Abstract

Food security extends beyond a population's immediate nutritional intake. It is not only an essential pillar of the nation concept, but has far-reaching implications that extend beyond national borders in today's globalized trading of agricultural commodities. The Global Hunger Index (GHI), an established metric for measuring food insecurity in developing countries, can be used to measure the overall impact of agricultural economic policies. Multiple regression and ANOVA tests were implemented to examine the significance a range of predictors had on determining GHI in India, Nigeria, and Brazil. Each country has a major impact on food security for their region, along with global economic policies. The predictors encompass a variety of factors including basic, political, economic, and infrastructural needs. The data for the research was acquired from The Food Agricultural Organization Food Security Report and the International Food Policy Research Institute for 1995-2011. The study finds that the GHI in India and Nigeria was significantly affected by gross domestic product per capita (GDPC) and water access, while only water was significant in determining Brazil's GHI. With this research as a template, policy makers can better tailor aide programs to optimize the global decrease of the GHI and improve global food security.

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Addressing food security is singularly the biggest policy consideration in developing countries, especially in low income countries and occasionally in medium income countries. Without adequate food security, the very concept of the nation state becomes untenable over the long term. Hence in developing nations, food security generally has had a bigger impact on societies and governments than human rights, democracy, and economic freedom. Although global poverty numbers have declined within the last 20 years, it is estimated that 870 million people still suffer from continuing severe malnutrition, while many more suffer from lingering hunger and dissatisfaction with their food security. Alongside this persistent food deprivation, developing countries have been industrializing at rapid paces over the last three decades. This has resulted in an unprecedented globalization of agricultural commodities and the growing appetite for these commodities by developing countries, as economically empowered populations seek access to a broader range and quantity of foods. With developing countries' economies growing more rapidly than those of developed countries, implementation of new food security policies will need to occur to increase food security to keep pace with urban development and also to ensure continued food security for developed countries. For effective policy formulations that specifically target decreases in malnutrition and hunger, it is necessary to formulate an effective index measuring food security, and then accurately identify the inputs affecting that index. Although there have been numerous metrics formulated to measure food security, the following will specifically consider Global Hunger Index. (FAO 2013).

Global Hunger Index

Although it is difficult to assign a numerical value on the toll malnutrition and hunger take on a country, the Global Hunger Index (GHI) gives us the most appropriate representation. GHI was developed at the International Food Policy Research Institute (IFPRI), which was established in 1975 by governments, private businesses, charitable foundations, and the World Bank to study hunger issues in developing countries. GHI has become an established metric for measuring food insecurity in developing countries and is used to measure regional and country relative differences in hunger, observe progress, and evaluate policy impact. It is the average of the following equally weighted percentages: proportion of population that is undernourished, prevalence of underweight in children under age five, and mortality rate of children under age five. Consequently, GHI values range from 0 to 100, reflecting what percentage of that country's population experiences malnutrition and hunger on a recurring basis. The GHI results in the following interpretations: extremely alarming (GHI ≥30), alarming (20.0≥ GHI ≤29.9) or serious (10.0≥ GHI ≤19.9) hunger situation. GHI scores <10 are considered to reflect minor hunger issue, and <5 are considered to represent successful policy outcome. (Nassar, 2012; Ecker 2013).

Agricultural Commodities Trade

The concept of economic efficiency is based on the lowest cost production of goods and services for which a demand exists. The essence of a free market lies in the hypothesis that economic efficiency occurs when an individual or group specialize in production of activities (i.e. goods or services) in which it can operate more efficiently than other entities. This principle is referred to in economics as comparative advantage, and is considered the force behind Adam Smith's "invisible hand guiding free market economies". This principle is well established in these three particular economies, and has been well tested and empirically validated. Applying this principle to international trade theory, it states that the worldwide production output (e.g. as measured by the cumulative addition of gross domestic product of each country) is maximized when each country concentrates on producing goods for which it has lower opportunity costs. A corollary of this efficiency hypothesis is that commodity trading, whether it occurs on Wall Street or a community market, is an efficient market entity for allocating the production, pricing and distribution of commodities. IFPRI has proposed using the international model for policy analysis of agricultural commodities and trade to model the dynamic effect of global commodities trading on food pricing and food security in developing countries. With a globalization of the trade in the agricultural commodities sector, an interdependency has been formed. As a result, food security has become an interconnected global issue. (Ecker 2012; FAO 2013)

