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Effect of Road Access in Domestic Economy of Nepal

(A Case Study of Selected Districts)

by

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ABSTRACT

The effect of road access status of various districts of Nepal on Gross Domestic Production (GDP) is evaluated and a model for the relationship between GDP and the road network development is calibrated. Two set of indicators; independent variables like transport road status (densities, connectivity indices, round year serviceability in year), population, land coverage and dependent variable economic status (GDP) are linked by statistical approach. The model thus formed is validated by using R^2 value, p-value and t-statistics and best regression model is determined. Power model is obtained as best fit model with highest R^2 value followed by lesser but very close to the highest R^2 value from a linear model. For the simplicity to use linear regression model is suggested. The linear regression model showed that all weather road density possesses double multiplicative effect than total road network density which has even higher multiplicative effect than population density. Suggesting for more public road sector investment in road network upgrading to all weather standard from fair weather standard than just to construct fair weather roads in Nepal, the result of this study has important implication in future investment planning for economic reforms.

Keywords: GDP, road access, road density, all weather road

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LIST OF ABBREVIATIONS

AD - Anno Domini

ANOVA - Analysis of Variance

ANCOVA - Analysis of Co-Variance

DoLIDAR - Department of Local Infrastructure Development and Agricultural Roads

DoR - Department of Roads

GDP - Gross Domestic Production

GNP - Gross Net Production

HDI - Human Development Index

KM - Kilometer

OECD - Organization for Economic Co-operation and Development

SPSS- Statistical Program for Social Sciences

UNDP - United Nations Development Program

USA - United States of America

WB - World Bank

CHAPTER 1: INTRODUCTION

1.1 Background

Economic development of a country is, in a broad sense, mainly driven by its level of investment, trade and consumption, and it is a phenomenon that not only diverges on the country level but also on the regional level. As a means of enabling trade, transport is assumed to be a key factor of the economic level achieved by a region.

The development of the transport infrastructure network has different economic and societal consequences. For the development of economy, transportation system, especially the road system, plays an important role to the countries like Nepal. Road system undertakes the transport tasks of human beings and goods. The most of the social and economic activities (e.g., working, recreation, freight, etc.) should use road networks; the success of these activities highly depends on the performance of road systems. So the existence of a connected road network is essential for economic success of the country. However, rural road network in most of the developing countries like Nepal are still in poor condition and under developed. In rural area people spend much time and efforts on transport activities to fulfill their basic needs, for example, rural communities in Nepal still do not have reliable access to main road networks and or easily connected to motorized routes within their locality (Aneniya, 2014). The availability and condition of rural transport network system is, therefore, an essential requirement for rural economic development.

If are affordable and appropriated for accessibility and connectivity from farms-to-farms, farmstead-to-villages as well as farmstead-to-local markets, provisions of all weather motorized roads is the essential conditions for rural development (WB, A Source Book for Poverty Reduction Strategies, 2001). Rural road accessibility and connectivity as a set of policies seeks to promote the well being of the rural and non-rural inhabitants by the means of supplying agricultural products both to the local markets as well as secondary industries in the sub-urban and in the urban centers (Ale, 2013). It is also pointed out that, improved accessibility as well as highly connected road will create market for agricultural products, opens up new land for economic opportunities and at the same time encourages farmers to improved on their various farming in other to

increase agricultural productivity and as well reduces spoilage and wastage of agricultural produce at various collection centers in the study area (Devkota, 2015). It is obvious that the development of road infrastructure generate more income thereby enhancing the gross product of selected territory. However, the main concern of the researcher is to assess how these road networks and their robustness effect the economy of the territory.

The most significant finding from (Fan & Chan-Kang, 2005) is that rural roads have benefit-cost ratios for national GDP that are about four times greater than benefit-cost ratios for high quality roads. Nepal's road network annually increased by 6.7% between FY95/96 and FY03/04, with the largest expansion occurring in roads classified as "district or rural roads", which grew annually by 11% during this period (WB, World Bank). Road density (expressed in kilometer/square kilometer of land; km/1,000 population, or km/\$1 million of GDP) has been used commonly as a proxy for rural accessibility and the percentage of paved road as a measure of the quality of rural access. Bangladesh is well endowed with rural roads (a road density of 1.84 km/km² compared to an average of 0.84 km/km² for South Asia). In Sri Lanka, 81% of the road network is paved. It is also possible to have accessibility without "good" mobility (as characterized by motorable all-weather roads), as in Nepal's mountain districts where a system of engineered trails and suspension foot bridges, pioneered with Swiss assistance, has radically cut down on travel time and improved access to markets and services (Rosenbloom, Butler, Walton, & Skinner, 2012). Accessibility is not dependent on mobility, and neither is good mobility a sufficient or necessary condition for good accessibility (W.B, 2006).

1.2 Statement of the Problem

It is believed that transport infrastructures have crucial effect on the opening of economic activities. Nepal has relatively less developed road infrastructure and it may have largely affected on the local economic multiplication. This research is mainly based on the following stated problems.

- i. How the socio-economic development are affected by availability of road infrastructures?

- ii. How to make a general estimation of GDP level of districts from the road connectivity status of districts of Nepal?

1.3 Objectives

The main objective of this study is to model the effect of the road network connectivity with the economy of the territory. The specific objectives are:

- i. To examine the effect of road access to the domestic economy
- ii. To develop a regression model between Gross Domestic Production (GDP) and road connectivity status of different districts of Nepal

CHAPTER 2: LITERATURE REVIEW

2.1 Road Network and Economy

Development of the road transport network plays an important role in the economic development of a country and, therefore the kilometers-age of paved roads existing in a country is often used as an index to assess the extent of its development. Roads contribute to the development of a country by bringing in direct benefits from their role in the development of activities such as agriculture, industry, commerce and mining and by bringing in indirect benefits from the enhancement in the value of property and the change it sets in the way of life and thinking of its people. It is therefore developed countries complete networks of roads and other transportation infrastructure and in the same way developing countries are making huge investments in developing and improving their transportation systems, including road networks (Aldagheiri, p. 2009).

As the road links districts, regions and people together, it shall be taken as a means of social and economic development (Hausmann & Hidalgo, 2011). The development of efficient road network is the way for enhancing mobility and accessibility which reduces the travel time and cost. Thus transport network is important for social development (Fouracre & Limited, 2001) along with economic development (Lacono & Levinson, 2015). The social and economic development associated with road network provides better access to education, health, delivery, employment opportunities and thus increasing the household income there by reducing poverty (Fan & Chan-Kang, 2005). Moreover, road development shall also enhance an area's economic development by providing basic infrastructure for investment and harnessing of local and regional economic development potential (Patarasuk, 2013) and also increases tourism flow (Hong, Ma, & Huan, 2014). The findings by (Worku, 2011) reveal that the total road network has significant growth spurring impact. When the network is disaggregated, asphalt road also has a positive sectoral impact, but gravel roads fail to significantly affect both overall and sectoral GDP growth, including agricultural GDP.

Despite these many social and economic benefits, road networks are also perceived as negative ecological effects on culture. Transportation infrastructure affects the structure of ecosystems, the dynamics of ecosystem function, and has direct effects on ecosystem

components, including their species composition. Clearly, the construction of transport lines results in the direct destruction and removal of existing ecosystems, and the reconfiguration of local landforms. However, transportation systems, and more specifically, roads, have a wide variety of primary, or direct, ecological effects as well as secondary, or indirect, ecological effects on the landscapes that they penetrate. The effects of roads can be measured in both abiotic and biotic components of terrestrial and aquatic ecosystems. (Coffin, 2007)

Besides these threats, transportation network provides access to farmlands, school, work zone and settlement zones there by reducing travel time and cost. Thus, farmers tend to increase agricultural productivity by expanding crop production along developed roads, which ultimately results in changed land use and thus growing the region's economy (Patarasuk, 2013). (Alvarez & Blazquez, 2014) were recommend that the both public and private sectors actively encourage investment in transport infrastructures in order to improve productivity growth and economic activity. The rapid development of road in Nepal is found growing since 1950. Tribhuvan Rajpath was opened to traffic since 1956 AD as a first highway in Nepal. In 2014 cabinet has amended 12424 km as strategic road network (DoR, 2014). However the history of rural roads is short and is started after 1993. Based on rural road statistics by DoLIDAR in 2013 AD, about 51,000 km of local roads is being constructed in Nepal. However most of them are fair weather tracks, these roads plays important role for the development of the rural part of the country (Thapa, 2013).

When it comes to direct benefits of transport infrastructure, economic growth is achieved with the money and time savings induced by improved transportation, and this mechanism is experienced at the regional level by governments or enterprises in various types of markets (Ottaviano and Puga, 1997; Ottaviano and Thisse, 2002; McCann, 2005). What drives the location of firms and consumers is the accessibility to spatially dispersed markets, which has been recognized for long in regional economics (Fujita and Thisse, 2002). The lower transport costs and greater accessibility for transport using production sectors and firms transferring goods from firms to retailers and for households engaged in commuting probably lead to the following consequences: higher efficiencies caused by scale economies, spatial agglomeration economies, market expansion and

restructuring, innovation benefits in spatial clusters, etc. Indeed, the accruing evidence of these economic mechanisms has been analysed and reported in the study of railways and highways in many countries in the recent literature (Rephann and Isserman, 1994; Surico, 2001; Bose and Haque, 2005; Lakshmanan, 2011). But, in a landlocked developing country like Nepal, road transportation is the abundantly available mode as railways, and waterways are not available.

