel and Machinery
12. Petroleum Products	Petroleum Products
13. Other Industries	Wood, Tobacco, Clay Products, Cement, and Miscellaneous
14. Construction	Construction
15. Transport	Transportation
16. Utility	Utility
17. Other Services	Trade, Social Services, Financial Services, Public Administration-Defense, Professional Services and Other Services
Activity-Commodity 5	**Activity-Commodity 17**
a. Agriculture	Cereal Crop, Commercial Crop, Livestock-Poultry-fishing, Forestry and Other Agriculture
b. Manufacturing	Other Food, Leather Products, Cloth, Readymade Garments, Chemical-Fertilizer, Machinery, Petroleum Products and Other Industries
c. Construction	Construction
d. Transport	Transport
e. Services	Other Services
Labour Factor 1	**Labour Factor 2**
• Labour	Labour Skilled and Labour Unskilled
Household 3	**Household 8**
• Rural Land Based	Landless, Marginal, Small, Large
• Rural Non-farm	Rural Non Farm Poor, and Rural Non Farm Non Poor
• Urban	Low Education and High Education