Global Effects of National Food Policy

Just as John Donne proclaimed that "no man is an island", the same can be said of national food and development policies of major countries. International trade, including agricultural commodities, has created an inter-dependency amongst nations that transcends national borders. A cursory examination of the GHI scores across the globe reveals that food security is a major issue in Africa and Asia, a lingering concern in South America, and largely resolved in North America, Europe and continental Australia. This viewpoint is backed up by the high GHI scores observed in many south Asian and sub-Saharan African countries, and moderate to high scores in North and South America. India, Nigeria and Brazil with their large populations, dominant regional economies, well established food security policies, and developing nation status, represent suitable surrogates for studying food security in their respective continents. (Thomas 2012).

India, with its 1.2 billion population and mixed economy merging market status, is a G-20 major economy. It is the 9th largest in the world as of 2012, and 3rd largest in Asia. However it is considered poor or low income on basis of GDP per capita (GDPC) of $1528 in 2012, a large improvement over $1028 in 2008. In 2012, it had a GHI index of 22.9 (i.e. alarming hunger), even though this is a significant reduction from 30.3 (i.e. extremely alarming hunger) in 1990. (United Nations, 2012; Blanchard, 2013).

Nigeria, with its 170 million population and mixed economy emerging market status, is the second largest economy in Africa after South Africa, and 31st largest in the world as of 2012. It is considered a poor or low income country based on GDPC of $1509 in 2012, a modest improvement from $1375 in 2008. In 2012, it had a moderately low GHI of 15.7 (i.e. serious hunger), a vast improvement from 24.1(i.e. alarming hunger) in 1990. (Thomas 2012).

Brazil, with its 197 million citizens and moderately free market economy status, is a G-20 major economy. It is the largest economy in South America, and 7th largest in the world. It is considered a middle income country based on GDPC of $12,079, a dramatic improvement from $8,629 in 2008 .It has a low GHI of less than 5 (food security not an issue), an improvement from 7.8 (minor hunger) in 1990. (United Nations, 2012).

Hunger in developing countries occurs due to three main factors: income, agricultural production, and national infrastructure. Income is obtained through wages from available economic activity, and government support programs (national or international), and must be sufficient to purchase the basic essentials of living. Agriculture production is the availability of land and goods to grow food for consumption and trade. National infrastructure is the ability to transport agricultural commodities and goods required for their production in an efficient manner to match demand and supply. Food security is affected by these factors. In developing countries, at least one of these factors is compromised. It is not possible to measure these conceptual and qualitative factors in a precisely and empirically but in modeling, where these factors are potential inputs, one looks for appropriate empirical surrogates. (Henson, 2008; Nassar 2012).

Food Aid Policies

Just as the old adage goes, "Give a man a fish and he eats for a day; teach a man to fish and he eats for a lifetime", the true success of aid policy is its absence at the end of a foreseeable timeline. However governments, aid organizations, and the public are keenly aware from anecdotal media stories that aid policy too often starts with the best of intentions but ends up as a failure. International trade, including agricultural commodities, has created an inter-dependency amongst nations that transcends national borders. The need for effective aid delivery, in an era of diminished funding, requires an effective model for predicting success and failures of development projects. The need for such a model for policy evaluation and formulation to address food security provides the motivation for this project. (FAO, 2013; Von Braun, 2013).

Methodology

Statement of Purpose

A statistical analysis of food security is carried out. This model must not only use a robust measure of food security (i.e. WHI) but the measure must be readily computable from existing databases, without the need to allocate resources to additional data collection. This report examines the correlation of GHI to a range of possible predictors, encompassing a variety of factors including basic, political, economic and infrastructural needs, for which data is readily available in existing databases.