In theory, provision of transport infrastructure is hypothesized to affect regional economic growth by lower transport costs and greater accessibility. Macroeconomics can help explain whether and to what degree transport infrastructure can lower production costs and increase the level of economic output (Samuelson, 1954; Krugman, 1991, 1995; Fujita et al., 1999; Lafourcade, 2009). Meanwhile, there are a variety of opinions among decision-makers and economists as to the causal mechanism between transport infrastructure improvements and output and productivity enhancements (Fujita and Thisse, 2002; Zhang and Sun, 2008; Lakshmanan, 2011). In a previous study of road network structure and economic development in terms of GDP of various districts of Nepal showed a strong correlation between road network density and connectivity and GDP. But this study failed to establish the distinction of contribution of quality and serviceability of roads in GDP (Devkota, 2015). This study intends to investigate the causal linkages between the road network development in terms of density, connectivity and quality expressed in terms of round year serviceability to the regional economy in terms of gross domestic production, in order to determine whether it is possible to establish the causality between them.

2.2 Network Robustness

Road network robustness is the insusceptibility of a road network to disturbing incidents, and could be understood as the opposite of network vulnerability. In other words, road network robustness is the ability of a road network to continue to operate correctly across a wide range of operational conditions (Ellens & Kooij, 2013) and (Immers, Stada, Yperman, & Bleukx, 2004).

Taking a number of corrective measures may enhance the robustness of the transportation system. These measures include the introduction of a certain redundancy or spare

capacity into the system and minimizing the interdependency of system components to prevent a local disturbance from propagating through the entire system. In our opinion the related notions of resilience and flexibility also have a bearing on the robustness of a system.

The robustness of a system may be improved by introducing a certain amount of redundancy or spare capacity into the system. Strictly speaking redundancy means the existence of more than one means to accomplish a given function. There are two types of redundancy: active and passive (or stand-by) redundancy. In the case of active redundancy both main system and spare system operate together in normal conditions but each system is capable of handling the complete task on its own in case of failure of the other. Passive redundancy means that the back-up system is activated only upon failure of the main system. A lack of redundancy may have catastrophic consequences. Examples are the recent major disruptions in electricity supply in New York, England and Italy. In the Netherlands the service quality on the national railway network has suffered considerably from a lack of redundancy.

On the road network insufficient spare capacity also may lead to degradation in the quality of service. This could potentially have grave consequences in situations necessitating a rapid evacuation of the population. On a smaller scale even relatively minor incidents may cause sizeable congestion on the road network that not only causes delays but also may interfere with the emergency services reaching the incident location. Incidental situations such as major road works, extreme weather conditions and large-scale public events also require some redundancy in road capacity.

The location of a link or a node is important in the sense that in certain cases congestion and associated unreliability are confined to the concerned link or a small part of the network. In other cases congestion at a centrally located link or node may cause a series of cascading failures disrupting traffic on large parts of the network. These cascading failures are enhanced by the presence of all types of interdependencies between system components (Alderson, 2002). Possible options to minimize interdependency in infrastructure networks are:

- Maintaining a hierarchy of essentially independent but well-connected functional road subsystems.
- Reducing the vulnerability of main network nodes for example by limiting the number of branches at an intersection and optimizing the distance between nodes.

2.3 Network Reliability

Several understandings about road network reliability exist from different interests in the research objectives. The most accepted definition of the network reliability is given by (Billington & Allan, 1992) and (Wakabayashi & Iida, 1992) as cited by (Li, 2008) as: *“Reliability is the probability of a road network performing its proposed service level adequately for the period of time intended under the operating conditions encountered.”* The prioritization of investments in road networks based on vulnerability indicators is still a relatively underexplored approach (Oliveira, Portugal, & Junior, 2014).

2.4 Graph theory-based measures and indices

The connection and arrangement of a road network is usually abstracted in network analysis as a directed planar graph $G=\{V, E\}$, where V is a collection of nodes (vertices) connected by directional links (edges) E (Xie & Levenson, 2006). The study by (Patarasuk, 2013) uses graph theory-based concepts in Lop Buri province, Thailand by employing alpha (a), beta (b), and gamma (c) indices to determine road connectivity. These indices are commonly used as measures of the levels of circuitry, complexity, or connectivity, respectively, in a network. In general, the higher the values of these indices, the higher degree of circuitry, complexity, and connectivity. Connectivity index algorithms used in the study are based on planar graphs, or graphs that can be made to lie in a plane such that no edges intersect at a point other than a node/vertex (Morlok, 1967). Network indices: a , b , and c have the following equations:

$$\text{alpha}, a = \frac{C}{C_{\max}} = \frac{e - v + 1}{2v - 5} \dots\dots\dots 1$$

$$\text{beta index}, b = \frac{C}{C_{\max}} = \frac{e}{v} \dots\dots\dots 2$$

$$\text{gamma index}, c = \frac{e}{e_{\max}} = \frac{e}{3v - 6} \dots\dots\dots 3$$

Where,

e is the number of links and v is the number of nodes.

In this study, an edge (or link) refers to a road segment and a node (or vertex) refers a point of an intersection where at least two road segments meet. Each of these indices was calculated for each district to measure the dynamics of road connectivity in districts.

2.5 Gross Domestic Products

Gross domestic product (GDP) at market prices is the expenditure on final goods and services minus imports: final consumption expenditures, gross capital formation, and exports less imports. GDP is one of the primary indicators used to gauge the health of a country's economy. It represents the total monetary value of all goods and services produced over a specific time period - as the size of the economy. This indicator is measured in currency amount (Local Currency or USD) per capita (GDP per capita) (OECD, 2015). Gross domestic product can be calculated using the following formula (investopedia):

$$\text{GDP} = \text{C} + \text{G} + \text{I} + \text{NX} \dots\dots\dots 4$$

Where, "C" is equal to all private consumption, or consumer spending, in a nation's economy, "G" is the sum of government spending, "I" is the sum of all the country's businesses spending on capital and "NX" is the nation's total net exports, calculated as total exports minus total imports ($\text{NX} = \text{Exports} - \text{Imports}$).

GDP is composed of goods and services produced for sale in the market and also includes some nonmarket production, such as defense or education services provided by the government. An alternative concept, gross national product, or GNP, counts all the output of the residents of a country. So if a German-owned company has a factory in the United States, the output of this factory would be included in U.S. GDP, but in German GNP Not all productive activity is included in GDP. For example, unpaid work (such as that performed in the home or by volunteers) and black-market activities are not included because they are difficult to measure and value accurately. That means, for example, that a baker who produces a loaf of bread for a customer would contribute to GDP, but would not contribute to GDP if he baked the same loaf for his family. Moreover, "gross" domestic product takes no account of the wear and tear on the machinery, buildings, and so on (the so-called capital stock) that are used in producing the output. If this depletion

of the capital stock, called depreciation, is subtracted from GDP, we get net domestic product. Theoretically, GDP can be viewed in three different ways.

- The production approach sums the “value added” at each stage of production, where value added is defined as total sales minus the value of intermediate inputs into the production process. For example, flour would be an intermediate input and bread the final product, or an architect’s services would be an intermediate input and the building the final product.
- The expenditure approach adds up the value of purchases made by final users—for example, the consumption of food, televisions, and medical services by households; the investments in machinery by companies; and the purchases of goods and services by the government and foreigners.
- The income approach sums the incomes generated by production for example, the compensation employees receive and the operating surplus of companies (roughly sales minus costs).

GDP in a country is usually calculated by the national statistical agency, which compiles the information from a large number of sources. In making the calculations, however, most countries follow established international standards. The international standard for measuring GDP is contained in the System of National Accounts, 1993, compiled by the International Monetary Fund, the European Commission, the organization for Economic Cooperation and Development, the United Nations, and the World Bank.

2.5.1 Real GDP

One thing people want to know about an economy is whether its total output of goods and services is growing or shrinking. But because GDP is collected at current, or nominal, prices, one cannot compare two periods without making adjustments for inflation. To determine “real” GDP, its nominal value must be adjusted to take into account price changes to allow us to see whether the value of output has gone up because more is being produced or simply because prices have increased. A statistical tool called the price deflator is used to adjust GDP from nominal to constant prices. GDP is important because it gives information about the size of the economy and how an economy is performing. The growth rate of real GDP is often used as an indicator of the general health of the economy. In broad terms, an increase in real GDP is interpreted as a sign that the economy is doing well, when real GDP is growing strongly, employment is likely to be increasing as companies hire more workers for their factories and people have more money in their pockets.

At present, concerns are in the opposite direction. After several years of exceptionally strong real GDP growth, many countries are experiencing a slowdown, with real GDP estimated to have declined in a number of industrial countries in recent quarters. But real GDP growth does move in cycles over time. Economies are sometimes in periods of boom, and sometimes periods of slow growth or even recession (with the latter sometimes defined as two consecutive quarters in which output declines). In the United States, for example, there were six recessions of varying length and severity between 1950 and 2007 (see chart). The National Bureau of Economic Research makes the call on the dates of U.S. business cycles.

2.5.2 Comparing GDPs of two countries

GDP is measured in the currency of the country in question. That requires adjustment when trying to compare the value of output in two countries using different currencies. The usual method is to convert the value of GDP of each country into U.S. dollars and then compare them. Conversion to dollars can be done either using market exchange rates—those that prevail in the foreign exchange market or purchasing-power-parity (PPP) exchange rates. The PPP exchange rate is the rate at which the currency of one country would have to be converted into that of another to purchase the same amount of goods and services in each country (see “Back to Basics” in the March 2007 issue of Finance & Development). There is a large gap between market and PPP-based exchange rates in emerging market and developing countries. For most emerging market and developing countries, the ratio of the market and PPP U.S. dollar exchange rates is between 2 and 4. This is because non-traded goods and services tend to be cheaper in low-income than in high-income countries, such as machinery, across two countries is the same. For advanced countries, market and PPP exchange rates tend to be much closer. These differences mean that emerging market and developing countries have a higher estimated dollar GDP when the PPP exchange rate is used. The IMF publishes an array of GDP data on its website (www.imf.org). International institutions such as the IMF also calculate global and regional measures of real GDP growth. These give an idea of how quickly or slowly the world economy or the economies in a particular region of the world are growing. The aggregates are constructed as weighted averages of the GDP in individual countries, with weights reflecting each country’s share of GDP in the group (with PPP exchange rates used to determine the appropriate weights).

CHAPTER 3: METHODOLOGY

3.1 Methodology Adopted

3.1.1 Statistical analysis

Regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables (or 'predictors'). Simple regression, Multiple regression, Factorial regression, Polynomial regression, Response surface regression, Mixture surface regression, One-way ANOVA, Main effect ANOVA, Factorial ANOVA, Analysis of covariance (ANCOVA), Homogeneity of slopes are the frequently used tools of regression analysis. The concept of these analysis shall be formulated as:

$$Y=f(X_1, X_2, X_3, X_4, \dots, X_n) \dots\dots\dots 5$$

Where,

Y=Dependent Variable, based on economy

X₁, X₂, X₃ = are independent variables based on network connectivity and salient features of the district or region

The analysis shall be performed by using SPSS version 16 and Microsoft Office Excel, STATA.

Building the Whole Model: Partitioning Sums of Squares

A fundamental principle of least squares methods is that the variation on a dependent variable can be partitioned, or divided into parts, according to the sources of the variation. Suppose that a dependent variable is regressed on one or more predictor variables, and that for convenience the dependent variable is scaled so that its mean is 0. Then a basic least squares identity is that the total sum of squared values on the dependent variable equals the sum of squared predicted values plus the sum of squared residual values. Stated more generally,

$$S(y - \bar{y})^2 = S(\hat{y} - \bar{y})^2 + S(y - \hat{y})^2 \dots\dots\dots 6$$

where the term on the left is the total sum of squared deviations of the observed values on the dependent variable from the dependent variable mean, and the respective terms on the right are (1) the sum of squared deviations of the predicted values for the dependent variable from the dependent variable mean and (2) the sum of the squared deviations of the observed values on the dependent variable from the predicted values, that is, the sum of the squared residuals. Stated yet another way,

$$\text{Total SS} = \text{Model SS} + \text{Error SS} \dots\dots\dots 7$$

Note that the Total SS is always the same for any particular data set, but that the Model SS and the Error SS depend on the regression equation. Assuming again that the dependent variable is scaled so that its mean is 0, the Model SS and the Error SS can be computed using

$$\text{Model SS} = \mathbf{b}'\mathbf{X}'\mathbf{Y} \dots\dots\dots 8$$

$$\text{Error SS} = \mathbf{Y}'\mathbf{Y} - \mathbf{b}'\mathbf{X}'\mathbf{Y} \dots\dots\dots 9$$

Building the Whole Model: Testing the Whole Model

Given the Model SS and the Error SS, one can perform a test that all the regression coefficients for the X variables (b_1 through b_k , excluding the b_0 coefficient for the intercept) are zero. This test is equivalent to a comparison of the fit of the regression surface defined by the predicted values (computed from the whole model regression equation) to the fit of the regression surface defined solely by the dependent variable mean (computed from the reduced regression equation containing only the intercept). Assuming that $X'X$ is full-rank, the whole model hypothesis mean square

$$\text{MSH} = (\text{Model SS})/k \dots\dots\dots 10$$

where k is the number of columns of X (excluding the intercept column), is an estimate of the variance of the predicted values. The error mean square

$$s^2 = \text{MSE} = (\text{Error SS})/(n-k-1) \dots\dots\dots 11$$

where n is the number of observations, is an unbiased estimate of the residual or error variance. The test statistic is

$$F = \text{MSH}/\text{MSE} \dots\dots\dots 12$$

where F has $(k, n - k - 1)$ degrees of freedom. If $X'X$ is not full rank, $r + 1$ is substituted for k , where r is the rank or the number of non-redundant columns of $X'X$. If the whole model test is not significant the analysis is complete; the whole model is concluded to fit

the data no better than the reduced model using the dependent variable mean alone. It is futile to seek a sub-model which adequately fits the data when the whole model is inadequate.

Building Models via Stepwise Regression

Stepwise model-building techniques for regression designs with a single dependent variable are described in numerous sources (e.g., see Darlington, 1990; Hocking, 1966, Lindeman, Merenda, and Gold, 1980; Morrison, 1967; Neter, Wasserman, and Kutner, 1985; Pedhazur, 1973; Stevens, 1986; Younger, 1985). The basic procedures involve (1) identifying an initial model, (2) iteratively "stepping," that is, repeatedly altering the model at the previous step by adding or removing a predictor variable in accordance with the "stepping criteria," and (3) terminating the search when stepping is no longer possible given the stepping criteria, or when a specified maximum number of steps has been reached.

Building Models via Best-Subset Regression

All-possible-subset regression can be used as an alternative to or in conjunction with *stepwise* methods for finding the "best" possible sub-model. Neter, Wasserman, and Kutner (1985) discuss the use of all-possible-subset regression in conjunction with *stepwise regression* "A limitation of the stepwise regression search approach is that it presumes there is a single "best" subset of X variables and seeks to identify it. As noted earlier, there is often no unique "best" subset. Hence, some statisticians suggest that all possible regression models with a similar number of X variables as in the stepwise regression solution be fitted subsequently to study whether some other subsets of X variables might be better." This reasoning suggests that after finding a stepwise solution, the "best" of all the possible subsets of the same number of effects should be examined to determine if the stepwise solution is among the "best." If not, the stepwise solution is suspect.

All-possible-subset regression can also be used as an alternative to stepwise regression. Using this approach, one first decides on the range of subset sizes that could be considered to be useful. Several different criteria can be used for ordering subsets in terms of "goodness." The most often used criteria are the subset multiple *R-square*, *adjusted R-square*, and *Mallow's Cp* statistics. When all-possible-subset regression is used in conjunction with stepwise methods, the subset multiple *R-square* statistics allows direct comparisons of the "best" subsets identified using each approach.

3.2 Research Design

The overall research flows in following sequence.