Overview

Economic data for the developed countries is routinely collected and computed in order to measure progress, assess policy impact, and assist policy formulation. However, in developing countries, such data is not necessarily sufficient for constructing economic models, in terms of range of performance metrics, possible predictors, accuracy of data collection, and frequency of measurements. Consequently, unlike economic models used in economically developed countries, such as those used in GDP and employment forecasting, there are fewer and less accurate models available to assess and formulate economic policy impact. Yet the need for such models is just as great in donor and host developing countries to tackle the greatest issue facing developing countries- food security. The challenge therefore is to develop such a model for food security. As a first step towards that goal, this paper carries out a statistical analysis of possible predictors impacting food security, as measured with GHI on a country basis.

General Model

The general model used for each country is a linear model where GHI is the response, and the covariates are Political Stability Index (PSI), percentage of roads in the country that are paved (Road), Gross Domestic Product per Capita (GDPC), percentage of population with access to clean drinking water (Water), and Domestic Food Price Index (DFPI). The general model used for this analysis is $\mathrm{Y} = \mathrm{f(PSI, Road, GDPC, Water, DFPI)}$, where in this context the function is defined as being linear.

GHI is a measurement used to measure food security in a given country. GHI is the unweighted average of the percentage of the population that is the undernourished, the percentage of children under 5 years old that are underweight, and the mortality rate of children under 5. Domestic Food Price Index is defined as the ratio of a country's Food Purchasing Power Parity to its general Purchasing Power Parity. GDP per capita is found by dividing the countries current GDP (in USD) by the total population. The predictor 'Water' is found by assessing the percentage of the population that has access to an improved water source. Lastly, Political Stability Index ranges from -2.5 to 2.5 and is a measure of how likely a violent revolution is, with higher values corresponding to a more stable political environment. The value of GHI ranges from 0 to 100 with lower values corresponding to less hunger.

It should be noted that a multivariable regression analysis is used here, whereby there is a single endpoint (e.g. GHI), and multiple covariates. Ideally, a multivariate regression analysis would be desirable, whereby there are multiple endpoints for modeling food security (e.g. GHI, money spent on food as percentage of income, nutritional adequacy of food, availability of food, etc.). However these measures are not readily available for developing countries. As well, even if such measures were available, the complexities of such a multidimensional response model diminish the usefulness for easy interpretation of food security and policy impact.

Data Collection

The data for this research paper was acquired from the Food Agricultural Organization Food Security Report and the International Food Policy Research Institute for 1995-2011. Although data was available beginning in 1960, by only going back 16 years, the significant predictors ensure that they are only being influenced by current trends. Due to the rapid technological and political advancement of developing countries, it makes sense to run regression models for just the last 16 years to ensure completeness in predicting modern significant predictors. Additionally, it is important to note that the GHI and certain predictor values for certain years were forecasted due to the low availability of data. Typically, these variables are not measured every year as it requires a census. The forecasted values for the variables were found by fitting a linear fit between years when that specific variable was recorded. For example, if the recorded GHI for a county was 20.0 in 2001 and 27.0 in 2008, then the forecasted value for 2004 would be 23.0. Forecasting GHI and other predictors for certain years is a statistically sounds method because we assume the function of the general model is linear. Using the data only over the last 16 years also ensures improved accuracy of the predictor and response values, as data collection methodology has likely improved.

Statistical Process

The various models were developed by first computing, in the statistical software R (version 3.0.1), a general model for each data set and then narrowing down which covariates to use as predictors based on goodness of fit, specifically the coefficient of determination (R-squared value), as well as the p-values of the ANOVA tables for the models, which measure the likelihood that the estimated parameters are derived from chance and are actually unrelated to the model. From there, general trends that appeared across all four sets of data were noted and used to choose the final models.

Results

The results of an initial linear regression analysis, using all 5 predictors (PSI, Road, GDPC, Water, DFPI) with GHI as a response, for each country (India, Nigeria, Brazil) are listed in **Tables 1.1**, **2.1**, and **3.1** of Appendix A respectively. A further linear regression analysis, based only on those predictors deemed to be significant, was carried out and is listed in **Tables 1.2**, **2.2** and **2.3** of Appendix A. Using output from the second regression, the ANOVA was run to signify significant predictors. Results of specific analysis for each country are listed in the following sub-sections. All raw data is listed in Appendix A, while complete statistical tests are found in Appendix B.