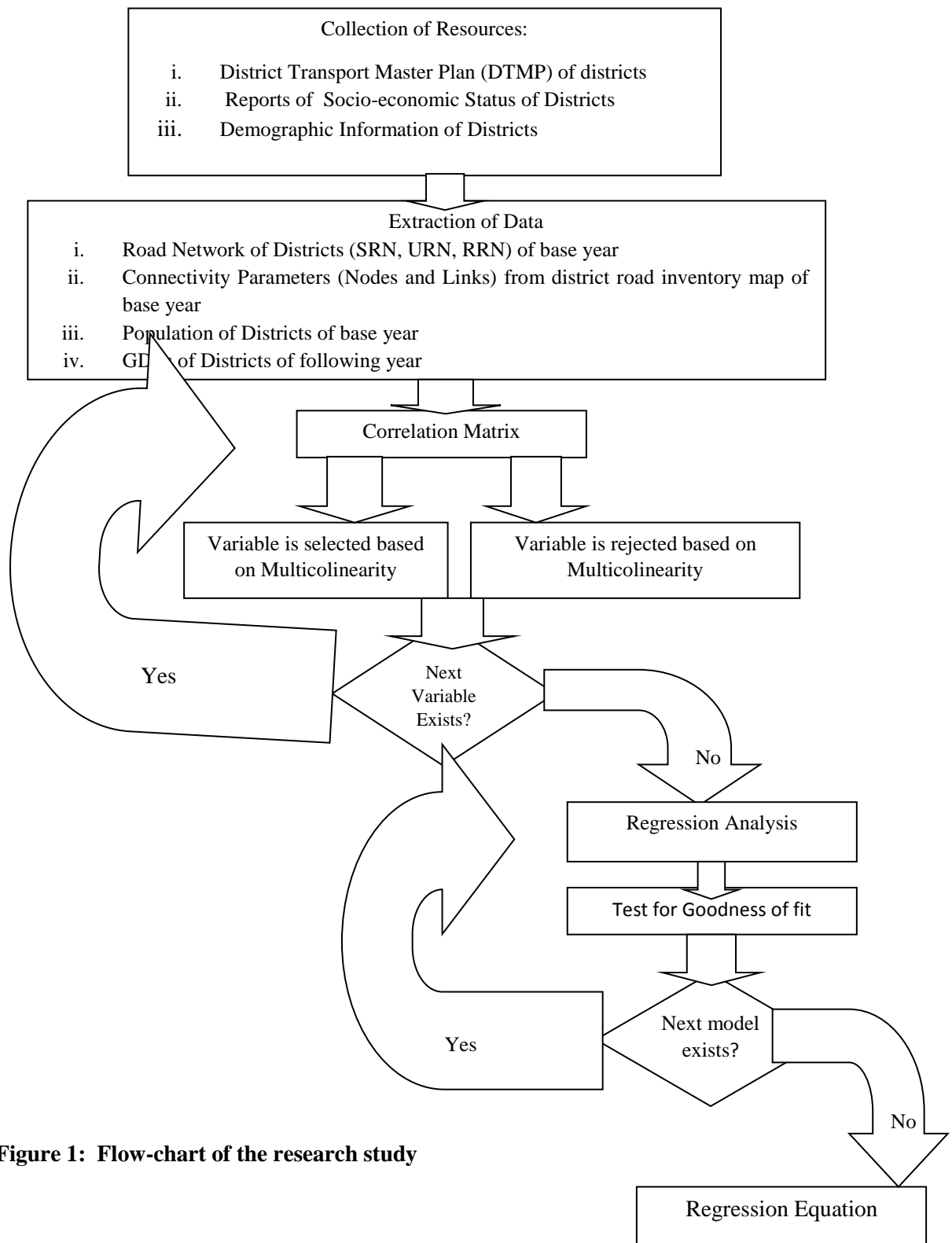


Figure 1: Flow-chart of the research study

3.3 Selection of Variables

Parameters selection has the crucial role in any research. For this study following initial parameters are taken.

Dependent Variable	Independent Variables
<ul style="list-style-type: none"> • Gross Domestic Production of districts 	<ul style="list-style-type: none"> • Population • Land area • Road Length (SR, UR, VR) • Road Access Level (all Weather/Fair weather) • Total road length • Road Connectivity Indices (Nodes/Links)

Table 1 List of identified variables

Based on the test of significance of variables through initial regression analysis and correlation matrix, variables are either retained, screened out or factored to make the higher degree of fit.

Dependent Variable	Factored Variables
<ul style="list-style-type: none"> • GDP per capita of districts 	<ul style="list-style-type: none"> • Road density per square kilometer area • Road density per 1000 population

Table 2 List of Prepared variables

3.4 Study area

The population for the study covers all 75 districts of Nepal. The data for the study rely on road network presented on District Transport Master Plan (DTMP) as developed by Ministry of Federal Affairs and Local Development and Federal Affairs (MoFALD).

For this study 9 districts are selected in random stratified sampling basis to cover all the geographical regions of Nepal namely: Bhojpur , Palpa, Kailali, Kapilbastu, Kaski and Makwanpur, Kathmandu, Jumla and Chitwan are selected. In choosing districts it is considered that they have recently prepared DTMP, in a same fiscal year.

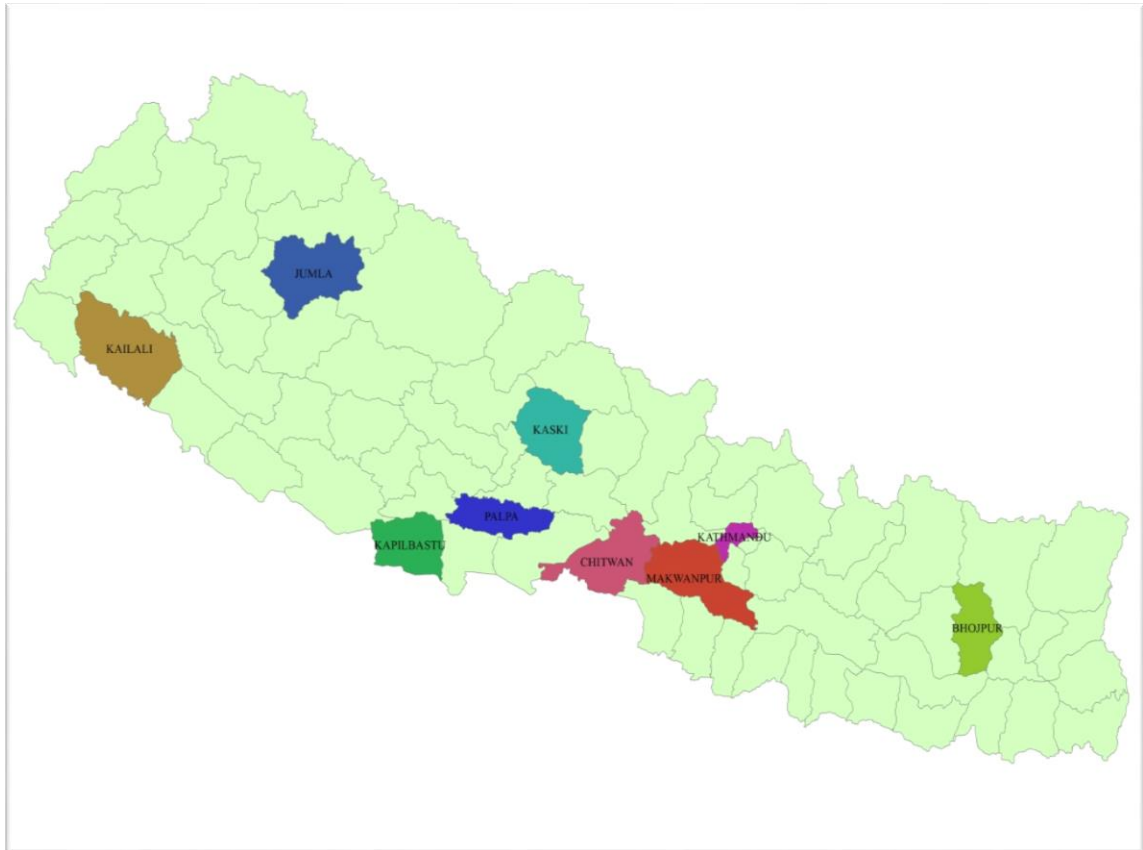


Figure 2: Map of Nepal showing selected districts for study

3.5 Data collection

Following categorical data were collected. The DTMPs of districts were collected from DoLIDAR. All the existing road network data were extracted including number of linkages and road classification (SRN, DCRN, VR, UR). Demographic and physiographic data were taken from Central Bureau of Statistics (CBS) reports. The population data thus collected was made projection to the period at which the existing DTMP report was prepared. Again the GDP data were collected from the Nepal Human Development Report (UNDP, p. 2014) for the year just next of the year of DTMP preparation.

CHAPTER 4: ANALYSIS AND RESULTS

4.1 General

All the historical GDP data as dependent variables and the road network density, connectivity and demographic data considered as the independent variables were arranged in a data matrix after the data collections. Then, correlation between the dependent and independent variables are checked to find the significance of the independent variables. The preliminary analysis was carried out to find the overall trend of road network density and their correlation with the GDP values of the territories. The preliminary analysis becomes the basis for the model development. This provides an insight for the variables to be included for the development of model. The analysis was followed by regression analysis.

4.2 Data Preparation

All the existing road network data were extracted including number of linkages and road classification (SRN, DCRN, VR, UR). Demographic and physiographic data were taken from Central Bureau of Statistics (CBS) reports. The population data thus collected was made projection to the period at which the existing DTMP report was prepared. Again the GDP data were collected from the Nepal Human Development Report (UNDP, p. 2014) for the year just next of the year of DTMP preparation.

4.2.1 Population of district

The population of districts selected for this study are obtained of two census years 2001 and 2011. But the road network data are of 2013. Hence the population is projected for the year 2013. The projection is based on the assumption of linear growth rate. The result is tabulated in the following table.

SN	District	Population 2001	Population 2011	Annual Growth Rate % (Linear)	Projected Population 2013	Remarks
1	Makwanpur	392604	420477	0.00710	426,469	

SN	District	Population 2001	Population 2011	Annual Growth Rate % (Linear)	Projected Population 2013	Remarks
2	Kailali	616697	775709	0.02578	816,227	
3	Bhojpur	203018	182459	0.00404	183,936	
4	Kapilvastu	481976	571936	0.01866	593,485	
5	Palpa	268558	261180	0.00101	261,710	
6	Kaski	380527	492098	0.02932	521,378	
7	Kathmandu	1081845	1744240	0.06123	1,964,373	
8	Chitwan	472048	579984	0.02287	606,810	
9	Jumla	89427	108921	0.02180	113,721	

Table 3 Population of Districts

4.2.2 Area of Districts

Area of each districts are taken from the GIS outputs from the datasheets issued by Survey Department of Nepal. As GDPs are measure of production outputs of economic activities within a territory, area data are of crucial importance in describing the GDP of the districts.

SN	District	Area of Land (sq. km)
1	Makwanpur	2426
2	Kailali	3235

SN	District	Area of Land (sq. km)
3	Bhojpur	1507
4	Kapilvastu	1738
5	Palpa	1373
6	Kaski	2017
7	Kathmandu	395
8	Chitwan	2218
9	Jumla	2531

Table 4 Area of Districts

4.2.3 Road Network

The road network retrieved from the DTMP report of the respective districts of the year 2013 are presented in following table. The total road network is composed of the strategic road network, urban road network and the rural road network. A road network is a collective term for the assemblages of road segments and crossings, so its measure is in terms of the lengths of roads and the degree of connectivity.

4.2.3.1 Total Length of Network

More the length of road more is the chance of accessibility of different regions. The length of total road network is useful to derive the road density.

SN	District	SRN (km)	URN (km)	RRN (km)	Total (km)
1	Makwanpur	335.14	87.87	1111.55	1534.56
2	Kailali	309.60	622.00	1560.00	2491.60
3	Bhojpur	116.00	26.00	253.42	395.42
4	Kapilvastu	131.00	108.67	941.60	1181.27
5	Palpa	199.59	57.00	417.50	674.09
6	Kaski	112.96	100.00	537.69	750.65
7	Kathmandu	267.79	97.26	713.24	1078.29
8	Chitwan	96.00	1065.00	1471.11	2632.11
9	Jumla	83.00	0.00	183.68	266.68

Table 5 Categorized Road Network Length of Districts

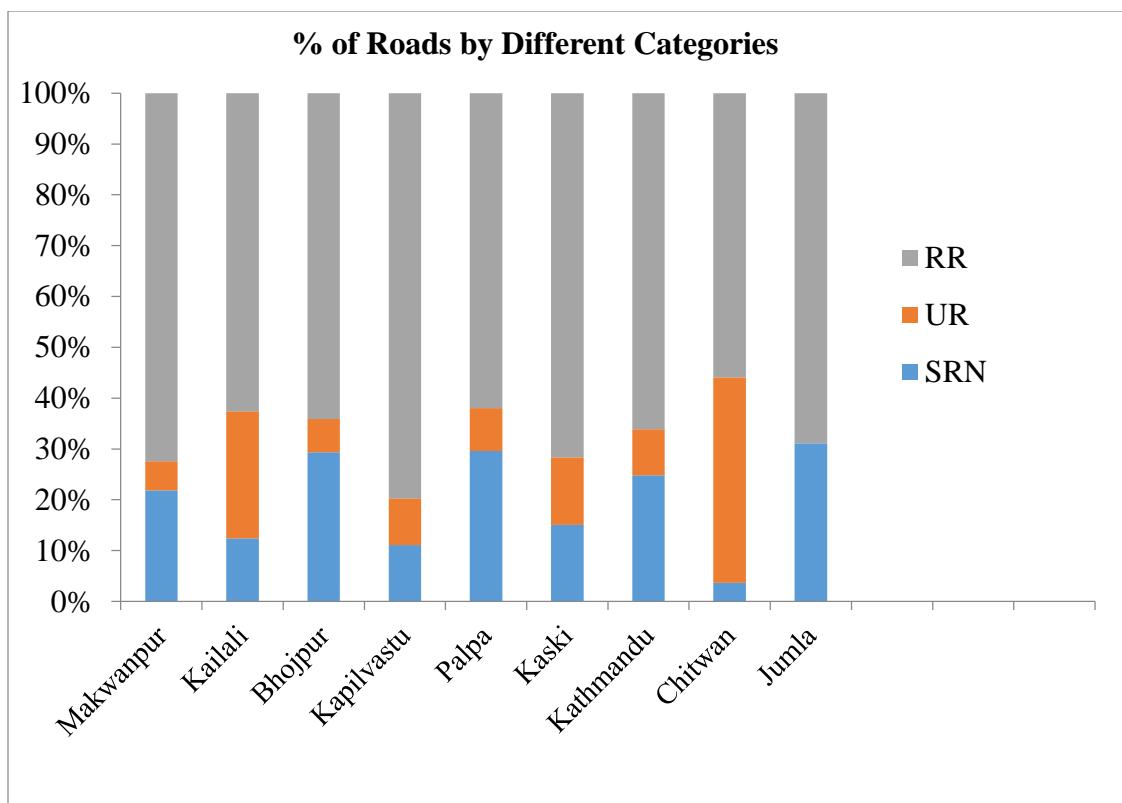


Figure 3: Ratio of different categories of roads in the districts

4.2.3.2 Density of Roads

From the categorical data of length of roads and area of districts road density per unit area are calculated. This normalizes the presence of roads in various sizes of districts.

SN	District	Density of Road per Unit Area (km/km ²)			
		SRN	UR	RR	Total
1	Makwanpur	0.138	0.036	0.458	0.63
2	Kailali	0.096	0.192	0.482	0.77
3	Bhojpur	0.077	0.017	0.168	0.26

SN	District	Density of Road per Unit Area (km/km ²)			
		SRN	UR	RR	Total
4	Kapilvastu	0.075	0.063	0.542	0.68
5	Palpa	0.145	0.042	0.304	0.49
6	Kaski	0.056	0.050	0.267	0.37
7	Kathmandu	0.678	0.246	1.806	2.73
8	Chitwan	0.043	0.480	0.663	1.19
9	Jumla	0.033	0.000	0.073	0.11

Table 6 Road Densities per Unit Area

Road density per unit population gives the normalization of roads for varying population sizes in same area of districts. Data is presented in road lengths per 1000 population.

SN	District	Density of Road per 1000 Population (km/1000 Pop)			
		SRN	UR	RR	Total
1	Makwanpur	0.786	0.206	2.606	3.60
2	Kailali	0.379	0.762	1.911	3.05
3	Bhojpur	0.631	0.141	1.378	2.15
4	Kapilvastu	0.221	0.183	1.587	1.99
5	Palpa	0.763	0.218	1.595	2.58

SN	District	Density of Road per 1000 Population (km/1000 Pop)			
		SRN	UR	RR	Total
6	Kaski	0.217	0.192	1.031	1.44
7	Kathmandu	0.136	0.050	0.363	0.55
8	Chitwan	0.158	1.755	2.424	4.34
9	Jumla	0.730	0.000	1.615	2.35

Table 7 Road Densities per 1000 Population

4.2.3.3 Connectivity of the Network

For degree of connectivity, number of nodes and links within the network of each districts were counted. Then alpha, beta and gamma index were calculated using graph theory based approach used by Patarasuk.

SN	District	Links (e)	Nodes (v)	Alpha (a)	Beta (b)	Gamma g)
1	Makwanpur	147	113	0.158	1.301	0.441
2	Kailali	67	55	0.124	1.218	0.421
3	Bhojpur	50	50	0.011	1.000	0.347
4	Kapilvastu	270	190	0.216	1.421	0.479
5	Palpa	225	162	0.201	1.389	0.469
6	Kaski	73	61	0.111	1.197	0.412

SN	District	Links (e)	Nodes (v)	Alpha (a)	Beta (b)	Gamma g)
7	Kathmandu	210	144	0.237	1.458	0.493
8	Chitwan	46	43	0.049	1.070	0.374
9	Jumla	19	20	0.000	0.950	0.352