India

For India (**Tables 1.1-1.4**), 'Water' and 'GDPC' were significant factors in predicting GHI. The first regression (**Table 1.1**) shows a linear regression model for India with all five predictors, two of which, 'Water' and 'GDPC', were deemed significant. Next, another regression (**Table 1.2**), including only 'Water' and 'GDPC', was run to reaffirm significance. The ANOVA tests (**Table 1.3-1.4**) signified these findings by also indicating that the same two stated predictors are significant. Based on multiple regressions and the ANOVA, 'Water' and 'GDPC' are deemed significant predictors in determining GHI at the set α=0.05.

Table 1.4 ANOVA for India with GHI as the response (Water First, GDPC Second)

Coefficients:	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**
Water	1	0.6345	0.6345	21.3536	0.0007392
GDPC	1	4.0908	4.0908	137.6690	1.465e-07
PSI	1	0.0633	0.0633	2.1302	0.17238
Road	1	0.1079	0.1079	3.6310	0.08317
DFPI	1	0.0060	0.0060	0.2034	0.6607612
Residuals	11	0.3269	0.0297		

Nigeria

For Nigeria (**Tables 2.1-2.4**), 'Water' and 'GDPC' are significant predictors of GHI. The initial linear regression analysis (**Table 2.1**), using all 5 predictors (PSI, Road, GDPC, Water, DFPI) with GHI as a response, was run. The regression model indicated only 'Water' significant at the set α=0.05. After running a regression juonly with the predictor 'Water' (**Table 2.2**), significance for 'Water' was reaffirmed. However after running multiple ANOVA tests (**Table 2.3-2.4**) to signify the results, both 'Water' and 'GDPC' were deemed significant in predicting WHI. This is because the ANOVA takes into consideration order since it uses the F-test and the reduction in sum of squares, which is based on the order in which the covariates were added to the model. The ANOVA runs the analysis in the order that the covariates are listed, constructs a new model using those covariates, and analyzes the reduction in the sum of squares and F statistics. By taking into account order, the results of the ANOVA analysis indicate that both predictors are significant factors in predicting GHI. After running the regression and the ANOVA on the Nigeria data set, 'Water' and 'GDPC' are significant predictors at the set α=0.05.

Table 2.4 ANOVA for Nigeria with GHI as the response (GDPC First, Water Second)

Coefficients:	*Df*	*Sum Sq*	*Mean Sq*	*F value*	*Pr(>F)*
GDPC	1	9.3865	9.3865	13.8405	0.0029
Water	1	8.9712	8.9712	13.2281	0.003406
PSI	1	0.0190	0.0190	0.0280	0.869917
Road	1	NA	NA	NA	NA
DFPI	1	0.2462	0.2462	0.3631	0.558031
Residuals	11	8.1383	0.6782		

Brazil

For Brazil (**Tables 3.1-3.3**), only Water was a significant factor. Hence there was only a single ANOVA (**Table 3.3**) to signify the predictor's significance. Both regression and the ANOVA signify 'Water' as the sole significant predictor for GHI at the set α=0.05.

Table 3.3 ANOVA for Brazil with GHI as the response

Coefficients:	*Df*	*Sum Sq*	*Mean Sq*	*F value*	*Pr(>F)*
Water	1	16.4398	562.6393	16.4398	8.513e-11
GDPC	1	0.0582	0.0582	1.9935	0.18564
PSI	1	0.0969	0.0969	3.3160	0.09589
Road	1	0.0797	0.0797	2.7268	0.12690
DFPI	1	0.0016	0.0016	0.0550	0.81881
Residuals	11	0.3214	0.0292		

Joint (India, Nigeria, and Brazil) Model

For the combined model (**Tables 4.1-4.4**), it was observed that 'GDPC', 'DFPI', and 'Road' were statistically significant predictors for GHI in the overall data. Even though in the ANOVA (**Table 4.4)**, GDPC has a low p-value, this is not significant in context because the low p-value only occurs due to the spread of the GDPC between the countries.