Table 8 Degree of Connectivity of Road Network

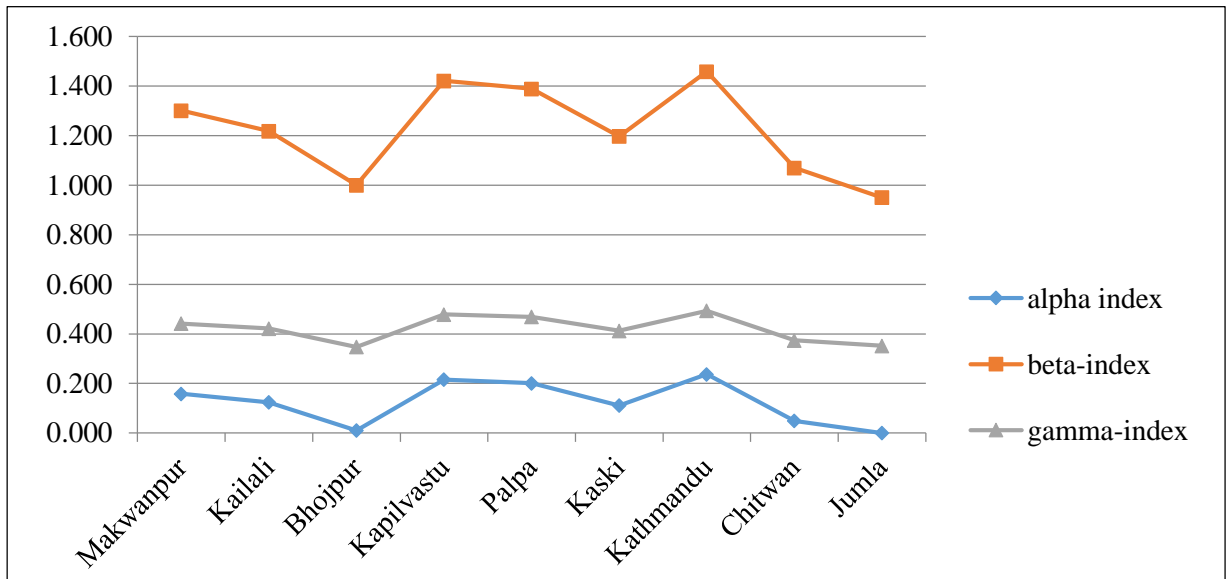


Figure 4: Variation of Connectivity Indices Across the Selected Districts

4.2.3.4 Quality of Road

Amongst the total roads, quality of roads are of prime importance. A simpler distinction for the quality of road is made by the service period of roads, expressed in terms of All Weather roads and Fair Weather Roads. Fair Weather Roads can give service in non-monsoon periods only but are not passable in the rainy seasons while All Weather Roads are passable round the year. Road surface, presence of river crossing structure and landslide activity are basic factors to decide whether the road serves all weather or only in fair weather. But in this study, all gravel or blacktopped roads are taken as all weather roads and earthen roads are treated fair weather roads.

SN	District	All Weather Roads (km)	Fair Weather Roads (km)	Remarks
1	Makwanpur	423.01	1111.55	
2	Kailali	553.00	1938.60	
3	Bhojpur	7.50	387.92	
4	Kapilvastu	239.67	941.60	
5	Palpa	256.59	417.50	
6	Kaski	351.25	399.40	
7	Kathmandu	757.12	321.17	
8	Chitwan	2255.59	376.52	
9	Jumla	0.00	266.68	

Table 9 Road Lengths Based on Service Period

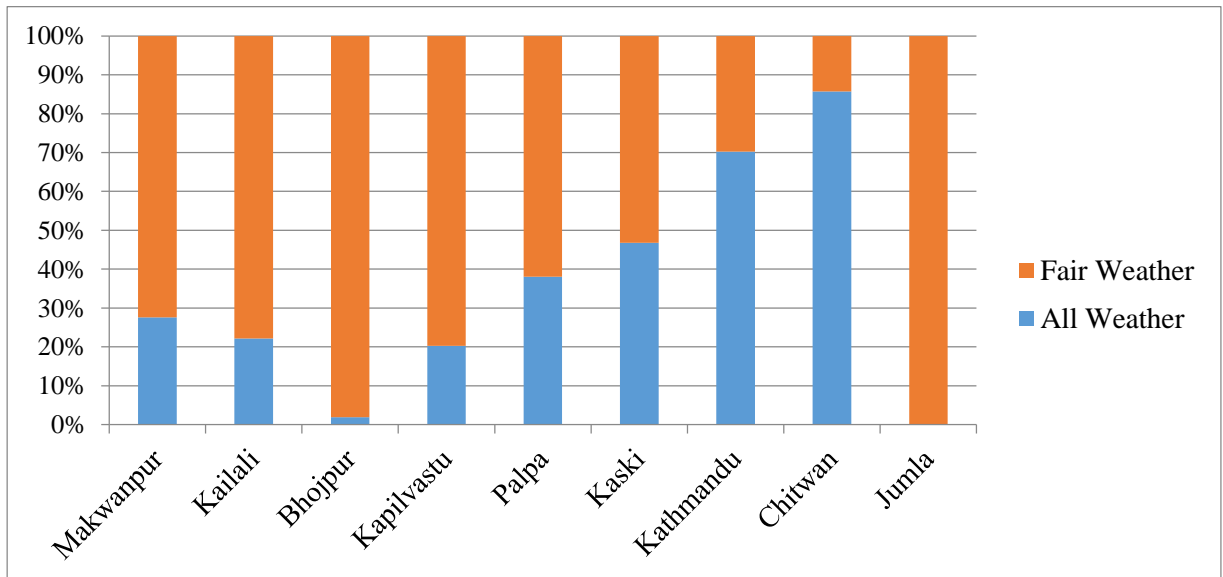
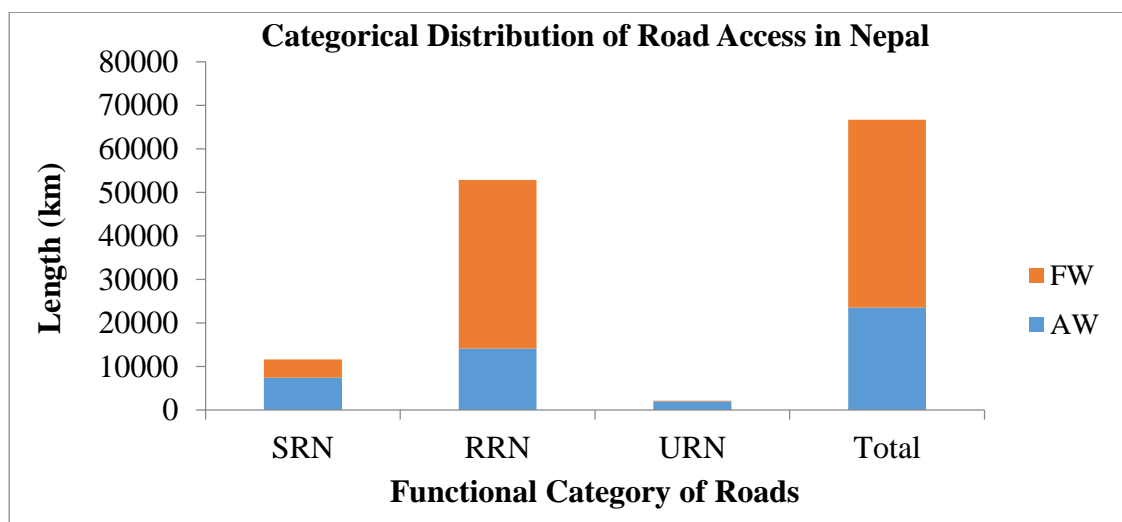


Figure 5: Relative Distribution of All Weather and Fair Weather Roads in Selected Districts

The area density and population density of All Weather and Fair Weather Roads of each districts are calculated and tabulated as below.

SN	District	Population Density (Pop/km ²)	Density of Road per Unit Area (km/km ²)		Density of Road per 1000 Population (km/1000 Pop)	
			AW Road	FW Road	AW Road	FW Road
1	Makwanpur	175.79	0.17	0.46	0.99	2.61
2	Kailali	252.31	0.17	0.60	0.68	2.38
3	Bhojpur	122.05	0.00	0.26	0.04	2.11
4	Kapilvastu	341.48	0.14	0.54	0.40	1.59
5	Palpa	190.61	0.19	0.30	0.98	1.60
6	Kaski	258.49	0.17	0.20	0.67	0.77
7	Kathmandu	4,973.10	1.92	0.81	0.39	0.16
8	Chitwan	273.58	1.02	0.17	3.72	0.62
9	Jumla	44.93	0.00	0.11	0.00	2.35

Table 10 Road Densities Based on Service Period



Source: Compilation from DoR and DoLIDAR reports

Figure 6: Categorical Distribution of road access in overall Nepal

4.2.4 Gross Domestic Production

Gross domestic production of a territory is the total value of goods and services produced in the boundary of that territory within a period of one year. Extracted from the human development report published by UNDP and planning commission of Nepal, the districts GDP are tabulated as in the following table.

SN	District	GDP Per Capita at Market Price, \$
1	Makwanpur	264.49
2	Kailali	323.76
3	Bhojpur	8,0.84
4	Kapilvastu	251.86
5	Palpa	113.58
6	Kaski	342.10
7	Kathmandu	2153.91
8	Chitwan	397.13
9	Jumla	49.00

Table 11: GDP per capita of districts, 2014

The selected districts are basically the production based economy, the major source of economic production is through the production of goods although Kathmandu, Kaski and Chitwan have some influential portion of service based economy too.

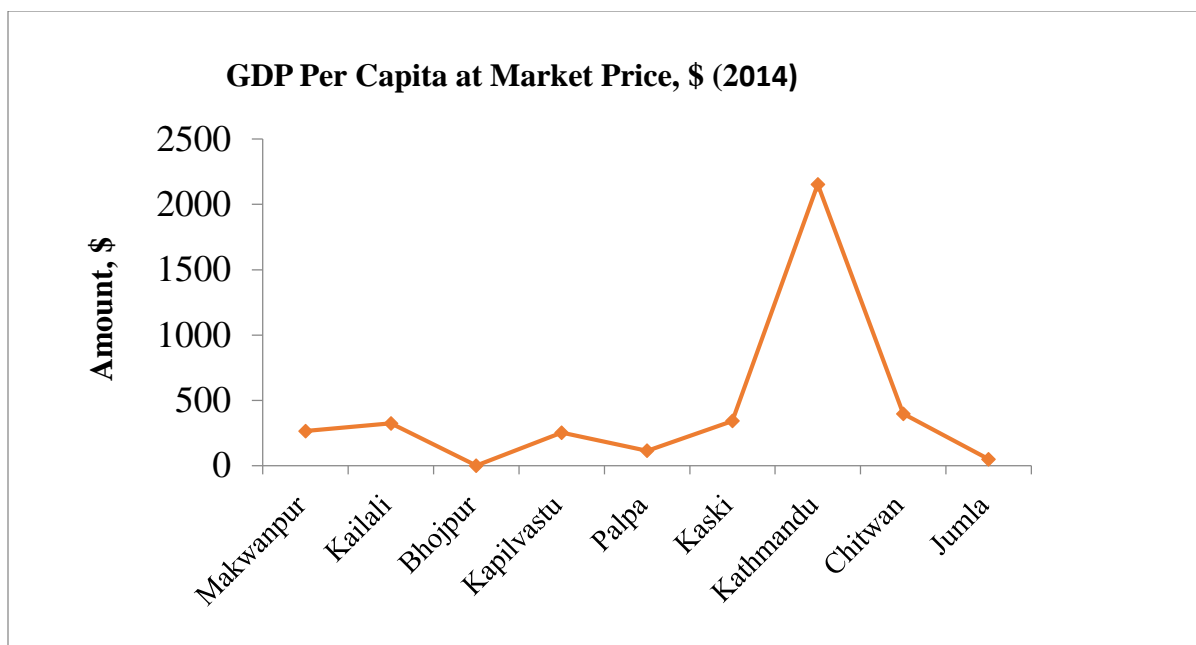


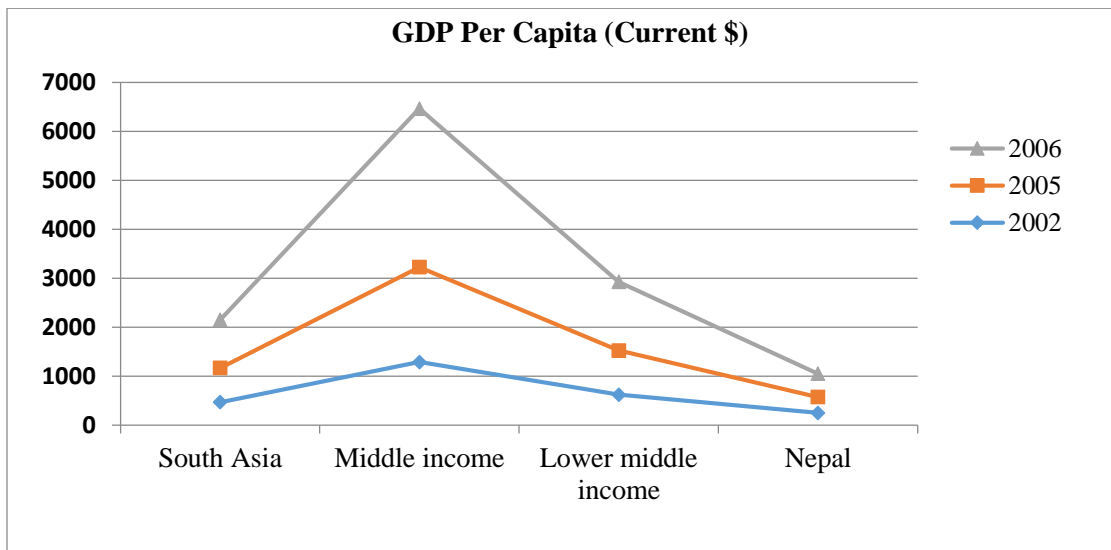
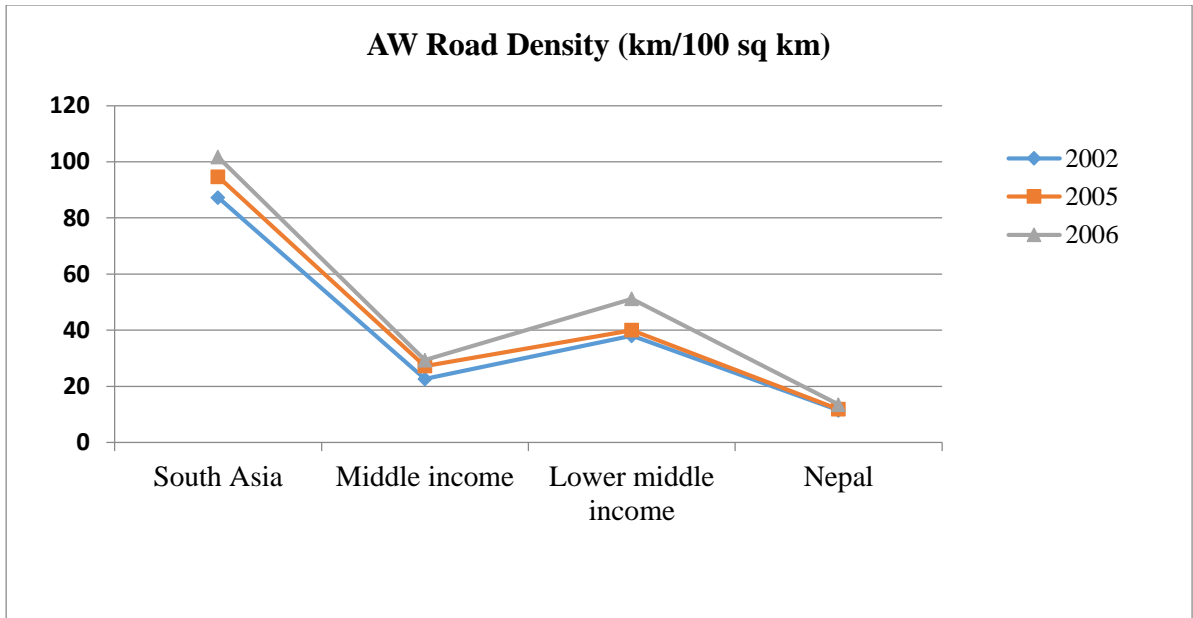
Figure 7: GDP per capita of the districts

4.3 Global Context of GDP and All Weather Roads

On careful comparison about the gross domestic production and density of all-weather roads of countries with different economy we find that the all-weather road network densities and GDP both lying back of them.

Countries	AW Road Density (km/100sq km)			GDP Per Capita (Current \$)		
	2002	2005	2006	2002	2005	2006
South Asia	87.26	94.66	101.68	470.43	696.87	984.77
High income: OECD	41.78	80.14	43.48	26902.47	34670.46	41275.43
Upper middle income	14.25	22.17	22.61	1943.22	2974.35	5117.61
Middle income	22.61	27.21	29.30	1290.55	1936.86	3238.72
Lower middle income	37.97	39.96	51.15	623.53	900.10	1403.29
Nepal	11.43	11.84	13.50	251.04	321.45	477.93

Data Adapted from WDI, WB; 2013



Data Adapted from WDI, WB; 2013

Figure 8: Comparison of all weather road density and GDP of Nepal with similar countries

Both all weather road density as well as GDP per capita expressed in Current \$ are least for Nepal among the groups of South Asian countries, middle or lower income countries.

4.4 Correlation Analysis

From the prepared data, stepwise correlation analysis was conducted in excel to check the significance of the variables. Independent variables with higher degree of correlation with dependent variables but less correlated with other dependent variables are chosen for the regression analysis. An initial correlation matrix is shown in Table-12.