Table 4.4 ANOVA for All 3 Countries with GHI as the response (Road First, DFPI Second, GDPC Third)

Coefficients:	*Df*	*Sum Sq*	*Mean Sq*	*F value*	*Pr(>F)*
Road	1	1836.42	1836.42	1313.4414	< 2.2e-16
DFPI	1	1269.99	1269.99	908.3241	< 2.2e-16
GDPC	1	28.25	28.25	20.2062	4.836e-05
Water	1	3.47	3.47	2.7268	0.1224
PSI	1	0.57	0.57	0.4110	0.5247
Residuals	45	62.92	1.40		

Discussion of Results

GHI is the average of the following inputs of equally weighted percentages: proportion of population that is undernourished, prevalence of underweight in children under age five, and mortality rate of children under age five. GDPC and 'Water' were found to be significant predictors of GHI for India and Nigeria. Besides a similar correlation for GHI, it should be noted that India and Nigeria, though different geographically and culturally, are both considered low income countries based on GDPC, and have similar GHI scores. It is plausible that 'Water' serves as a predictor for GHI, since the availability of clean water likely affects mortality in children under age 5, which is a component of WHI. GDPC would affect all three inputs of GHI because it determines the ability to buy food (for adults and children) and child healthcare, which have direct effect on each input of GHI.

For Brazil, 'Water' was the sole significant predictor of GHI, notwithstanding the fact that GDPC varied by a factor of nearly 3 across the 15 years. This is most likely due to GDPC not being relevant to food security once a threshold GDPC is achieved because GHI is not a measure of how affluent a country is but specifically whether the population has access to a food. Once a certain income is reached, it is likely that the average family has enough money to afford basic necessities.

For the joint model, it was concluded that 'DFPI' and 'Road' were significant predictors. 'GPDC' was omitted because this is not significant in context because the low p-value only occurs due to the spread of the GDPC between the countries. India and Nigeria are low income countries, while Brazil is a medium income country. The difference in predictors of GHI between the joint model and separate country models occurs because the joint model data encompasses a larger and more varied data set, hence different predictors are significant. This suggests that a single joint model should not be used for determining predictors for GHI.

PSI (political stability index) was not a significant predictor for GHI for any country or joint models. This is understandable in the context that India, Nigeria and Brazil are considered largely politically stable since civil unrest does not occur to extent that it would significantly affect access to food. For countries that are in midst of civil conflict, this lack of significance would not necessarily be the case.

It should be noted that our statistical analysis is only appropriate for identifying statistically significant predictors of GHI rather than computing correlations. For the latter, alternative statistically analysis, not presented here, would be required.

Summary

Food security in developing countries was assessed using standard statistical methodology utilizing multivariable regression and ANOVA to correlate GHI, a surrogate for food security, with economic development indices. Country models, rather than a single joint model, must be used to determine predictors of GHI. For India and Nigeria, 'GDPC' and 'Water' were statistically significant predictors of GHI. If one makes the reasonable assumption that India and Nigeria, despite differences in geography and culture, both are representative of the broader group of low income developing countries, then this correlation for GHI should generally also hold for other low income developing countries. Thus, to improve food security in these types of countries, development policies should be directed towards raising income and increasing accessibility of clean drinking water. For Brazil, a medium income country, 'Water' was a statistically significant factor for determining GHI. Brazil's food security, as based on WHI, transitioned from a minor concern to a successfully resolved issue over the 15 years reviewed. This is most likely due to GDPC not being relevant to food security once a threshold GDPC is achieved. Based on these findings, future investigations could lead to country specific models that measure impact of policies on GHI.