	<i>GDP Per Capita</i> <i>a</i>	<i>Pop D</i>	<i>SRND -A</i>	<i>SRND -P</i>	<i>URD -A</i>	<i>URD -P</i>	<i>RRD -A</i>	<i>RRD -P</i>	<i>TRD -A</i>	<i>TRD -P</i>	<i>AWD -A</i>	<i>AWD -P</i>	<i>a</i>	<i>b</i>	<i>g</i>
GDP Per Capita a	1.00														
PopD	0.88	1.00													
SRND -A	0.85	0.98	1.00												
SRND -P	-0.51	-0.46	-0.32	1.00											
URD -A	0.44	0.31	0.23	-0.64	1.00										
URD -P	-0.01	-0.21	-0.27	-0.40	0.86	1.00									
RRD -A	0.87	0.95	0.92	-0.58	0.53	0.04	1.00								
RRD -P	-0.50	-0.69	-0.64	0.37	0.16	0.54	-0.48	1.00							
TRD -A	0.88	0.93	0.90	-0.59	0.60	0.13	0.99	-0.44	1.00						
TRD -P	-0.43	-0.63	-0.60	0.27	0.37	0.72	-0.41	0.96	-0.35	1.00					
AWD -A	0.90	0.89	0.84	-0.60	0.69	0.24	0.94	-0.42	0.97	-0.28	1.00				
AWD -P	0.14	-0.14	-0.18	-0.33	0.82	0.92	0.10	0.54	0.18	0.70	0.32	1.00			
a	0.39	0.51	0.59	-0.26	0.01	-0.25	0.60	-0.29	0.54	-0.36	0.39	-0.12	1.0		
b	0.39	0.51	0.58	-0.26	0.00	-0.25	0.59	-0.28	0.54	-0.36	0.38	-0.11	1.0	1.0	
g	0.39	0.52	0.60	-0.26	0.00	-0.27	0.60	-0.30	0.54	-0.37	0.39	-0.13	1.0	1.0	1.0

Table 12 Initial Correlation Matrix of Dependent and Independent Variables

In the correlation matrix all the road densities normalized by population came to be insignificant as dependent variables. And also, urban and rural road densities are very

poorly correlated with per capita GDP values. So these are screened out and remaining dependent variables are again taken for correlation analysis. From the correlation analysis all types of road densities expressed in terms of per 1000 population are very weakly correlated with GDP. So, they are screened out. All the three connectivity indices are strongly interrelated, so only one of them is taken for further correlation and regression analysis. SRN density has multi-collinearity effect with total road density while RRN and URN density also do so and are weakly correlated with GDP per capita. So, they are also screened out for regression analysis.

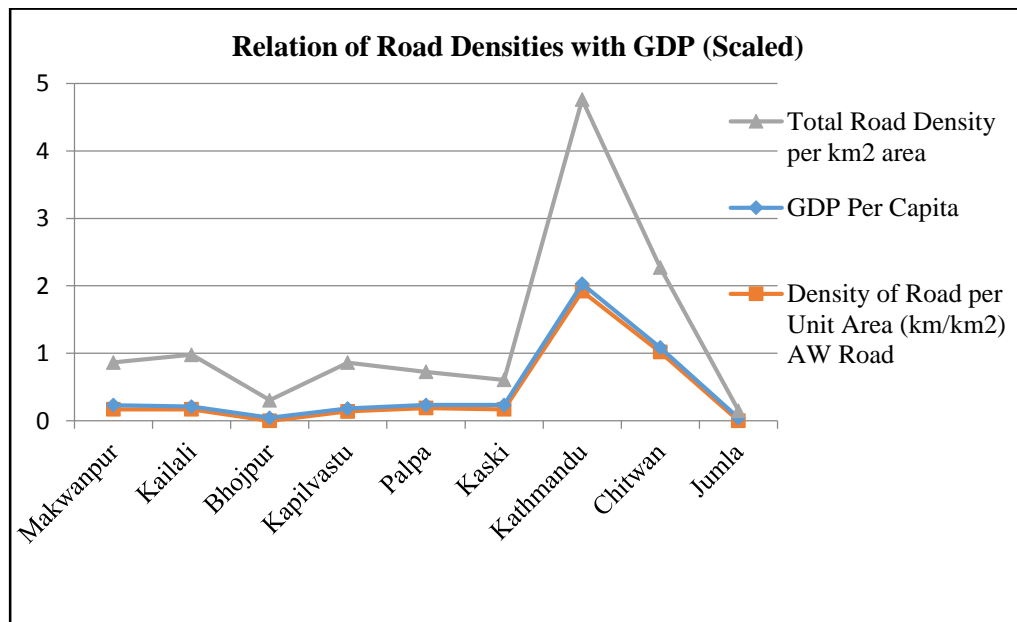


Figure 9: Relation of GDP and AW roads density

The graphical representation illustrates that there is higher degree of correlation between all weather road density and scaled GDP than total road density and scaled GDP. This phenomenon is considered for the subsequent correlation and regression analysis.

4.5 Regression Analysis

The parameters in thus obtained after screening out other parameters based on presence of multi co-linearity effect, stepwise regression analysis was conducted in excel solver. Four types of equations of linear, exponential and power model are fitted and the corresponding parameters are estimated using excel. The summary of the result of regression analysis are tabulated as below.

Model Type	Model Equation	A	B	C	D	E	Adjusted R ² Value	Remarks
Linear	$Y=A+BX_1+CX_2+DX_3+EX_4$	0.0365	8.6E-06	0.02798	0.0443	0.01489	0.74	Taken for Simplicity
Exponential	$Y=A+B.e^{X_1}+C.e^{X_2}+D.e^{X_3}+E.e^{X_4}$	0.032	2.9E-05	0.0176	0.0279	0.0022	0.73	
Power	$Y=A+BX_1+CX_2+D*E^{X_3*X_4}$	0.0459	1.8E-05	0.014	0.00018	10	0.69	
	$Y=A+BX_1+C*E^{X_2*X_4}+DX_3$	0.0465	3.14E-06	4.07E-06	0.0207	10	0.75	Best Fit

Table 13 Regression Analysis Output: Equations and Value of Parameters

Here, X1 = Population Density (per km²), X2 = Total Road Density (km/km²) , X3 = All Weather Road Density (km/km²) and X4 = Beta Index

4.4 Results and Discussions

Power regression is best fitted among the resulted four types of analysis as it has highest R² Value i.e. 0.75. The best fit regression equation of dependent variable GDP per capita, \$ in terms of the chosen dependent variables comes as:

$$\mathbf{GDP\ per\ capita = 0.0465 + 3.14e^{-06}PopD + 4.07e^{-06} * 10^{TRD*\beta} + 0.0207AWRD}$$

Linear regression model has also very close R² Value to that of best fit regression model i.e. 0.74. Hence for the simplicity of linear model, it is suggested to adopt. The Suggested Regression equation comes as:

$$\mathbf{GDP\ per\ capita = 0.036 + 8.6e^{-06}PopD + 0.028TRD + 0.044AWRD + 0.015\beta}$$

where,

GDP per capita is in USA dollar (\$)

PopD is population density in per square kilometer land area

TRD is the total road network density in km per square kilometer land area

AWRD is the total all weather roads density in km per square kilometer land area and,

β is the beta index of road network connectivity.

Since the data were collected only for nine districts and all of them were used for formulation of model, validation of the obtained regression equation was only possible with R² Value i.e only through statistical validation.

The result shows that for GDP, all weather road density has higher multiplicative coefficient i.e at least double than the total road density. Meaning that, all weather roads provides round year services and thus economic activities are boomed. GDP for selected districts are less dependent to the road densities per population. It is because, the selected districts have more agro production based economy with only less volume of service based economy. Agro production based economy is dependent on land area. Also, population density has very less multiplicative coefficient to contribute for GDP.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

The main objective of this thesis work was to seek the relation of road network development to the economic upliftment of any territory. For this purpose, nine districts of Nepal were selected through purposive sampling basis for the study. These districts cover the almost all types of geographical, physiological and economical variation that are prevailing across all districts of Nepal.

5.1 Summary and Conclusion

Due to time, budget and availability of data constraints, it was not possible to conduct the study in all the districts of Nepal. In the selected nine districts, their economic activities expressed in terms of GDP were checked for the correlation with the road network availability and quality. The regression analysis illustrated that GDP per capita increases with increase in road network density per unit area. But increase in mere the lengths of road network has less implications in GDP. But increase in connectivity of road network and round year serviceability of roads, say all weather service roads, enhances the GDP per capita value, ie. economic activities of districts. This is an important finding of this study as it guides the further public investments in road sector in an eye of economic development perspective. The idea given by similar previous study made by of network structure and economic development of nation is updated with the new idea of introducing the quality of roads for economic development of a region.

5.2 Recommendations

With the effort to develop regression model of GDP with road network characteristics as the main objective of this research, rigorous study was conducted and based on its results following recommendations are made which may have policy implications on road investment and development in Nepal.

- Higher Priority should be given to upgrade the fair weather roads to all weather service standards. In doing so, higher degree of economic development of any territory is possible as suggested by the regression result.

- Greater the connectivity of road network, i.e more the road segments are interconnected, higher will be the chance of economic activities in that region supported by the added reliability and flexibility.

5.3 Future Researches

This is the initial step toward the development of correlation and regression analysis domestic economic development and the level of road access of particular territory.

- i. The quality of the analysis may be improved by introducing actual volume of transportation trips data. But these data are not presently available and could not be used in this study. If data could be collected in that way, this study may get significantly improved.
- ii. Time Series data of road networks and GDPs of districts were not available. So could not be used in this study. If such data could be collected, prediction model of GDP could be formulated.
- iii. A effective transportation information management system is lacking in Nepal. If such system is introduced by transportation authority or planning commission, it would be useful for trips data and hence could make such study very effective.

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