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Appendix A

Brazil																	
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
World Hunger Index	10	10	10	10	10	9	9	9	8	8	8	6	6	6	6	6	6
Index of Political Stability	-1.15	-1.17	-1.00	-0.70	-1.15	-1.52	-1.35	-1.69	-1.64	-1.72	-1.65	-1.99	-1.97	-1.81	-1.85	-2.08	-1.94
Percent of paved roads	8.90	9.30	9.10	9.60	5.60	5.50	6.00	7.00	8.00	9.00	10.00	10.50	11.00	12.00	13.00	13.25	13.46
GDP per capita (current $USD)	4751.07	5109.35	5220.86	4980.99	3413.26	3696.15	3129.76	2812.33	3041.68	3609.88	4743.27	5793.40	9500.00	7197.03	8628.95	10992.94	12593.89
Improved water source	91.00	92.00	92.00	93.00	94.00	94.00	94.00	94.00	95.00	95.00	96.00	96.00	97.00	97.00	97.00	98.00	98.00
Domestic Food Price Index	1.49	1.36	1.28	1.26	1.25	1.24	1.23	1.25	1.31	1.27	1.23	1.19	1.22	1.28	1.27	1.29	1.31
India																	
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
World Hunger Index	17	17	17	18	19	20	24.2	21	20	19	19	19	19	19	19	19	22.9
Index of Political Stability	-0.95	-0.91	-1.00	-1.11	-1.05	-0.98	-0.98	-1.25	-1.54	-1.21	-0.99	-1.09	-1.17	-1.12	-1.40	-1.32	-1.20
Percent of paved roads	55.40	54.70	56.50	57.00	46.67	47.46	47.74	47.40	48.00	48.62	46.99	47.72	48.24	49.54	50.00	51.50	52.00
GDP per capita (current $USD)	380.1	406.89	422.92	420.97	448.1	450.42	459.58	480.21	558.44	642.56	731.74	820.3	1,055.14	1,027.91	1,130.52	1,397.10	1,508.54
Improved water source	75	76	78	79	80	81	82	83	85	85	86	88	89	90	91	92	92
Domestic Food Price Index	2.60	2.51	2.35	2.42	2.49	2.46	2.35	2.39	2.42	2.36	2.37	2.36	2.46	2.38	2.19	2.12	2.21
Nigeria																	
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
World Hunger Index	20	20.9					18.2										15.7
Index of Political Stability	-1.25	-1.17	-1.00	-0.70	-1.00	-1.52	-1.55	-1.69	-1.64	-1.72	-1.65	-1.99	-1.97	-1.81	-1.85	-2.08	-1.94
Percent of paved roads	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
GDP per capita (current $USD)	255.5	313.44	314.3	272.44	287.92	371.77	378.83	455.33	508.43	644.03	802.79	1,014.58	1,129.09	1,374.67	1,091.26	1,443.21	1,501.72
Improved water source (% of population with access)	50	51	52	52	53	53	54	55	55	56	57	56	57	58	58	58	59
Domestic Food Price Index	2.72	2.69	2.69	2.59	2.45	2.37	2.55	2.55	2.38	2.34	2.47	2.43	2.32	2.38	2.38	2.42	2.39

Appendix B

Table 1.1 Linear Regression Model For India With All Predictors

Coefficients:	Estimate	Standard Error	t-Value	Pr(>|t|)
(Intercept)	12.5363324	4.5869413	2.733	0.019472
PSI	0.2715211	0.3479648	0.780	0.451672
Road	-0.0430987	0.0221900	-1.942	0.078141
GDPC	-0.0027728	0.0004542	-6.104	7.69e-05
Water	0.1913303	0.0385447	4.964	0.000426
DFPI	-0.2814080	0.6239856	-0.451	0.660761

Residual standard error: 0.1724 on 11 degrees of freedom. Multiple R-squared: 0.9375, Adjusted R-squared: 0.9091 F-statistic: 33 on 5 and 11 DF, p-value: 2.895e-0

Table 1.2 Linear Regression Model For India With Predictors GDPC and Water

Coefficients:	Estimate	Standard Error	t-Value	Pr(>|t|)
(Intercept)	6.0246424	1.5352615	3.924	0.00153
GDPC	-0.0033292	0.0003123	-10.659	4.21e-08
Water	0.2360809	0.0206348	11.441	1.72e-08

Residual standard error: 0.1898 on 14 degrees of freedom. Multiple R-squared: 0.9036, Adjusted R-squared: 0.8898. F-statistic: 65.62 on 2 and 14 DF, p-value: 7.734e-08

Table 1.3 ANOVA for India with GHI as the response (GDPC First, Water Second)

Coefficients:	Df	Sum Sq	Mean Sq	F value	Pr(>F)
GDPC	1	0.0122	0.0122	0.4115	0.53436
Water	1	4.7131	4.7131	158.6111	7.068e-08
PSI	1	0.0633	0.0633	2.1302	0.17238
Road	1	0.1079	0.1079	3.6310	0.08317
DFPI	1	0.0060	0.0060	0.2034	0.66076
Residuals	11	0.3269	0.0297		

Table 1.4 ANOVA for India with GHI as the response (Water First, GDPC Second)

Coefficients:	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Water	1	0.6345	0.6345	21.3536	0.0007392
GDPC	1	4.0908	4.0908	137.6690	1.465e-07
PSI	1	0.0633	0.0633	2.1302	0.17238
Road	1	0.1079	0.1079	3.6310	0.08317

DFPI	1	0.0060	0.0060	0.2034	0.6607612
Residuals	11	0.3269	0.0297		

Table 2.1 Linear Regression Model For Nigeria With All Predictors

Coefficients:	**Estimate**	**Standard Error**	**t-Value**	**Pr(>|t|)**
(Intercept)	43.888408	17.177491	2.555	0.0252
PSI	0.056074	0.984418	0.057	0.9555
Road	NA	NA	NA	NA
GDPC	0.001674	0. 0.001179	1.420	0.1810
Water	-0.549307	0.239199	-2.296	0.0405
DFPI	1.630640	2.706291	0.603	0.5580

Residual standard error: 0.8235 on 12 degrees of freedom. Multiple R-squared: 0.6959, Adjusted R-squared: 0.5945. F-statistic: 6.865 on 4 and 12 DF, p-value: 0.004094

Table 2.2 Linear Regression Model for Nigeria with Predictor Water

Coefficients:	**Estimate**	**Standard Error**	**t-Value**	**Pr(>|t|)**
(Intercept)	39.04757	4.17095	9.362	1.18e-07
Water	-0.36746	0.07583	-4.846	0.000214

Residual standard error: 0.8339 on 15 degrees of freedom. Multiple R-squared: 0.6102, Adjusted R-squared: 0.5842. F-statistic: 23.48 on 1 and 15 DF, p-value: 0.0002137

Table 2.3 ANOVA for Nigeria with GHI as the response (Water First, GDPC Second)

Coefficients:	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**
Water	1	16.3304	16.3304	24.0793	0.0003616
GDPC	1	2.0273	2.0273	2.9892	0.1094357
PSI	1	0.0190	0.0190	0.0280	0.8699171
Road	NA	NA	NA	NA	0.5580315
DFPI	1	0.2462	0.2462	0.3631	0.5580315
Residuals	12	8.1383	0.6782		

Table 2.4 ANOVA for Nigeria with GHI as the response (GDPC First, Water Second)

Coefficients:	***Df***	***Sum Sq***	***Mean Sq***	***F value***	***Pr(>F)***
GDPC	1	9.3865	9.3865	13.8405	0.0029
Water	1	8.9712	8.9712	13.2281	0.003406
PSI	1	0.0190	0.0190	0.0280	0.869917
Road	1	NA	NA	NA	NA

DFPI	1	0.2462	0.2462	0.3631	0.558031
Residuals	12	8.1383	0.6782		

Table 3.1 Linear Regression Model for Brazil with All Predictors

Coefficients:	*Estimate*	*Standard Error*	*t-Value*	*Pr(>|t|)*
(Intercept)	4.262e+01	6.411e+00	6.649	3.62e-05
PSI	3.590e-01	2.269e-01	1.582	0.142
Road	-5.505e-02	3.646e-02	-1.510	0.159
GDPC	8.440e-06	3.321e-05	0.254	0.804
Water	-3.828e-01	6.283e-02	-6.093	7.82e-05
DFPI	-2.216e-01	9.446e-01	-0.235	0.819

Residual standard error: 0.1709 on 11 degrees of freedom. Multiple R-squared: 0.9811, Adjusted R-squared: 0.9725. F-statistic: 114.1 on 5 and 11 DF, p-value: 4.273e-09

Table 3.2 Linear Regression Model for Brazil With Predictor Water

Coefficients:	*Estimate*	*Standard Error*	*t-Value*	*Pr(>|t|)*
(Intercept)	49.78118	2.13094	23.36	3.29e-13
Water	-0.47209	0.02245	-21.02	1.53e-12

Residual standard error: 0.1928 on 15 degrees of freedom. Multiple R-squared: 0.9672, Adjusted R-squared: 0.965. F-statistic: 442.1 on 1 and 15 DF, p-value: 1.527e-12

Table 3.3 ANOVA for Brazil with GHI as the response (Water First)

Coefficients:	*Df*	*Sum Sq*	*Mean Sq*	*F value*	*Pr(>F)*
Water	1	16.4398	562.6393	16.4398	8.513e-11
GDPC	1	0.0582	0.0582	1.9935	0.18564
PSI	1	0.0969	0.0969	3.3160	0.09589
Road	1	0.0797	0.0797	2.7268	0.12690
DFPI	1	0.0016	0.0016	0.0550	0.81881
Residuals	11	0.3214	0.0292		

JOINT
Table 4.1 Linear Regression Model For Combination of All 3 Countries With All Predictors

Coefficients:	*Estimate*	*Standard Error*	*t-Value*	*Pr(>|t|)*
(Intercept)	-1.510e+01	6.217e+00	-2.429	0.01922
PSI	3.386e-01	5.282e-01	-0.641	0.52473
Road	1.070e-01	3.364e-02	3.182	0.00265

GDPC	-4.786e-04	1.052e-04	-4.549	4.06e-05
Water	7.489e-02	4.595e-02	1.630	0.11018
DFPI	1.127e+01	1.676e+00	6.725	2.61e-08

Residual standard error: 1.182 on 45 degrees of freedom. Multiple R-squared: 0.9803, Adjusted R-squared: 0.9782. F-statistic: 449 on 5 and 45 DF, p-value: < 2.2e-16

Table 4.2 Linear Regression Model For All 3 Countries With Predictors GDPC, Road, DFPI

Coefficients:	***Estimate***	***Standard Error***	***t-Value***	***Pr(>|t|)***
(Intercept)	-4.977e+00	1.279e+00	-3.892	0.000313
GDPC	-4.370e-04	9.814e-05	-4.453	5.2e-05
Road	1.560e-01	1.080e-02	14.436	< 2e-16
DFPI	-8.768e+00	5.480e-01	15.998	< 2e-16

Residual standard error: 1.194 on 47 degrees of freedom. Multiple R-squared: 0.9791, Adjusted R-squared: 0.9778. F-statistic: 733.4 on 3 and 47 DF, p-value: < 2.2e-16

Table 4.3 ANOVA for All 3 Countries with GHI as the response (Road First, DFPI Second, GDPC Second)

Coefficients:	***Df***	***Sum Sq***	***Mean Sq***	***F value***	***Pr(>F)***
Road	1	1836.42	1836.42	1313.4414	< 2.2e-16
DFPI	1	1269.99	1269.99	908.3241	< 2.2e-16
GDPC	1	28.25	28.25	20.2062	4.836e-05
Water	1	3.47	3.47	2.7268	0.1224
PSI	1	0.57	0.57	0.4110	0.5247
Residuals	45	62.92	1.40		

Table 4.4 ANOVA for All 3 Countries with GHI as the response (Water First, GDPC Second, PSI Third)

Coefficients:	***Df***	***Sum Sq***	***Mean Sq***	***F value***	***Pr(>F)***
Water	1	826.27	826.27	590.962	< 2.2e-16
GDPC	1	1347.78	1347.78	908.3241	< 2.2e-16
PSI	1	19.02	19.02	20.2062	0.0006059
Road	1	882.40	882.40	2.7268	< 2.2e-16
DFPI	1	63.24	63.24	0.4110	2.606e-08
Residuals	45	62.92	1.40		